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ESSAYS

ON THE

MICROSCOPE.

Truth discovering to Time, Science instructing her Children in the Improvements on the Microscope.

London, Published July 1st 1787, by Geo. Adams, No. 60 Fleet Street.

ESSAYS

ON THE

MICROSCOPE;

CONTAINING

A PRACTICAL DESCRIPTION OF THE MOST IMPROVED MICROSCOPES:

A GENERAL HISTORY of INSECTS,

THEIR

TRANSFORMATIONS, PECULIAR HABITS, AND ŒCONOMY:

AN ACCOUNT OF THE

VARIOUS SPECIES AND SINGULAR PROPERTIES OF THE

HYDRÆ AND VORTICELLÆ:

A DESCRIPTION OF

Three Hundred and Seventy-Nine Animalcula,

WITH A CONCISE

CATALOGUE OF INTERESTING OBJECTS:

A VIEW OF THE

ORGANIZATION OF TIMBER,

AND THE

CONFIGURATION OF SALTS WHEN UNDER THE MICROSCOPE.

BY GEORGE ADAMS,

MATHEMATICAL INSTRUMENT MAKER TO HIS MAJESTY, AND OPTICIAN TO HIS ROYAL HIGHNESS THE PRINCE OF WALES.

LONDON:

PRINTED FOR THE AUTHOR, BY ROBERT HINDMARSH, PRINTER TO HIS ROYAL HIGHNESS THE PRINCE OF WALES, No. 32, CLERKENWELL-CLOSE; AND SOLD BY THE AUTHOR, AT HIS SHOP, TYCHO BRAHE'S HEAD, No. 60, FLEET-STREET.

M.DCC.LXXXVII.

TO THE

KING.

SIR,

EVERY work that tends to enlarge the boundaries of ſcience, has a peculiar claim to the protection of Kings. He that diffuſes ſcience, civilizes man, opens the inlets to his happineſs, and co-operates with the Fountain and Source

6 of

of all knowledge. By ſcience truth is advanced; and of DIVINE TRUTH Kings are the repreſentatives.

The work which I have now the honour to preſent to YOUR MAJESTY, calls the attention of the reader to thoſe laws of Divine order by which the univerſe is governed and ſupported: in it we find that the minuteſt beings ſhare in the protection, and triumph in the bounty of the Sovereign of all things: that the infinitely ſmall manifeſt to the aſtoniſhed eye the ſame proportion, regularity, and deſign, which are conſpicuous to the unaſſiſted ſight in the larger parts of creation. By finding

finding all things formed in beauty, and produced for uſe, the mind is raiſed from the fleeting and evaneſcent appearances of matter to contemplate the permanent principles of truth, and acknowledge that the whole proceeds from the wiſdom that originates in love.

It was by YOUR MAJESTY's goodneſs and gracious patronage that I was firſt induced to undertake a deſcription of mathematical and philoſophical inſtruments, that I might thereby facilitate the attainment of thoſe ſciences that are connected with them, and by ſhewing what was already obtained, excite emulation, and quicken invention.

It

It is to the ſame goodneſs that I am indebted for this opportunity of ſubſcribing myſelf,

SIR,

YOUR MAJESTY's

Moſt humble,

Moſt obedient,

and moſt dutiful

Subject and Servant,

GEORGE ADAMS.

P R E F A C E.

IN the preface to my ESSAYS ON ELECTRICITY AND MAGNETISM, I informed the public that it was my intention to publiſh, from time to time, eſſays deſcribing the conſtruction and explaining the uſe of mathematical and philoſophical inſtruments, in their preſent ſtate of improvement. This work will, I hope, be conſidered as a performance of my promiſe, ſo far as relates to the ſubject here treated of.

The firſt chapter contains a ſhort hiſtory of the invention and improvements that have been made on the microſcope, and Father Torrè's method of making his celebrated glaſs globules. The ſecond treats of viſion, in which I have endeavoured to explain, in a familiar manner, the reaſon of thoſe advantages which are obtained by the uſe of magnifying lenſes; but as the reader is ſuppoſed to be unacquainted with the elements of this ſcience, ſo many intermediate ideas have been neceſſarily omitted, as muſt in ſome degree leſſen the force, and weaken the perception of the truths intended to be inculcated: to have given theſe would have required a treatiſe on optics.

In the third chapter, the moſt improved microſcopes, and ſome others which are in general uſe, are particularly deſcribed; no pains have been ſpared to leſſen the difficulty of obſervation, and remove obſcurity from deſcription; the relative advantages of each inſtrument are briefly pointed out, to enable the reader to ſelect that which is beſt adapted to his purſuits. The method of preparing different objects for obſervation, and the cautions neceſſary to be obſerved in the uſe of the microſcope, are the ſubject of the fourth chapter.

When I firſt undertook the preſent eſſays, I had confined myſelf to a re-publication of my father's work, entitled, Micrographia Illuſtrata; but I ſoon found that both his and Mr. Baker's tracts on the microſcope were very imperfect. Natural hiſtory had not been ſo much cultivated at the period when they wrote, as it is in the preſent day. To the want of that information which is now eaſily obtained, we may, with propriety, impute their errors and imperfections. I have endeavoured to remedy their defects, by arranging the ſubjects in ſyſtematic order, and by introducing the microſcopic reader to the ſyſtem of Linnæus, as far as relates to inſects: by this he will learn to diſcriminate one inſect from another, to characterize their different parts, and thus be better enabled to convey inſtruction to others, and to avoid error himſelf.

As the transformations which inſects undergo, conſtitute a principal branch of their hiſtory, and furniſh many objects for the microſcope, I have given a very ample deſcription of them; the more ſo, as many microſcopic writers, by not conſidering theſe changes with attention, have fallen into a variety of miſtakes.

Here

Here I intended to ſtop; but the charms of natural hiſtory are ſo ſeducing, that I was led on to deſcribe the peculiar and ſtriking marks in the œconomy of theſe little creatures. And ſhould the purchaſer of theſe eſſays receive as much pleaſure in reading this part as I did in compiling it; ſhould it induce him to ſtudy this branch of nature; nay, ſhould it only lead him to read the ſtupendous work of the moſt excellent Swammerdam, he will have no reaſon to regret his purchaſe, and one of my warmeſt wiſhes in compiling it will be gratified.

In the next chapter I have endeavoured to give the reader ſome idea of Mr. Lyonet's "anatomical and microſcopical deſcription of the coſſus, or caterpillar of the willow." As this book is but little known in our country, I thought that a ſpecimen of the indefatigable labour of this patient and humane anatomiſt would be acceptable to all lovers of the microſcope; and I have, therefore, appropriated a plate, which, while it ſhews what may be effected when microſcopic obſervation is accompanied by patience and induſtry, diſplays alſo the wonderful organization of this inſect. This is followed by a deſcription of many miſcellaneous objects; objects, of which no idea could be formed without the aſſiſtance of glaſſes.

To deſcribe the freſh-water polype, or hydra; to give a ſhort hiſtory of the diſcovery of theſe curious animals, and ſome account of their ſingular properties, is the buſineſs of the ſucceeding chapter. The properties of theſe animals are ſo extraordinary, that they were conſidered at firſt to be as contrary to the common courſe of nature, as they really were to the received opinions of animal life. Indeed, who can even now contemplate, without

 aſtoniſh-

aſtoniſhment, animals that multiply by ſlips and ſhoots like a plant, that may be grafted together as one tree to another, that may be turned inſide out like a glove, and yet live, act, and perform all the various functions of their little ſpheres. As nearly allied to theſe, the chapter finiſhes with an account of thoſe vorticellæ which have been enumerated by Linnæus. It has been my endeavour to diſſipate confuſion, by the introduction of order, to diſpoſe into method, and ſelect under proper heads the ſubſtance of all that is known relative to theſe little creatures, and in the compaſs of a few pages to give the reader the information that is diſperſed through volumes.

From the hydræ and vorticellæ it was natural to proceed to the animalcula which are to be found in vegetable infuſions. Microſcopic beings, that ſeem as it were to border on the infinitely ſmall, that leave no ſpace deſtitute of inhabitants, and are of greater importance in the immenſe ſcale of beings than our contracted imagination can conceive, yet ſmall as they are, each of them poſſeſſes all that beauty and proportion of organized texture which is neceſſary to it's well being, and ſuited to the happineſs it is called forth to enjoy. I have pointed out the decided characters which fix them in the ſcale of animal life, characters that it is preſumed are a full confutation of the fanciful theories of Needham and Buffon. A ſhort account of three hundred and ſeventy-nine of theſe minute beings is then given, agreeable to the ſyſtem of the laborious Muller,* enlarging conſiderably his deſcription of thoſe animalcula that are moſt eaſily met with, better known, and conſequently more intereſting to the generality of readers.

The

* Muller, Animalcula Infuſoria.

The conſtruction of timber, and the diſpoſition of it's component parts, as ſeen by the microſcope, is the ſubject of the next chapter; a ſubject confeſſedly obſcure. With what degree of ſucceſs this attempt has been proſecuted, muſt be left to the judgment of the reader. The beſt treatiſe on this part of vegetation is that of Mr. Duhamel du Monceaus " ſur la Phyſique des Arbres." If either my time, or ſituation in life, would have permitted it, I ſhould have followed his plan; but being confined to buſineſs, and to London, I can only recommend it to thoſe lovers of the works of the Almighty, who live in the country, to purſue this important branch of natural hiſtory. There is no doubt but that new views of the operations in nature, and of the wiſdom with which all things are contrived, would amply repay the labour of inveſtigation. Every part of the vegetable kingdom is rich in microſcopic beauties, from the ſtatelieſt tree of the foreſt, from the cedar of Lebanon, to the lowlieſt moſs, and the hyſſop that ſpringeth out of the wall, all conſpiring to ſay how much is hid from the natural ſight of man, how little can be known till it receives aſſiſtance, and is benefited by adventitious aid.

From the wonderful organization of animals, and the curious texture of vegetables, we proceed to the mineral kingdom, and take a curſory view of the configuration of ſalts and ſaline ſubſtances, exhibiting a few ſpecimens of the beautiful order in which they arrange themſelves under the eye, after having been ſeparated by diſſolution: every ſpecies working as it were upon a different plan, and producing cubes, pyramids, hexagons, or

some

ſome other figure peculiar to itſelf, with a conſtant regularity amidſt boundleſs variety.

Though all nature teems with objects for the microſcopic obſerver, yet ſuch is the indolence of the human mind, or ſuch it's inattention to what is obvious, that among the purchaſers of microſcopes many have complained that they knew not what ſubjects to apply to their inſtrument, or where to find objects for examination. To obviate this complaint, a catalogue is here given, which is interſperſed with the deſcription of a few inſects, and other objects, which could not be conveniently introduced in the foregoing chapters. By this catalogue it is hoped that the uſe of the microſcope will be extended, and the path of obſervation facilitated.

To avoid the faſtidious parade of quotation, and the charge of plagiariſm, I have ſubjoined to this preface a liſt of the authors I have conſulted. As my extracts were made at very diſtant periods, it would have been impoſſible for me to remember to whom I was indebted for every new fact, or ingenious obſervation. It may, however, be neceſſary to inform the reader, that Mr. Marſham gave me the Linnæan names for the inſects which are deſcribed in this work.

The plates were drawn and engraved with a view to be folded up with the work; but as it is the opinion of many of my friends that they would, by this means, be materially injured, I have been adviſed to have them ſtitched in ſtrong blue paper, and leave it to the purchaſer to diſpoſe of them to his own mind.

A List of the Authors which have been consulted in the Compilation of these Essays.

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ON THE

MICROSCOPE.

CHAP. I.

A Concise History of the Invention and Improvements which have been made upon the Instrument called a Microscope.

IT is generally ſuppoſed, that microſcopes were invented about the year 1680, a period fruitful in diſcoveries, a time when the mind began to emancipate itſelf from thoſe errors and prejudices by which it had been too long enſlaved, to aſſert it's rights, extend it's powers, and follow the paths which lead to truth. The honor of the invention is claimed by the Italians and the Dutch; the name of the inventor, however, is loſt; probably the diſcovery did not at firſt appear ſufficiently important, to engage the attention of thoſe men, who, by their reputation in ſcience, were able to eſtabliſh an opinion of it's merit rebuilt a little farther off a fize bigger, and the number of them increafed at the fame time.

Thus they continually enlarge their apartments, pull down, repair, or re-build, according to their wants, with a degree of fagacity, regularity, and forefight, not even imitated by any other kind of animals or infects.

The nurferies are inclofed in chambers of clay, like thofe which contain the provifions, but much larger. In the early ftate of the neft they are not bigger than an hazel-nut, but in great hills are often as large as a child's head of a year old.

The difpofition of the interior parts of thefe hills is very much alike, except when fome infurmountable obftacle prevents; for inftance, when the king and queen have been firft lodged near the foot of a rock, or of a tree, they are certainly built out of the ufual form, otherwife pretty nearly according to the following plan.

The royal chamber is fituated at about a level with the furface of the ground, at an equal diftance from all the fides of the building, and directly under the apex of the hill. It is on all fides, both above and below, furrounded by what may be called the royal apartments, which have only labourers and foldiers in them, and can be intended for no other purpofe than for thefe to wait in, either to guard or ferve their common father and mother, on whofe fafety depends the happinefs, and, according to the negroes, even the exiftence of the whole community.

Thefe

These apartments compofe an intricate labyrinth, which extends a foot or more in diameter from the royal chamber on every fide. Here the nurferies and magazines of provifions begin, and being feparated by fmall empty chambers and galleries, which go round them, or communicate from one to the other, are continued on all fides to the outward fhell, and reach up within it two-thirds or three-fourths of it's height, leaving an open area in the middle under the dome, which very much refembles the nave of an old cathedral; this is furrounded by three or four very large gothic-fhaped arches, which are fometimes two or three feet high next the front of the area, but diminifh very rapidly as they recede from thence, like the arches of aifles in perfpective, and are foon loft among the innumerable chambers and nurferies behind them.

All thefe chambers, and the paffages leading to and from them, being arched, they help to fupport one another; and while the interior large arches prevent them falling into the center, and keep the area open, the exterior building fupports them on the outfide.

There are, comparatively fpeaking, few openings into the great area, and they for the moft part feem intended only to admit that genial warmth into the nurferies which the dome collects.

The interior building, or affemblage of nurferies, chambers, &c. has a flattifh top, or roof, without any perforation, which would keep the apartments below dry, in cafe through accident the dome fhould receive any injury, and let in water; and it is never exactly flat and uniform, becaufe they are always adding to it by building more chambers and nurferies: fo that the divifions,

or

or columns, between the future arched apartments, reſemble the pinnacles upon the fronts of ſome old buildings, and demand particular notice, as affording one proof that for the moſt part the inſects project their arches, and do not make them by excavation.

The area has alſo a flattiſh floor, which lies over the royal chamber, but ſometimes a good height above it, having nurſeries and magazines between. It is likewiſe water-proof, and contrived ſo as to let the water off, if it ſhould get in and run over, by ſome ſhort way, into the ſubterraneous paſſages, which run under the loweſt apartments in the hill, in various directions, and are of an aſtoniſhing ſize, being wider than the bore of a great cannon. There is an account of one that was meaſured, that was perfectly cylindrical, and thirteen inches in diameter.

Theſe ſubterraneous paſſages, or galleries, are lined very thick with the ſame kind of clay of which the hill is compoſed, and aſcend the inſide of the outward ſhell in a ſpiral manner; and winding round the whole building up to the top, interſect each other at different heights, opening either immediately into the dome in various places, and into the interior building, the new turrets, &c. or communicating thereto by other galleries of different bores or diameters, either circular or oval.

From every part of theſe large galleries are various ſmall pipes, or galleries, leading to different parts of the building; under ground there are a great many which lead downward, by ſloping deſcents three and four feet perpendicular among the gravel, from whence the labouring termites cull the finer parts, which being worked

worked up in their mouths to the confiftence of mortar, becomes that folid clay, or ftone, of which their hills and all their buildings, except their nurferies, are compofed.

Other galleries again afcend and lead out horizontally on every fide, and are carried under ground near to the furface, a vaft diftance: for if you deftroy all the nefts within one hundred yards of your houfe, the inhabitants of thofe which are left unmolefted farther off, will neverthelefs carry on their fubterraneous galleries, and invade the goods and merchandizes contained in it by fap and mine, and do great mifchief if you are not very circumfpect.

But to return to the cities from whence thefe extraordinary expeditions and operations originate, it feems there is a degree of neceffity for the galleries under the hills being thus large, being the great thoroughfares for all the labourers and foldiers going forth or returning upon any bufinefs whatever, whether fetching clay, wood, water, or provifions; and they are certainly well calculated for the purpofes to which they are applied, by the fpiral flope which is given them; for if they were perpendicular, the labourers would not be able to carry on their building with fo much facility, as they afcend a perpendicular with difficulty, and the foldiers can fcarce do it at all. It is on this account that fometimes a road like a ledge is made on the perpendicular fide of any part of the building within their hill, which is flat on the upper furface, and half an inch wide, and afcends gradually like a ftair-cafe, or like thofe roads which are cut on the fides of hills and mountains, that would otherwife be inacceffible: by which, and

and ſimilar contrivances, they travel with great facility to every interior part.

Having given ſome idea of the neſts, we now proceed to give a more particular account of the inſects themſelves, which will be exceedingly neceſſary to a tolerable acquaintance with their œconomy and management, their manner of building, fighting, and marching, and to a more particular account of their uſes in the creation, and of the vaſt miſchief they cauſe to mankind. There are of every ſpecies of termites three orders; of theſe orders the working inſects, or labourers, are always the moſt numerous; in the TERMES BELLICOSUS there ſeem to be at the leaſt one hundred labourers to one of the fighting inſects, or ſoldiers. They are in this ſtate about one-fourth of an inch long, and twenty-five of them weigh about a grain, ſo that they are not ſo large as ſome of our ants; from their external habit and fondneſs for wood, they have been very expreſſively called wood-lice by ſome people, and the whole genus has been known by that name, particularly among the French. They reſemble them, it is true, very much at a diſtance; they run as faſt, or faſter, than any other inſect of their ſize, and are inceſſantly buſtling about their affairs.

The ſecond order, or ſoldiers, have a very different appearance from the labourers, and have been by ſome authors ſuppoſed to be the males, and the former neuters; but they are, in fact, the ſame inſects as the foregoing, only they have undergone a change of form, and approached one degree nearer to the perfect ſtate. They are now much larger, being half an inch long, and equal in bulk to fifteen of the labourers. There is now, likewiſe, a moſt remarkable circumſtance in the form of the head and mouth; for in the former ſtate the mouth is evidently calculated for gnawing and holding bodies; but in this ſtate, the jaws being ſhaped juſt like two very ſharp awls a little jagged, they are incapable of any thing but piercing or wounding, for which purpoſes they are very effectual, being as hard as a crab's claw, and placed in a ſtrong horney head, which is of a nut-brown colour, and larger than all the reſt of the body together, which ſeems to labour under great difficulty in carrying it: on which account, perhaps, the animal is incapable of climbing up perpendicular ſurfaces.

The third order, or the inſect in it's perfect ſtate, varies it's form ſtill more than ever; the head, thorax, and abdomen, differ almoſt entirely from the ſame parts in the labourers and ſoldiers; and beſides this, the animal is now furniſhed with four fine large browniſh tranſparent wings, with which it is, at the time of emigration, to wing it's way in ſearch of a new ſettlement: in ſhort, it differs ſo much from it's form and appearance in the two other ſtates, that it has never been ſuppoſed to be the ſame animal, but by thoſe who have ſeen it in the ſame neſt; and ſome of theſe have diſtruſted the evidence of their ſenſes. It was ſo long before Mr. Smeathman met with them in the neſts, that he doubted the information which was given him by the natives, that they belonged to the ſame family: indeed, you may open twenty neſts without finding one winged one; for thoſe are to be found only juſt before the commencement of the rainy ſeaſon, when they undergo the laſt change, which is preparative to their colonization. Add to this, they ſometimes abandon an outward part of their building, the community being diminiſhed by ſome accident that is unknown; ſometimes different ſpecies of the real ant (formica)

 poſſeſs

poſſeſs themſelves by force of a lodgment, and ſo are frequently diſlodged from the ſame neſt, and taken for the ſame kind of inſects. This is often the caſe with the neſts of the ſmaller ſpecies, which are frequently totally abandoned by the termites, and completely inhabited by different ſpecies of ants, cockroaches, ſcolopendræ, ſcorpions, and other vermin fond of obſcure retreats, that occupy different parts of their roomy buildings.

In the winged ſtate they have alſo much altered their ſize as well as form. Their bodies now meaſure between ſix and ſeven-tenths of an inch in length, and their wings above two inches and a half from tip to tip, and they are equal in bulk to about thirty labourers, or two ſoldiers. They are now alſo furniſhed with two large eyes placed on each ſide of the head, and very conſpicuous; if they have any before, they are not eaſily to be diſtinguiſhed. Probably, in the two firſt ſtates, their eyes, if they have any, may be ſmall like thoſe of moles; for as they live like theſe animals always under ground, they have as little occaſion for theſe organs, and it is not to be wondered at that we do not diſcover them; but the caſe is much altered when they arrive at the winged ſtate, in which they are to roam, though but for a few hours, through the wide air, and explore new and diſtant regions. In this form the animal comes abroad during, or ſoon after, the firſt tornado, which at the latter end of the dry ſeaſon proclaims the approach of the enſuing rains, and ſeldom waits for a ſecond or third ſhower; if the firſt, as is generally the caſe, happens in the night, and brings much wet after it, the quantities that are to be found the next morning all over the ſurface of the earth, but particularly on the waters, is aſtoniſhing; for their wings are only calculated to carry them a few hours; and after the

the riſing of the ſun, not one in a thouſand is to be found with four wings, unleſs the morning continues rainy, when here and there a ſolitary being is ſeen winging it's way from one place to another, as if ſolicitous only to avoid it's numerous enemies, particularly various ſpecies of ants, which are hunting on every ſpray, on every leaf, and in every poſſible place, for this unhappy race, of which, probably, not a pair in many millions get into a place of ſafety, fulfil the firſt law of nature, and lay the foundation of a new community.

Not only all kinds of ants, birds, and carnivorous reptiles, as well as inſects, are upon the hunt for them, but the inhabitants of many countries eat them.

They are now become, from one of the moſt active, induſtrious, and rapacious, from one of the moſt fierce and implacable little animals in the world, the moſt innocent, helpleſs, and cowardly! never making the leaſt reſiſtance to the ſmalleſt ant. The ants are to be ſeen on every ſide in infinite numbers, of various ſpecies and ſizes, dragging theſe annual victims of the laws of nature to their different neſts. It is wonderful that a pair ſhould ever eſcape ſo many dangers, and get into a place of ſecurity. Some, however, are ſo fortunate; and being found by the labouring inſects that are continually running about the ſurface of the ground under their covered galleries, the little induſtrious creatures immediately incloſe them in a ſmall chamber of clay, ſuitable to their ſize, into which at firſt they leave but one ſmall entrance, large enough for themſelves and the ſoldiers to go in and out, but much too little for either of the royal pair to make uſe of; and when neceſſity obliges them to make more entrances, merit with the reſt of the world, and hand down the name of the inventor to ſucceeding ages. Men of great literary abilities are too apt to deſpiſe the firſt dawnings of invention, not conſidering that all real knowledge is progreſſive, and that what they deem trifling may be the firſt and neceſſary link to a new branch of ſcience.

The microſcope extends the boundaries of the organs of viſion, enables us to examine the ſtructure of plants and animals; preſents to the eye myriads of beings, of whoſe exiſtence we had before formed no idea; opens to the curious an exhauſtleſs ſource of information and pleaſure; and furniſhes the philoſopher with an unlimited field of inveſtigation. It leads, to uſe the words of an ingenious writer, to the diſcovery of a thouſand wonders in the works of his hand, who created ourſelves, as well as the objects of our admiration; it improves the faculties, exalts the comprehenſion, and multiplies the inlets to happineſs; is a new ſource of praiſe to him, to whom all we pay is nothing of what we owe; and while it pleaſes the imagination with the unbounded treaſures it offers to the view, it tends to make the whole life one continued act of admiration.

It is not difficult to fix the period when the microſcope firſt began to be generally known, and was uſed for the purpoſe of examining minute objects; for though we are ignorant of the name of the firſt inventor, we are acquainted with the names of thoſe who introduced it into public view, and engaged their attention to it, by exhibiting ſome of it's wonderful effects. Zacharias Janſens and his ſon had made microſcopes before the year 1619, for in that year the ingenious Cornelius Drebell

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they are never larger; ſo that, of courſe, the voluntary ſubjects charge themſelves with the taſk of providing for the offspring of their ſovereigns, as well as to work and to fight for them, until they ſhall have raiſed a progeny capable at leaſt of dividing the taſk with them.

The buſineſs of propagation, however, ſoon commences; and the labourers having conſtructed a ſmall wooden nurſery, as before deſcribed, carry the eggs and lodge them there as faſt as they can obtain them from the queen.

About this time a moſt extraordinary change begins to take place in the queen, to which we know nothing ſimilar, except in the PULEX PENETRANS of LINNÆUS, the JIGGER of the Weſt-Indies, and in the different ſpecies of COCCUS COCHINEAL. The abdomen of this female begins gradually to extend and enlarge to ſuch an enormous ſize, that an old queen will have it increaſed ſo as to be fifteen hundred or two thouſand times the bulk of the reſt of her body, and twenty or thirty thouſand times the bulk of a labourer; the ſkin between the ſegments of the abdomen extends in every direction, and at laſt the ſegments are removed to half an inch diſtance from each other, though at firſt the length of the whole abdomen is not above half an inch. They preſerve their dark-brown colour, and the upper part of the abdomen is marked with a regular ſeries of brown bars, from the thorax to the poſterior part of the abdomen, while the intervals between them are covered with a thin, delicate, tranſparent ſkin, and appear of a fine cream colour, a little ſhaded by the dark colour of the inteſtines and watery fluid ſeen here and there beneath. It is ſuppoſed that the animal is upwards of two years old

old when the abdomen is increaſed to three inches in length: they have ſometimes been found of near twice that ſize. The abdomen is now of an irregular oblong ſhape, being contracted by the muſcles of every ſegment, and is become one vaſt matrix full of eggs, which make long circumvolutions through an innumerable quantity of very minute veſſels, that circulate round the inſide in a ſerpentine manner, which would exerciſe the ingenuity of a ſkilful anatomiſt to diſſect and develope. This ſingular matrix is not more remarkable for it's amazing extenſion and ſize, than for it's periſtaltic motion, which reſembles the undulating of waves, and continues inceſſantly without any apparent effort of the animal; ſo that one part or other alternately is riſing and ſinking in perpetual ſucceſſion, and the matrix ſeems never at reſt, but is always protruding eggs to the amount, as have been frequently counted in old queens, of ſixty in a minute, or eighty thouſand and upwards in one day of twenty-four hours.

Theſe eggs are inſtantly taken from her body by her attendants, (of whom there always are, in the royal chamber and galleries adjacent, a ſufficient number in waiting) and carried to the nurſeries, which in a great neſt may ſome of them be four or five feet diſtant in a ſtrait line, and conſequently much farther by their winding galleries. Here, after they are hatched, the young are attended and provided with every thing neceſſary, until they are able to ſhift for themſelves, and take their ſhare of the labours of the community. The foregoing is an accurate deſcription and account of the termes bellicoſus, or ſpecies that builds the large neſts, in it's different ſtates.

Thoſe

Thoſe which build either the roofed turrets, or the neſts in the trees, ſeem, in moſt inſtances, to have a ſtrong reſemblance to them, both in their form and œconomy, going through the ſame changes from the egg to the winged ſtate. The queens alſo increaſe to a great ſize when compared with the labourers, but very ſhort of thoſe queens before deſcribed. The largeſt are from about an inch to an inch and a half long, and not much thicker than a common quill. There is the ſame kind of periſtaltic motion in the abdomen, but in a much ſmaller degree; and as the animal is incapable of moving from her place, the eggs, no doubt, are carried to the different cells by the labourers, and reared with a care ſimilar to that which is practiſed in the larger neſts.

It is remarkable of all theſe different ſpecies, that the working and the fighting inſects never expoſe themſelves to the open air, but either travel under ground, or within ſuch trees and ſubſtances as they deſtroy; except, indeed, when they cannot proceed by their latent paſſages, and find it convenient or neceſſary to ſearch for plunder above ground: in that caſe they make pipes of that material with which they build their neſts. The larger ſort uſe the red clay; the turret builders uſe the black clay; and thoſe which build in the trees employ the ſame ligneous ſubſtance of which their neſts are compoſed.

The termites, except their heads, are exceedingly ſoft, and covered with a very thin and delicate ſkin; being blind, they are no match on open ground for the ants, who can ſee, and are all of them covered with a ſtrong horny ſhell not eaſily pierced, and are of diſpoſitions bold, active, and rapacious.

Whenever

Whenever the termites are diflodged from their covered ways, the various fpecies of the former, who probably are as numerous above ground as the latter are in their fubterraneous paffages, inftantly feize and drag them away to their nefts, to feed the young brood. The termites are, therefore, exceedingly folicitous about the preferving their covered ways in good repair; and if you demolifh one of them for a few inches in length, it is wonderful how foon they rebuild it. At firft, in their hurry, they get into the open part an inch or two, but ftop fo fuddenly, that it is very apparent they are furprized: for though fome run ftrait on, and get under the arch as fpeedily as poffible in the further part, moft of them run as faft back, and very few will venture through that part of the track which is left uncovered. In a few minutes you will perceive them re-building the arch, and by the next morning they will have reftored their gallery for three or four yards in length, if fo much has been ruined; and upon opening it again, will be found as numerous as ever under it, paffing both ways. If you continue to deftroy it feveral times, they will at length feem to give up the point, and build another in a different direction; but if the old one led to fome favourite plunder, in a few days will rebuild it again; and, unlefs you deftroy their neft, never totally abandon their gallery. They do confiderable damage to houfes, &c. They make their approaches chiefly under ground, defcending below the foundations of houfes and ftores at feveral feet from the furface, and rifing again either in the floors, or entering at the bottom of the pofts, of which the fides of the buildings are compofed, bore quite through them, following the courfe of the fibres to the top, or making lateral perforations and cavities here and there as they proceed.

While

While ſome are employed in gutting the poſts, others aſcend from them, entering a rafter, or ſome other part of the roof. If they once find the thatch, which ſeems to be a favourite food, they ſoon bring up wet clay, and build their pipes, or galleries, through the roof in various directions, as long as it will ſupport them; ſometimes eating the palm-tree leaves and branches of which it is compoſed, and perhaps (for variety ſeems very pleaſing to them) the rattan, or other running plant, which is uſed as a cord to tie the various parts of the roof together, and that to the poſts which ſupport it. Thus, with the aſſiſtance of the rats, who, during the rainy ſeaſon, are apt to ſhelter themſelves there, and to burrow through it, they very ſoon ruin the houſe, by weakening the faſtenings and expoſing it to the wet. In the mean time, the poſts will be perforated in every direction, as full of holes as that timber in the bottoms of ſhips, which has been bored by the worms; the fibrous and knotty parts, which are the hardeſt, being left to the laſt.

Theſe inſects are not leſs expeditious in deſtroying the ſhelves, wainſcotting, and other fixtures of an houſe, than the houſe itſelf. They are continually piercing and boring in all directions, and ſometimes go out of the broadſide of one poſt into that of another adjoining to it; but they prefer and always deſtroy the ſofter ſubſtances the firſt, and are particularly fond of pine and fir-boards, which they excavate and carry away with wonderful diſpatch and aſtoniſhing cunning: for, except a ſhelf has ſomething ſtanding upon it, as a book, or any thing elſe which may tempt them, they will not perforate the ſurface, but artfully preſerve it quite whole, and eat away all the inſide, except a few fibres, which barely keep the two ſides connected together; ſo

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that a piece of an inch-board, which appears ſolid to the eye, will not weigh much more than two ſheets of paſteboard of equal dimenſions, after theſe animals have been a little while in poſſeſſion of it. In ſhort, the termites are ſo inſidious in their attacks, that we cannot be too much on our guard againſt them: they will ſometimes begin and raiſe their works, eſpecially in new houſes, through the floor. If you deſtroy the work ſo begun, and make a fire upon the ſpot, the next night they will attempt to riſe through another part; and if they happen to emerge under a cheſt, or trunk, early in the night will pierce the bottom, and deſtroy or ſpoil every thing in it before the morning. On theſe accounts the inhabitants ſet all their cheſts and boxes upon ſtones or bricks, ſo as to leave the bottoms of ſuch furniture ſome inches above the ground, which not only prevents theſe inſects finding them out ſo readily, but preſerves the bottoms from a corroſive damp, which would ſtrike from the earth through, and rot every thing therein: a vaſt deal of vermin alſo would harbour under, ſuch as cockroaches, centipedes, millepedes, ſcorpions, ants, and various other noiſome inſects.

Though the view we have given of the various proceedings of inſects in forming their habitations, has already run to ſome length, we cannot with propriety neglect taking ſome further notice of the wonderful induſtry and art which is manifeſted in theſe reſpects by the caterpillar; and more particularly ſo, as it is by it we obtained the foundations of all our preſent knowledge of the natural hiſtory of inſects.

Some ſpecies of caterpillars form a kind of hammock, in which they eat and go through their varied changes; while others erect a tent, under which they live, until they have consumed the surrounding herbs. They then leave their abodes, and pitch their tents in a more fruitful spot.

Many associate together all their lives, others only for a certain period. Those who live together proceed from the same moth who deposited the eggs near each other, or rather laid them in a heap, forming as it were a kind of nest. These are generally hatched in the same day, and live together, constituting a new species of republic, in which all are brethren. They often amount to near six hundred in a family, though they are frequently to be found with only about two hundred. Of these social caterpillars there are some species which never quit the society while they are in a larva state, even placing the chrysalis close together. There are other kinds who associate only for a short period.

Among the vast variety of insects which inhabit the oak, there is a species of caterpillar which live separate till they arrive at a certain age: they then assemble together, and do not quit each other till they attain their perfect state. As the number which are thus assembled is considerable, the nest is also very large. They remain in-doors during the day, not leaving their habitation till sun-set. When they go out, one of the body precedes the rest as a chief, whom they regularly follow: when the leader stops, the rest do the same, and wait till it goes on again, before they recommence their march. The first file generally consists of a single caterpillar, which are succeeded by a double file, these by three in a row, which are then followed by files of five, and so on. They keep exceeding close to each other, not leaving any interval either between the ranks, or those in each rank: all of them

them following their captain in every direction, whether ſtrait or crooked. After they have taken their repaſt, which is done on the march, they return to their neſt in the ſame order in which they ſet out.

This mode is followed till they are full grown, when each forms a cone, in which it is changed into a chryſalis. Mr. Bonnet has ſhewn, that though theſe caterpillars proceed often very far from their neſt, it is by no means difficult for them to get back again, becauſe they ſpin over all the places in their rout. The firſt leads the way, the ſecond follows ſpinning, the third ſpins after the firſt and ſecond, and ſo on with the reſt. All theſe threads form by degrees a ſmall ſhining track, a little path; and all theſe paths meet at the neſt. To be fully convinced of the uſe of theſe threads, let any one but break the continuation of them in ſome place or other, and he ſhall ſee the little caterpillars turn back, as if they were at a loſs, till one more daring than the reſt reſtores the communication by ſpinning new threads.

The reader who is deſirous of a fuller information concerning the habits of theſe, as well as many other inſects, muſt be referred to the laborious and intereſting memoirs of M. de Reaumur. Happy if he ſhould, like M. de Geer, be induced thereby to follow the ſteps of ſo great a maſter; he will derive from thence a continual ſource of new pleaſures and increaſing delights; and the more he extends the boundaries of his obſervations, the more he will be convinced that INFINITY is, as it were, impreſſed on all the works of the Creator.

Different ſpecies of caterpillars are often to be found in great numbers on the ſame tree or plant; but then as they ſeem to have no connection with each other, and the actions of the one have no influence on the other, they may be conſidered as ſolitary; but there are others who ſeem ſtill more independent of each other, and greater friends to ſolitude, conſtructing a lodging, formed of leaves tied together with conſiderable ingenuity, in which they live as in a hermitage. The operation by which theſe tie the leaves together, is far ſurpaſſed by another kind, who fold and bend one part of the leaf till it meets the other. Theſe are again exceeded by thoſe who roll the leaves which they inhabit. For this purpoſe, the caterpillar chuſes a part of a leaf which it finds in ſome degree bent: here it eſtabliſhes it's abode, and begins it's work, moving the head with great velocity, in a curved line, or rather vibrating it like a pendulum, the middle of the body being the center on which it moves. At each motion of the head a thread is ſpun, and fixed to that part to which the head ſeems to be applied. The threads are extended from the bent to the flat part of the leaf, being always adjuſted, both in length and ſtrength, to the nature of the leaf, and the curvature which is to be given to it.

M. de Geer attending to the operations of a ſpecies of this kind of caterpillar, obſerved, that at each new thread it ſpun, the edges of the leaf inſenſibly approached to each other, and were bent more and more, in proportion as the caterpillar ſpun new threads; when the laſt thread that was ſpun was tight, that which preceded it was looſe and floating in the air. To effect this, the caterpillar, after it has fixed a thread to the two edges of the leaf, (and before it ſpins another) draws it towards itſelf by the hooks of of it's feet, and by this means bends the leaf; it then ſpins another thread, to maintain the leaf in this poſition, which it again pulls towards itſelf, and repeats the operation, till it has bent the leaf in it's whole direction. It now begins again, placing the threads further back upon the bent part of the leaf, and by proceeding in this manner, it is rolled up; when it has finiſhed this buſineſs, it ſtrengthens the work, by faſtening the ends of the leaf together. The habitation thus formed is a kind of hollow cylinder, open to the light at both ends, the ſides of it affording the inſect food and protection, for within it the creature feeds in ſafety. In the ſame caſe they are alſo transformed: at the approach of the change the caterpillar lines the rolled leaf with ſilk, that the rough parts of it may not injure the chryſalis.

A great number of the ſmaller larva require an artificial covering, to protect them from the open air. Among theſe, ſome inhabit the interior parts of leaves, making their way between the ſuperior and inferior membranes, living upon the parenchymous parts of the leaf: and as they are exceeding ſmall, a leaf affords them a ſpacious habitation. If the diſtance between the membranes is not large enough for them, they enlarge the ſpace by forming different folds in one of them, in which they can move with eaſe: from theſe circumſtances they have been named by Mr. Reaumur miners of leaves. This illuſtrious author has deſcribed theſe larva, the flies into which they are changed, and all the various methods made uſe of by them in performing this work. Some mine a large oval or circular ſpace; others form a kind of gallery, which are ſometimes ſtrait, ſometimes crooked. They only leave a thin membrane on the upper ſide of the leaf; but they leave the under ſide more ſubſtantial. One ſpecies brought one, which was made by them, with him into England, and ſhewed it to William Borrell and others. It is poſſible this inſtrument of Drebell's was not ſtrictly what is now meant by a microſcope, but was rather a kind of microſcopic teleſcope, ſomething ſimilar in principle to that lately deſcribed by Mr. Aepinus, in a letter to the Academy of Sciences at Peterſburg. It was formed of a copper tube ſix feet long and one inch diameter, ſupported by three braſs pillars in the ſhape of dolphins; theſe were fixed to a baſe of ebony, on which the objects to be viewed by the microſcope were alſo placed. In contradiction to this, Fontana, in a work which he publiſhed in 1646, ſays, that he had made microſcopes in the year 1618: this may be alſo very true, without derogating from the merit of the Janſens, for we have many inſtances in our own times of more than one perſon having executed the ſame contrivance, nearly at the ſame time, without any communication from one to the other. In 1685, Stelluti publiſhed a deſcription of the parts of a bee, which he had examined with a microſcope.

If we conſider the microſcope as an inſtrument conſiſting of one lens only, it is not at all improbable, that it was known to the ancients much ſooner than the laſt century, nay, even in a degree to the Greeks and Romans: for it is certain, that ſpectacles were in uſe long before the above-mentioned period: now as the glaſſes of theſe were made of different convexities, and conſequently of different magnifying powers, it is natural to ſuppoſe, that ſmaller and more convex lenſes were made, and applied to the examination of minute objects. In this ſenſe, there is alſo ſome ground for thinking the ancients were not ignorant of the uſe of lenſes, or at leaſt of what approached nearly to, and might in ſpecies of moth which proceeds from theſe larva is very ſmall, but exceedingly beautiful.

The larva of the phryganea moſtly live in little caſes of their own building, which are formed of a variety of materials, that they train after them in the water wherever they go. Theſe caſes are generally cylindrical, and open at both ends; the inſide is lined with ſilk ſpun by the larva, the outſide formed of different ſubſtances, as bits of reed, ſtone, gravel, and ſome entirely of ſmall ſhells, &c. which they arrange and manage with ſingular dexterity. They never quit this caſe. When they walk they put out the head, and a few of the firſt rings of the body, training the caſe after them.

Having lived in the water for ſome time, they become inhabitants of the air. They aſſume the pupa form in the water, cloſing up the two ends of the caſe with bars of ſilk, by which it is ſecured from the attacks of it's enemies; and at the ſame time there is a free paſſage for the water, which is ſtill neceſſary for it's exiſtence; at a proper period the pupa forces it's way through the caſe, and makes for the land, where it's further change inſtantly commences, and is ſoon completed.

We ſhall cloſe theſe ſpecimens of the induſtry of inſects with an account of that which is diſplayed by the larva of the tinea. The greateſt part of the body of theſe little creatures, except the head and ſix fore feet, is covered over with a thin tender ſkin; the body of the inſect is cylindrical, and lodged in a tube which is open at both ends. Soon after they are born they begin to cover themſelves, and are, therefore, ſeldom to be found but in theſe tubes

tubes or cafes. They are, in general, fo fmall, that it is not eafy to diftinguifh the cafes without a magnifier; but as the body lengthens, the cafe becomes too fhort: it is, therefore, part of it's daily employ to lengthen the cafe. For this purpofe, it extends the head beyond the tube, and having found the materials which anfwer it's purpofe, it tears it off, and brings it to the end of the tube, and fixes it there, repeating this manœuvre till it has fufficiently lengthened it; after it has finifhed one end, it turns itfelf round within the cafe, and performs the fame operation at the other.

This does not terminate their labours, for the tube muft alfo be increafed in diameter, as it foon becomes too fmall for the body; the means they make ufe of to enlarge it, is precifely the fame as we ourfelves fhould adopt under fimilar circumftances. The infect flits the tube at the two oppofite fides, at the fame end, and inferts in the flit two pieces of the required fize; it then performs the fame at the other end. By this means they foon enlarge it fufficiently, without expofing themfelves to the air during the operation. The outfide of thefe cafes is made of filk, hair, &c. The infide is of filk only. Their covering always partakes of the colour of the cloth, or tree, &c. from whence it was taken. If it paffes over a red piece, the colour will be red. When they are come to their perfect growth, they abandon the cloth, and feek for a proper place wherein they may pafs from their prefent to a more perfect ftate.

I cannot conclude this long chapter better than in the words of Mr. Stillingfleet. "Many are apt to treat with contempt any man whom they fee employed in poring over a mofs, or examining an infect, from day to day, thinking that he fpends his time and his life in unimportant and barren fpeculations; yet were the whole fcene of nature laid open to our views, were we admitted to behold the connections and dependencies of every thing on every other, and to trace the œconomy of nature through the fmaller as well as greater parts of this globe, we might, perhaps, be obliged to own we were miftaken; that the fupreme architect had contrived his works in fuch a manner, that we cannot properly be faid to be unconcerned in any one of them; and therefore, that ftudies, which feem upon a flight view to be quite ufelefs, may in the end appear to be of no fmall importance to mankind. Nay, were we only to look back into the hiftory of arts and fciences, we muft be convinced that we are apt to judge over haftily of things of this nature. We fhould there find many proofs that he who gave this inftinctive curiofity to fome of his creatures, gave it for good and great purpofes, and that he rewards with ufeful difcoveries all thefe minute refearches.

" It is true this does not always happen to the fearcher, or his contemporaries, nor even fometimes to the immediate fucceeding generation; but I am apt to think, that advantages of one kind or other always accrue to mankind from fuch purfuits; fome men are born to obferve and record what perhaps by itfelf is perfectly ufelefs, but yet of great importance to another who follows and goes a ftep farther, ftill as ufelefs; to him another fucceeds, and thus by degrees, till at laft one of a fuperior genius comes, who laying all that has been done before this time together, brings on a new face of things, improves, adorns, exalts human fociety.

" All

" All thofe fpeculations concerning lines and numbers, fo ardently purfued, and fo exquifitely conducted by the Grecians, what did they aim at? or what did they produce for ages? a little arithmetic, and the firft elements of geometry, were all they had need of. This Plato afferts; and though, as being himfelf an able mathematician, and remarkably fond of thefe fciences, he recommends the ftudy of them; yet he makes ufe of motives that have no relation to the common purpofes of life.

" When Kepler, from a blind and ftrong impulfe, merely to find analogies in nature, difcovered that famous one between the diftance of the feveral planets from the fun, and the periods in which they complete their revolutions, of what importance was it to him or the world?

" Again; when Galileo, pufhed on by the fame irrefiftible curiofity, found out the law by which bodies fall to the earth, did he, or could he, forefee that any good would come from his ingenious theorems? or was any immediate ufe made of them?

" Yet had not the Greeks pufhed their abftract fpeculations fo far, had not Kepler and Galileo made the above-mentioned difcoveries, we never could have feen the greateft work that ever came from the hands of man, Sir Ifaac Newton's Principia.

" Some obfcure perfon, whofe name is not fo much as known, diverting himfelf idly, as a ftander-by would have thought, with trying experiments on a feemingly contemptible piece of ftone, found out a guide for mariners on the ocean, and fuch a guide as no fcience, however fubtil and fublime it's fpeculations may be,

 however

however wonderful it's conclusions, would ever have arrived at. It was mere curiosity that put Sir Thomas Millington upon examining the minute parts of flowers; but his discoveries have produced the most perfect and most useful system of botany that the world has yet seen.

" Other instances might be produced to prove, that bare curiosity in one age is the source of the greatest utility in another; and what has frequently been said of chymists, may be applied to every other kind of vertuosi. They hunt, perhaps, after chimeras and impossibilities; they find something really valuable by the bye. We are but instruments under the Supreme Director, and do not so much as know, in many cases, what is of most importance for us to search after; but we may be sure of one thing, viz. that if we study and follow nature, whatever paths we are led into, we shall at last arrive at something valuable to ourselves and others, but of what kind we must be content to remain ignorant."

R. HINDMARSH, Printer.

CHAP.

CHAP. VI.

Giving some Account of the Anatomical Structure of the Cossus, or Caterpillar, which is found in the Trunk of the Willow; and several other miscellaneous Objects.

Of all the modifications of which matter is ſuſceptible, the moſt noble is undoubtedly the organization thereof. In the ſtructure of animals, the Sovereign Wiſdom is exhibited to us in the moſt ſtriking manner. The body of an animal is a little particular ſyſtem, more or leſs complicated, and which, like the ſyſtem of the univerſe at large, is the reſult of the combination and connection of a multitude of different pieces, which all conſpire to produce one general effect, the manifeſtation of the principle which we term life. So wonderful are theſe combinations, that we are incapable of comprehending, or even of admiring ſufficiently, the aſtoniſhing apparatus of ſprings, levers, counterweights, of tubes of different diameters, &c. which conſtitute theſe organical machines. The interior parts of the inſect, the moſt vile in appearance, would abſorb all the powers of the moſt able anatomiſt. He would be loſt in the labyrinth as ſoon as he attempted to explore all it's windings. A truth that will be evident to every one who confiders only the fmall portion of the anatomy of the caterpillar here exhibited, which is extracted from the wonderful work of Mr. Lyonet, entitled " Traité Anatomique de la Chenille qui ronge le Bois de Saule," to which the reader muft be referred for a more ample account of the ftructure of this animal; enough will be given here to convince every one of the power and ufe of microfcopic glaffes in the difplay of the wonders of creation; enough will be introduced to prove to the reader that it is not matters of magnitude which only engage the attention or art of the Almighty, " he delights to be elaborate on the minuteneffes and minims of nature; to open his immenfity, as it were, within a fpeck; to lavifh his fkill and ornaments on infects and butterflies; and to inform ants and bees with better fagacity and fcience than the moft laboured fyftems of human policy can exhibit. For the littleneffes of our God are great beyond conception, and while the univerfe cannot contain him, his wifdom and might, his goodnefs and glory, and the fulnefs of his infinity, are entire, and difplayed through every point of infinite fpace."*

Our theme no great (of ONE exclufive) knows;
No little when from ONE, that ONE it flows.
* * * * * * * *
Where ONE, and only ONE, is truly GREAT!
All equidiftant, or alike all near,
The reptile minim, or the rolling fphere;
Alike minutely great, or greatly lefs,
In form finite, INFINITUDE exprefs;
Exprefs the feal of CHARACTER DIVINE,
And bright, thro' HIS INFORMING RADIANCE SHINE.

We

* Brooke's Juliet Grenville, vol. 1, p. 198.

We ſhall firſt give a general deſcription of the animal itſelf, and then proceed to explain thoſe anatomical parts of it which are repreſented at Fig. 1, 2, 3, 4, 5, 6, 7, of Plate XII. This inſect, like every other caterpillar, proceeds from an egg, which the parent moth takes care to depoſit in general againſt the trunk of the willow; to this it is attached by a viſcous humor, which ſoon becomes ſo hard that the rain cannot diſſolve it.

The egg is very ſmall, of an oblong ſpheroidal ſhape; when examined by the microſcope, we find broad waving furrows running through the whole length of it, which are again croſſed by cloſe ſtreaks, giving it the appearance of a wicker baſket. It is probable that they are hatched ſome time in Auguſt, becauſe the ſmall caterpillars are often to be found in September. When ſmall, they are generally to be met with under the bark of the tree to which the eggs were fixed; a humid oozing from the hole they have made to get under the bark, is often a direction where to ſearch for them; though it is not always a certain ſign, becauſe the ſame effect is often occaſioned by other inſects.

Theſe caterpillars change very little in their colour, being nearly the ſame when they are full grown as when they are very young. Like many others they are capable of ſpinning as ſoon as they are born. They change alſo ſeveral times their ſkin, but as it is almoſt impoſſible to raiſe them under a glaſs, it is not eaſy to determine how many times they moult or put off their ſkin; if we are to judge of the number of times by the difference in ſize between the new born and full grown caterpillar; and if we compare theſe with the increaſe of the head, every time it moults; we may reaſonably conclude, that it changes oftener

oftener than the generality of caterpillars, that is, more than four, five, or six times, for some have been observed to moult above nine times.

We have already taken notice of these changes in the last chapter. The caterpillar generally fasts for some days previous to the moulting, the fleshy and other interior parts of the head are then detached from the old skull, and retire as it were within the neck; it is soon however cloathed with pieces similar to those it has abandoned, only larger and at first very soft. When the new skin and the other parts are formed, the old skin is to be opened, and all the members withdrawn from it, an operation naturally difficult, but which must be rendered more so from the soft and weak state of the little creature at that time. The caterpillar is always much larger after the change.

It appears from the experiments of M. Lyonet, that this caterpillar generally passes two winters at least, if not three, before it assumes the pupa state, but then it neither acts nor eats in the winter, forming at the approach of this season a little case or habitation, the inside of which is lined with silk, and the outside covered with small pieces of wood like fine saw-dust: inclosed in this it waits the return of spring. They are sometimes three inches and an half long when full grown, the smallest about two inches. The size which they attain is very great, if compared with that of the new born caterpillar, which does not exceed one twelfth of an inch, an increase in growth much superior to that of the larger animals.

It

It generally prepares for the pupa ſtate in the month of May; it's firſt care being to find a hole in the tree ſufficient to give iſſue to the moth: and if it finds none proper for the purpoſe, it makes one equal in ſize to the future pupa. The hole being made or found, it begins to conſtruct a caſe or cone, which it forms of thin pieces of wood, uniting them together, by ſilk, into an ellipſoid ſhape; the outſide is formed of little ſticks united together in all directions; the caterpillar takes care that the pointed end of the caſe may be always oppoſite to the mouth of the hole: having finiſhed the outſide of the caſe, it lines the inſide with a ſilken tapeſtry, of a cloſe texture in all parts, except the pointed end, and where the tiſſue is looſer, in order to facilitate it's eſcape at a proper ſeaſon. The work being finiſhed, the caterpillar places itſelf in the caſe in ſuch a manner, that it's head may always lay towards the opening of the hole in the tree or pointed end of it's caſe.

In this ſtate it remains at reſt for ſome time; the colour of the ſkin firſt becomes pale, afterwards the whole ſkin appears brown. The interior parts of the head are detached from the ſkull, the legs retire or withdraw themſelves from their exterior caſe, the body ſhortens, the poſterior part grows ſmall, while the anterior part ſwells ſo much, as at laſt to burſt the ſkin, which, by a variety of motions, it puſhes down to the tail, and thus exhibits the pupa, in which the parts of the future moth may be eaſily traced.

The covering of the pupa is at firſt ſoft, humid, and white, but it ſoon dries and hardens, and is then of a marron colour; the fore-part, in which the lineaments of the head, the legs, and

6 the

in ſome inſtances be ſubſtituted for them. The two principal reaſons which ſupport this opinion are, firſt, the minuteneſs of ſome ancient pieces of workmanſhip, which are to be met with in the cabinets of the curious: the parts of ſome of theſe are ſo ſmall, that it does not appear at preſent how they could have been executed without the uſe of magnifying glaſſes, or of what uſe they could have been when executed, unleſs they were in poſſeſſion of glaſſes to examine them with. A remarkable piece of this kind, a ſeal with very minute work, and which to the naked eye appears very confuſed and indiſtinct, but beautiful when examined with a proper lens, is deſcribed "Dans l'Hiſtoire de l'Academie des Inſcriptions," tom. 1. p. 333. The ſecond argument is founded on a great variety of paſſages, that are to be ſeen in the works of Jamblichus, Pliny, Plutarch, Seneca, Agellius, Piſidias, &c. From theſe paſſages it is evident that they were enabled by ſome inſtrument, or other means, not only to view diſtant objects, but alſo to magnify ſmall ones; for if this is not admitted, the paſſages appear abſurd, and not capable of having a rational meaning applied to them. I ſhall only adduce a ſhort paſſage from Piſidias, a chriſtian writer of the ſeventh century, Τα μελλοντα ως δια διοπτρου συ βλεπεις· "You ſee things future by a *dioptrum*:" now we know of nothing but a proſpective glaſs or ſmall teleſcope, whereby things at a diſtance may be ſeen as if they were near at hand, the circumſtance on which the ſimile was founded. It is alſo clear, that they were acquainted with, and did make uſe of that kind of microſcope, which is even at this day commonly ſold in our ſtreets by the Italian pedlars, namely, a glaſs bubble filled with water. Seneca plainly affirms it, *Literæ quamvis minutæ et obſcuræ, per vitream pilam aquâ plenam, majores clarioreſque cernuntur.*" Nat. Quæſt. lib. 1. cap. 7. "Letters, though minute and the wings of the moth may be difcovered, is quite immoveable, but the pofterior part is moveable. The anterior end of this pupa is furnifhed with two horns, one above the other, under the eyes; there are alfo on it's back feveral rows of points one under the other, the points directed towards the tail. The pupa remains in it's cafe for fome weeks; as foon as the moth that is formed therein finds itfelf enabled to break the bonds by which it is confined, it begins to agitate itfelf within the cafe; the points are then rendered of effential fervice, thofe on the back ferve as a fulcrum, to prevent it's flipping backwards, while it is opening the hole of the cone with thofe on the head.

The new-formed moth labours in general about a quarter of an hour before it can effectually open the cafe. This being done, by redoubled efforts it enlarges the hole, and preffes itfelf forwards, till it arrives at the edge, where it makes a fudden ftop; for if it advanced further it would fall to the ground, and probably lofe it's life, or be materially injured by the fall. Here then the pupa repofes itfelf for a time, after which the moth begins to difengage itfelf from the bonds which confine it; when it has efcaped from the pupa, it fixes itfelf againft the trunk of the tree, with the head upwards, and often remains in this fituation for fome hours, during which time the wings and members are perfectly developed, and rendered fit for action. I have been informed by Mr. Marfham, that it generally pufhes at leaft one-third of the cafe out of the hole before it halts.

DESCRIP-

DESCRIPTION OF PLATE XII.

The body of the caterpillar in this plate is divided into twelve parts, correfponding to it's rings. Thefe divifions are marked in Fig. 2 and 3, Plate XII. by the numbers 1, 2, 3, up to 12; to the firft number the word RING is annexed.

Each of thefe rings is diftinguifhed from that which follows, and that which precedes it, by a kind of neck or fmall hollow part. By conceiving a line to pafs through thefe necks, and forming boundaries to the rings, we acquire twelve more divifions; thefe are alfo marked 1, 2, 3, 4, &c. to 12, but to the firft the word DIVISION is affixed.

To facilitate further the defcription of this animal, M. Lyonet found it neceffary to form fome ideal divifions, or rather lines, to pafs through it. He therefore fuppofed, firft, a line to pafs down the middle of the back, and this he called the fuperior line, becaufe it marked the moft elevated part of the back of the caterpillar; the inferior line, one directly oppofite to the former, and paffing from the head down the belly to the tail.

In all caterpillars, on the right and left of each ring, except the fecond, third, and laft, there is a little organ, fomething to appearance like an elliptic fpot; thefe are termed the fpiracula, and have been mentioned feveral times in this work; as they are fituated nearly at equal diftances from the fuperior and inferior lines, they furnifh us with a further fub-divifion, called the lateral lines, which pafs through the fpiracula, the one on the right, the other on the left fide of the caterpillar.

Thefe four lines, which we may conceive to divide the caterpillar longitudinally into four equal parts, are attended with this remarkable circumftance, that each of them mark the place under the fkin that is occupied by a confiderable vifcera; the heart, or rather the thread of hearts, lies under the fuperior line; the fpinal marrow immediately over the inferior line; the two tracheal arteries follow the courfe of the lateral lines.

At equal diftances from the fuperior and two lateral lines, and the inferior lines, we may fuppofe four intermediate lines. The two between the fuperior and lateral lines are called intermediate fuperior lines; the two others which are oppofite to them, and between the lateral and inferior lines, the intermediate inferior lines.

AN EXPLANATION OF FIGURES 1 AND 2, PLATE XII; OR AN ACCOUNT OF THE MUSCLES OF THE CATERPILLAR WHEN OPENED BY THE BELLY.

Of all the interior parts of the caterpillar, none prefent fo beautiful a view, or a more wonderful and fymmetrical arrangement, than that of the mufcles; the more fo, if they are taken away by equal ftrata on both fides, fo as to expofe at the fame time the fimilar mufcles on the oppofite fide, and by this means exhibit to the aftonifhed eye their exact form and correfpondence.

Fig. 1 and 2 is a reprefentation of the mufcles of two different caterpillars, opened at the belly, and fuppofed to be joined together at the fuperior lines; for as the mufcles on the oppofite

6 fide

ſide of each caterpillar are perfectly ſimilar, it was not only unneceſſary to repreſent them, but by joining another view of the muſcles, as in Fig. 2, we are enabled to exhibit thoſe muſcles which were covered in Fig. 1, and by this means ſave much time in the deſcription, and the addition of another plate.

The dorſal muſcles, or thoſe of the back, are marked by capital letters; the gaſtric muſcles, or thoſe of the belly, by Roman letters; the lateral muſcles by Greek characters. Mr. Lyonet has only given a name to thoſe among the latter, which are marked θ; theſe are placed upon all the diviſions, from the ſecond to the eleventh; they are called dividing muſcles, on account of their ſituation; a muſcle that has been once marked with a letter always retains the ſame, both in the deſcription and the other figures.

PREPARATION.

The caterpillar was emptied, and the muſcles freed from the maſſes of fat, the nerves, and other veſſels, which, if they had been left, would have confuſed the view of the muſcles, and rendered it difficult to diſtinguiſh and trace them.

FIRST RING.

The muſcle A is double. The anterior one is thick at top, and ſeems to be divided into different muſcles on the upper ſide, but it has no ſuch appearance on the under ſide. One of their inſertions is towards the head, at the ſkin of the neck; the other inſertion of the firſt muſcle A is a little above, and that of the

 ſecond

fecond mufcle A is a little below the firft fpiraculum, near which they are fixed to the fkin.

α is long and flender; it is fixed by it's anterior extremity under the gaftric mufcles (a and b) of the firft ring, to the circumflex fcale of the bafe of the lower lip. After having paffed under fome of the arteries, it introduces itfelf under the mufcle θ, and communicates there with the mufcle c of the fecond ring.

β is fometimes fingle, fometimes double, and fometimes triple; it is hardly poffible to open the caterpillar by the belly without breaking it; the anterior fixture is to the pofterior edge of the fide of the parietal fcale; the lower fixture is at the middle of the ring, near the inferior line.

The mufcles marked ζ are three in number; the firft is fixed at one extremity near the lower edge of the upper part of the parietal fcale; the other end divides itfelf into three or four tails, which are fixed to the fkin of the caterpillar under the mufcle δ.

The anterior end of the fecond has it's infertion near the former; that of the third a little under the two foregoing, at the fkin of the neck, under the mufcle A. Thefe two laft paffing over the cavity of the firft pair of limbs, are fixed by feveral tails to the edge oppofite to this cavity.

In this fubject there are two mufcles marked δ, fometimes there is only one; their anterior fixture is to the lower edge of the parietal fcale; the other ends are inferted in the firft fold of the fkin of the neck, on the belly fide.

β and

β and δ are beſt ſeen in Fig. 3, where they are entire, not being injured by an unnatural extenſion.

OF THE SECOND AND FOLLOWING RINGS, TO THE LAST.

Two large dorſal muſcles, A and B, are diſcovered in the ſecond and four following rings. There are three, A, B, C, in the 7th, 8th, 9th, and 10th rings; four, A, B, C, D, are to be ſeen at the 11th ring; and five, A, B, C, D, E, at the anterior part of the 12th ring.

All theſe files, or ranges of muſcles, A, B, C, and E, as well as the gaſtric muſcles, a, b, c, d, appear at firſt ſight only as a ſingle muſcle, running nearly the whole length of the caterpillar; but when this is detached from the animal, it is found to conſiſt of ſo many diſtinct muſcles, each muſcle only the length of one of the rings; their extremities are fixed to the diviſions of each ring, excepting the muſcle a, which at the 6th, 7th, 8th, and 9th rings has it's inſertions rather beyond the diviſions. Each row of muſcles appears as one, becauſe they are cloſely connected at top by ſome of the fibres, which paſs from one ring to the other. The muſcles A, B, C, E, from their ſituation may be called the right muſcles of the back; and for the ſame reaſon the muſcles a, b, c, and d, may be called the right muſcles of the belly.

From the third ring the muſcles A, which are twelve in number, gradually diminiſh in breadth to the lower part of the laſt ring; at the 8th and three following diviſions they communicate with the muſcles B, and at the 11th with D. In the lower part of of the laſt ring, A is much broader than it was in the preceding ring; one extremity of it is contracted, and communicates with B; the lower inſertion is at the membrane I, which is the exterior ſkin of the fœcal bag.

It may be proper to obſerve, that the muſcles, A and B, of the lower part of the laſt ring, cannot be ſeen until a large muſcle is removed, which on one ſide is fixed to the ſubdiviſion of this ring, on the other to the fœcal bag.

The right muſcles B are alſo twelve in number; they begin at the ſecond ring, and grow larger from thence to the 7th: from the 7th to the ſubdiviſion of the 12th they are one-half narrower; the deficiency in width is ſupplied by the ſix muſcles C, which go with it from the 7th to the ſubdiviſions of the 12th ring. The muſcles B and C have a lateral communication at the 8th, 11th, and 12th diviſions; C is wanting at the ſubdiviſion of the 12th ring; it's place is filled up by B, which becomes broader in that part.

We have now only to ſpeak of the three floating muſcles V. The firſt of theſe originates at the firſt ring, from whence it introduces itſelf under N, where it is fixed, and then ſubdivides, and paſſes under parts which render it inviſible in this figure.

The ſecond floating muſcle begins at the ſecond diviſion, being fixed to the anterior extremity B of the ſecond ring; from thence it directs itſelf towards the ſtomach, and after communicating with the caſe of the corpus craſſum, it divides and ſpreads itſelf into eight muſcles, which run along the belly.

The

The third, V, begins at the third divifion, originating partly at the fkin, partly at the junction of the mufcles B of the fecond and third ring. It directs itfelf obliquely towards the belly, meeting it near the third fpiraculum; branching from thence, it forms the oblique mufcles of this vifcera.

The thin long mufcle θ, which is at the fubdivifion of the laft ring, and covers the anterior infertion of the large mufcle (a), where the ring terminates, (il eft fans paire) it is fingle; it begins at one extremity of the mufcle c, at the fore part of the ring, runs along the fubdivifion, round the belly of the caterpillar, and finifhes on the other fide, at the extremity of a fimilar mufcle C.

EXPLANATION OF FIG. 2, PLATE XII.

PREPARATION.

All the dorfal mufcles, thirty-five in number, were taken out, as well as the feven lateral ones which have been defcribed in the preceding figure.

All the ftrait mufcles of the belly were alfo taken away, as well as the mufcular roots ç, and the ends of the gaftric mufcles c, which are at the third and fourth divifion.

At the fecond divifion the middle of the mufcle θ was removed, the extremities only being left to point out where it was inferted.

The

The tracheal artery was alfo removed.

EXPLANATION OF THE FIRST RING.

We fee fully here the mufcles C * ζ and (i) which were but partly feen in the preceding figure, and the gaftric mufcles g, which were not feen there.

The mufcles C * occupy two rings; it is very difficult to determine their precife number; ten may be counted at the anterior end, which are collected in one fafcicle, and inferted at the fide of the upper part of the parietal fcale, immediately under the mufcles ζ; towards the lower end thefe mufcles fpread like a fan, and a greater number may be counted; they communicate laterally with each other by reciprocal branches, which makes it difficult to determine whether they fhould be confidered as fingle mufcles, or as fo many diftinct ones. The lower extremity of all but the two laft crofs, at the fuperior line of the fecond ring, the tails of fimilar mufcles on the oppofite fide; after which, they are inferted at the fkin beyond this line.

There are five lateral mufcles ζ, fometimes fix; they have their firft fixture at the fide of the head, their lower part widens, and is inferted lengthways in the fecond divifion.

The mufcles θ of the firft ring, as well as the fimilar mufcles of the nine other rings, are better feen in this than in Fig. 1; as they are placed over the divifions, they may be termed dividing mufcles. That of the fecond divifion has been feparated to fhew the mufcles underneath. It is fingle as well as that of the third divifion

divifion; that of the fourth is double; they appear more numerous in the fucceeding divifions, though they are, in general, only double, feldom triple, but much thicker; thofe of the third and fourth divifion pafs over the tracheal artery, whilft all the others go under it: we find them at all the divifions but the firft and laft.

SECOND RING.

The dorfal mufcles are fufficiently feen in this ring, to enable the obferver to form fome idea concerning them.

C is the only one which is fairly expofed; it has it's pofterior infertion at the third divifion, near the intermediate fuperior line, from whence advancing obliquely it becomes forked, one branch paffes under the dividing mufcle, and is fixed to the fkin, from whence it again proceeds, and forms the fine long mufcle α of the firft ring. The other branch is fixed to the fkin, near the lateral line, under the mufcle γ of the fecond ring.

When the mufcle C and fome of the mufcles C * are removed, we fee the whole of D; the direction of this mufcle is entirely contrary to that of C.

After taking away D, we difcover the mufcle E, which is inclined towards the fame fide as C, but not fo obliquely. By taking away E we are enabled to fee the mufcle F, which is parallel to D: thefe three laft mufcles are fixed to the divifions which terminate the rings; the lateral mufcles are not feen fo as to be defcribed.

and obſcure, appear larger and clearer through a glaſs bubble filled with water." Thoſe who wiſh to ſee further evidence concerning the knowledge of the ancients in optics, may conſult Smith's Optics, Dr. Prieſtley's Hiſtory of Light and Colours, the Appendix to an Eſſay on the firſt Principles of Natural Philoſophy by the Rev. Mr. Jones, Dr. Rogers's Diſſertation on the Knowledge of the Ancients, and Mr. Duten's Enquiry into the Origin of the Diſcoveries attributed to the moderns.

The hiſtory of the microſcope, like that of nations and arts, has had it's brilliant periods, in which it has ſhone with uncommon ſplendor, and been cultivated with extraordinary ardour; theſe have been ſucceeded by intervals marked with no diſcovery, and in which the ſcience ſeemed to fade away, or at leaſt lie dormant, till ſome favorable circumſtance, the diſcovery of a new object, or ſome new improvement in the inſtruments of obſervation, awakened the attention of the curious, and animated their reſearches. Thus, ſoon after the invention of the microſcope, the field it preſented to obſervation was cultivated by men of the firſt rank in ſcience, who enriched almoſt every branch of natural hiſtory, by the diſcoveries they made with this inſtrument: there is indeed ſcarce any object ſo inconſiderable, that it has not ſomething to invite the curious eye to examine it; nor is there any, which, when properly examined, will not amply repay the trouble of inveſtigation.

I ſhall firſt ſpeak of the SINGLE MICROSCOPE, not only as it is the moſt ſimple, but becauſe, as we have already obſerved, it was invented and uſed long before the double or compound microſcope. When the lenſes of the ſingle microſcope are very convex,

THE THIRD RING

Prefents four dorfal mufcles, C, D, E, F. The firft dorfal mufcle, C, is inferted at the third divifion under the mufcles θ and α, where it communicates, by means of fome fibres, with the mufcle f of the fecond ring; from thence it proceeds obliquely towards the intermediate fuperior line, and is fixed at the fourth divifion.

As foon as C is retrenched, the mufcle D is feen; this grows wider from the anterior extremity; it lies in a contrary direction to the mufcle C, and is inferted into the third and fourth divifions.

The mufcle E lies in the fame direction as the mufcle C, but not fo obliquely; the lower infertion is at the fourth divifion, the other is at the third, immediately under C.

The mufcle F is nearly parallel to D, which joins to it; the firft infertion is vifible, the other is at the fourth divifion, under the mufcles E and G.

There are no lateral mufcles to be defcribed in this ring.

THE EIGHT FOLLOWING RINGS.

There are only two dorfal mufcles, and no lateral ones, to be defcribed in thefe rings.

Of

Of thefe two mufcles, D is the only one that is altogether feen; it is very large, and diminifhes gradually in breadth, from ring to ring, to the laft, branching off in fome places.

E is one of the ftrait mufcles of the back, and is inferted at the divifions of it's own ring, under the dividing mufcles θ.

Anterior Part of the Twelfth Ring.

There are three dorfal mufcles, D, E, F, to be confidered in this part.

The mufcle D is fimilar to D of the preceding ring, only that it terminates at the fubdivifion of it's ring, and is confequently only half as long.

E is of the fame length, and differs from the mufcle E of the preceding ring only in it's direction.

The mufcle F is parallel to E, and fhorter; it's anterior end does not reach the twelfth divifion.

Posterior Part.

There is only one dorfal mufcle here, which is faftened by fome fhort mufcles to the fubdivifions of the laft ring, traverfing the mufcles α, and being fixed there, as if defigned to ftrengthen them, and to vary their direction.

α is a ſingle muſcle; it's anterior inſertion is viſible, the other end is fixed to the bottom of the foot of the laſt leg; it is uſed to move the foot.

The anterior part of the muſcle β is divided into three or four heads, which croſs the ſuperior line obliquely, and are fixed to the ſkin a little above it. The other end is faſtened to the membrane T.

AN EXPLANATION OF FIGURES 3 AND 4, OF PLATE XII. OR AN ACCOUNT OF THE MUSCLES OF THIS CATERPILLAR WHEN IT IS OPENED AT THE BACK.

PREPARATION FOR FIG. 3.

The muſcles were not only diſengaged from all extraneous matter, as before, but as it repreſents the third figure of Mr. Lyonet, on the muſcles of the caterpillar's back a great many had been removed before the parts of the inſect appeared, as delineated in this figure.

FIRST RING.

Only two gaſtric muſcles, c d, are ſeen here; c is broad, and has three or four little tails; the firſt fixture is at the baſe of the lower lip, from whence it deſcends obliquely, and is fixed between the inferior and lateral line.

The

The little muſcle d is faſtened on one ſide to the firſt ſpiraculum, and on the other ſide, a little lower to the intermediate inferior and the lateral line; it ſeems to be the antagoniſt of P, which opens the ſpiracula.

The lateral muſcles β ϑ are very well ſeen in this figure; the poſterior fixture of ϑ is under the muſcle C, near the ſkin of the neck; β is fixed a little on the other ſide of C, at the middle of the ring.

SECOND RING.

Three gaſtric muſcles, g, h, i, appear here; g and h are fixed at the folds which terminate the ring; i has only it's anterior fixture there.

h is triple; in one of the diviſions it is ſeparated into two parts.

i approaches more the inferior line, and is fixed a little beyond the middle of the ring, where the ſimilar muſcle on the oppoſite ſide is forked to receive it.

THIRD RING.

h, which was triple in the preceding ring, is double here; that part which is neareſt the inferior line is the broadeſt; it has three tails, of which only two are viſible.

The

The mufcle i is exactly fimilar to that of the preceding ring, and is croffed in the fame manner by the mufcle from the oppofite fide of the ring.

THE EIGHT FOLLOWING RINGS.

The mufcle f, in all thefe rings, is very broad and ftrong; the anterior fixture is at the intermediate inferior line, on the fold of the firft divifion of the ring; the other fixture is beyond the lower divifion, with this difference, that at the 10th and 11th rings the fixture is at the laft fold of it's ring; whereas in the others it paffes over, and is inferted in the fkin of the following ring.

In all thefe rings the firft extremity of g is faftened to the fold which feparates the ring from the preceding one, and is parallel to f, and placed at the fide of it.

The fix firft, g, are forked; that of the fourth ring is very much fo; it does not unite till it is near it's anterior infertion. The longeft tail lays hold of the following, and is inferted near the inferior line; the other inferts itfelf near the fame line, at about the middle of it's own ring.

The two laft, g, do not branch out, but terminate at the divifions without reaching the following ring.

The mufcle h is placed at the fide of f, has nearly the fame direction, and finifhes at the folds of the ring.

ANTE-

ANTERIOR PART OF THE TWELFTH RING.

The only gaſtric muſcle left here is e; it is placed on the intermediate inferior line; in it's direction it ſeparates from it's lateral, and is inſerted at the folds of the upper diviſion, and at the ſubdiviſion of this ring.

LOWER PART OF THE TWELFTH RING.

c is a large muſcle, with ſeveral diviſions; one placed under (b) of the preceding figure, one extremity is fixed near the lateral line, at the ſubdiviſion of it's ring, the other to the fœcal bag, a little lower than the muſcle b.

EXPLANATION OF FIG. 4, PLATE XII.

All the gaſtric muſcles deſcribed in the preceding figure diſappear in this, as well as all thoſe lateral and dorſal ones whoſe letters are not found in this figure.

FIRST RING.

e f g are the gaſtric muſcles, which are beſt ſeen here.

e is narrow and long; it paſſes under and croſſes f, one of it's inſertions is at the lower line, the other is at the lateral, between the ſpiraculum and the neck.

f is

f is ſhort, broad, and nearly ſtrait, placed along the intermediate line, but between it and the lateral; it paſſes under e, and is fixed to the fold of the ſkin which goes from one leg to the other; the lower inſertion is near the ſecond diviſion.

There are ſometimes three muſcles g, and ſometimes four; their lower fixture is about the middle of the ring; the anterior inſertion is at the fold of the ſkin, near the neck.

The muſcles i and h are alſo fixed to the ſame fold; the other end of h is fixed under the muſcle Π, near the ſpiraculum.

Above the upper end of f, a muſcular packet g, formed by the ſeparation of two floating muſcles, may be ſeen; though only imperfectly, as they were injured by the diſſection.

SECOND RING.

Six gaſtric muſcles, k, l, m, n, o, p, may be pretty well diſtinguiſhed in this ring.

k is a large oblique muſcle, with three or four diviſions, placed at the anterior part of it's ring; the head of it is fixed between the inferior line and it's intermediate one, at the fold of the ſecond diviſion, from whence it croſſes the inferior line, and it's ſimilar muſcle; it terminates to the right and left of this line.

l is a narrow muſcle, whoſe head is fixed to the fold of the ſecond diviſion, the tail of it lies under n, and is faſtened to the edge of the ſkin that forms the cavity for the leg.

6 m, two

m, two mufcles of the fame obliquity, placed one on the other; the head of it is inferted in the fkin, under the mufcle β, and communicates, by a bed of fibres, with the tail of the mufcle γ; the other end is fixed to the intermediate inferior line, at the fold of the third divifion.

n is large and broad; it covers the lower edge of the cavity of the limb, and the extremity of the tail of l; the firft fixture is at the fkin, near the intermediate line, from whence it goes in a perpendicular direction towards m, and introduces itfelf under o and m, where it is fixed.

o is narrow and bent, and covers a little the edge of the cavity of the leg; one end terminating there, the other end finifhes at the third divifion near m.

p is alfo bent; it runs near the anterior edge of the cavity of the leg; one end meets the head of o, the other end terminates at a raifed fold, near the inferior line.

On the fide of the lateral mufcle o there is a triangular mufcle, fimilar to q of the following ring; it is entirely concealed in this by the mufcle m.

THIRD RING.

This ring has no mufcle, fimilar to m of the preceding ring.

k only differs from the mufcle of the fecond ring, in that it is croffed by the oppofite mufcle, whereas k croffes the oppofite mufcle.

As the mufcles l, n, o, p, of this ring are fimilar to thofe of the preceding one, they need not be defcribed.

q is a triangular mufcle; the bafe of it is faftened to the laft fold of it's ring, on the lower fide it is fixed to the mufcle o, the fummit to the fkin at the edge of the cavity for the leg.

THE EIGHT FOLLOWING RINGS.

We difcover here the gaftric mufcles, i, k, l, m.

The mufcle i is quite ftrait, and is placed at a little diftance from the inferior line; it is broad at the fourth ring, but diminifhes gradually in breadth to the eleventh. It is united at the fourth, but is divided into two heads, which divaricate in the following rings. In the fix next rings thefe heads are fixed nearly at the fame place with a and f; in the other two it terminates at the fold of the ring. The anterior infertion of the firft and laft is at the fold, where the ring begins; that of the fix others is fomewhat lower, under the place where the mufcle i, which precedes them, finifhes.

k is an oblique mufcle, whofe lower infertion is at the fkin near i; the other at the intermediate inferior, upon the fold which feparates the following ring; it is miffing in the eleventh ring.

l is

I is a large muſcle which co-operates with M; in opening and ſhutting the ſpiraculum, one of it's fixtures is near the intermediate inferior line, at about the ſame height as i; the tail finiſhes a little lower than the ſpiraculum.

TWELFTH RING.

There remains here only the gaſtric muſcle d, which is a faſcicle of ſix, ſeven, or eight muſcles; the firſt fixture of theſe is at the ſubdiviſion of the ring, near the inferior line; one or two croſs this, and at the ſame time the ſimilar muſcles of the oppoſite ſide. Their fixture is at the bottom of the foot; their function is to concur with the muſcle α, in bringing back the foot, and looſen the claw from what it lays hold of.

We perceive here the muſcle α; one of it's inſertions is at the bottom of the foot, near d; the other extremity near the ſubdiviſion of the ring.

EXPLANATION OF FIG. 5 AND 6, PLATE XII.

The anatomical delineation of the head, which is given at Fig. 5 and 6, ſhould be conſidered as conſiſting of two figures, which join in the middle, being terminated by the inferior and ſuperior lines. It will be impoſſible in this place to give more than a very looſe idea of the head of the caterpillar in theſe two figures, as M. Lyonet found it neceſſary to employ twenty, in order to diſplay properly the organization of this part. Theſe will, however, be ſufficient to give ſome idea of it to thoſe who cannot procure or read the work itſelf; it may alſo ſerve to ſtimulate thoſe who vex, and confequently the magnifying power very great, the field of view is fo fmall, and it is fo difficult to adjuft with accuracy their focal diftance, that it requires fome practice to render the ufe thereof familiar; at the fame time, the fmallnefs of the aperture to thefe lenfes has been found injurious to the eyes of fome obfervers: notwithftanding, however, thefe defects, the great magnifying power, as well as the diftinct vifion which is obtained by the ufe of a deep fingle lens, more than counterballances every difficulty and difadvantage. It was with this inftrument that Leeuwenhoek and Swammerdam, Lyonet and Ellis examined the minima of nature, laid open fome of her hidden receffes, and by their example ftimulated others to the fame purfuit.

The conftruction of the fingle microfcope is fo fimple, that it is fufceptible of but little improvement, and has therefore undergone but few alterations; and thefe have been chiefly confined to the mode of mounting it, or the additions to it's apparatus. The greateft improvement this inftrument has received, was made by Dr. Lieberkuhn, about the year 1740; it confifted in placing the fmall lens in the center of a highly-polifhed concave fpeculum of filver, by which means he was enabled to reflect a ftrong light upon the upper furface of an object, and thus examine it with great eafe and pleafure. Before this contrivance, it was almoft impoffible to examine fmall opake objects with any degree of exactnefs and fatisfaction; for the dark fide of the object being next the eye, and alfo overfhadowed by the proximity of the inftrument, it's appearance was neceffarily obfcure and indiftinct.

Dr.

have leifure to extend further the anatomy of infects; for it is only by a comparifon of their's with that of man, that we can ever afcertain their true place in the fcale of creation. If this comparifon could be accurately difcovered, the true philofopher would be able to trace their final caufe, or rather the originating fource of their exiftence, and point out the degree in which they accorded with thofe laws of goodnefs and truth, by which the univerfe and all it's parts are regulated and governed.

The head, as reprefented in thefe figures, is magnified about three hundred and forty-three times; it is feparated from the neck, and difengaged from the fat. The figures here under confideration reprefent the head in the third and fourth ftate of examination, when a great many parts had been removed, in order to difcover thofe that are here feen.

H H, the two palpi. The truncated mufcles D belong to the lower lip, and form a part of it's moving mufcles. K is the two ganglions of the neck united. I I, the two filk veffels. L, the oefophagus. M, the two diffolving veffels.

ד ג ב א are the continuation of four cephalic arteries. Fig. 5, S S, T T, V V, and Z, are the ten abductor mufcles of the jaw. Fig. 6, under e e and f f, are feen four occipital mufcles. a k, a nerve of the firft pair belonging to the ganglion of the neck; b, a branch of this nerve.

Fig.

FIG. 7, PLATE XII.

Is an outline of the head, magnified confiderably more than in the laſt figures, exhibiting the nerves as ſeen from the under part.

Excepting in two or three nerves (and theſe may be eaſily known, becauſe each nerve of the ſame pair is marked with a ſimilar letter), only one nerve of each pair is drawn, as a greater number would have occaſioned much confuſion.

The nerves of the firſt ganglion of the neck are deſigned by capital letters.

The nerves of the ganglion a of the head are diſtinguiſhed by Roman letters.

The nerves of the ſmall ganglion by Greek characters.

Thoſe of the frontal ganglion, except one, by numbers.

A GENERAL IDEA OF THE INTERIOR PARTS OF THE CATERPILLAR.

Having deſcribed ſo many of the parts as to evince the amazing wonders that are diſplayed in this inſect, I proceed to give a more particular account of the nature of ſome of thoſe parts.

OF

OF THE DIFFERENT ORDERS OF MUSCLES, BY WHICH THE CATERPILLAR IS ENABLED TO MOVE ALL THE VARIOUS PARTS OF THE BODY.

Theſe muſcles have neither the exterior form, nor the colour of thoſe of larger animals. In their natural ſtate they are ſoft, and have the appearance of a jelly; they are of a greyiſh blue, and the ſilver-coloured appearance of the aerial or pulmonary veſſels, which creep over and penetrate their ſubſtance, exhibits under the microſcope a moſt beautiful ſpectacle. When the caterpillar has been ſoaked for ſome time in ſpirit of wine, they loſe their elaſticity and tranſparency, and become firm, opake, and white; the aerial veſſels diſappear. At firſt ſight they might be taken for tendons, as they are of the ſame colour, and poſſeſs almoſt the ſame luſtre. They are generally flat, and of an equal ſize throughout; the middle ſeldom differs either in colour, ſubſtance, or ſize, from the extremities.

The ends are fixed to the ſkin; the reſt of the muſcle is generally free and floating; ſeveral of them branch out conſiderably; the branches extend ſometimes ſo far, that it is not always eaſy to diſcover whether they are diſtinct and ſeparate muſcles, or parts of another. They are of a moderate ſtrength; thoſe that have been ſoaked in ſpirit of wine, when examined by the microſcope, will be found to be covered with a membrane, which may be ſeparated from them; they then appear to conſiſt of ſeveral parallel bands, directed according to the length of the muſcle. Theſe, when divided by the aſſiſtance of very fine needles, appear to be compoſed of ſtill ſmaller faſcicles of fibres, in the ſame direction, which, when examined with a very deep magnifier,

magnifier, and in a favourable light, appear twifted like a fmall cord. The mufcular fibres of the fpider, which are much larger than thofe of the caterpillar, are found on examination to confift of two fubftances, one foft, and the other hard; the laft is twifted round the former fpirally, and thus gives to it the afore-mentioned cord-like appearance.

If the mufcles are feparated by means of very fine needles, in a drop of fome fluid, we find that they are not only compofed of fibres, membranes, and aerial veffels, but alfo of nerves; and from the drops of oil that may be feen floating on the fluid, that they are alfo furnifhed with many unctuous particles.

The number of mufcles in a caterpillar is very great, exceeding by much thofe of the human body; the reader may form fome idea of their quantity, by looking at Fig. 1 and 2, 3 and 4, of Plate XII. They occupy the greateft part of the head; there is an aftonifhing number at the oefophagus, the inteftines, &c. the fkin is as it were lined by different beds of them, placed one under the other, and ranged with very great fymmetry.

The number of mufcles that our obferver has been able to diftinguifh is truly aftonifhing; he found 228 in the head, 1647 in the body, 2066 in the inteftinal tube, making in all 4041.

THE SPINAL MARROW, and the brain of the caterpillar, if they can be faid to have any, feems to have very little relation to thofe of man; in the laft, the brain is inclofed in a bony cavity; it occupies the greateft part of the head, and is anfractuous, and divided into lobes. There is nothing fimilar to this in the caterpillar;

pillar; we find indeed in the head of that which we are defcribing, a part which feems to anfwer the purpofe of the brain, becaufe the nerves that are diffeminated through the head are derived from it; but then this part is unprotected, and fo fmall, that it does not occupy one-fifth part of the head; the furface is fmooth, and has neither lobes nor any anfractuofity: and if we muft call this a brain, the caterpillar may be faid to have thirteen, as there are twelve more fuch parts following each other in a line; they are nearly of the fame fize with that in the head, and of the fame fubftance, and it is from them that the nerves are diftributed through the whole body. Left the idea of thirteen brains might be difagreeable to his readers, M. Lyonet has called thefe parts ganglions.

The fpinal marrow in the human fpecies defcends down the back, inclofed in a bony cafe; is large with refpect to it's length, and not divided into branches, diminifhing in thicknefs in proportion as it is removed further from the brain. In the caterpillar, the fpinal marrow goes along the belly, is not inclofed in any tube, is very fmall, forks out at intervals, and is nearly of the fame thicknefs throughout, except at the ganglions. For a defcription of the innumerable veffels, and curious texture of thefe parts, we muft refer the reader to M. Lyonet's work. The fubftance of the fpinal marrow, and of the ganglions, is not near fo tender and eafily feparated as in man; it has a very great degree of tenacity, and does not break without confiderable tenfion. The fubftance of the ganglions differs from that of the fpinal marrow, as no veffels can be difcovered in the latter, whereas the former are full of very delicate ones. The patient anatomift of the caterpillar has counted forty-five pair of nerves, and two fingle ones;

ones; ſo that there are ninety-four principal nerves, whoſe ramifications are innumerable.

The TRACHEAL ARTERIES of the caterpillar are two large aerial veſſels that creep under the ſkin, cloſe to the ſpiracula, one at the right ſide of the inſect, the other at the left, each of them communicating with the air, by means of nine ſpiracula; they are nearly as long as the body, beginning at the firſt ſpiraculum, and going a little farther than the laſt, terminating in ſome branches, which extend to the extremities of the body.

Round about each ſpiraculum the tracheal artery puſhes forth a great number of branches, which are again divided into ſmaller ones, which further ſubdivide, and ſpread through the whole body of the caterpillar.

The tracheal artery, and it's numerous ramifications, are all open elaſtic veſſels, which may be preſſed cloſe together, or drawn out conſiderably, but return immediately to their uſual ſize when the tenſion ceaſes. They are naturally of a ſilver colour, and have a very beautiful appearance in the microſcope.

This veſſel and it's principal branches are compoſed of three coats, which may be ſeparated one from the other. The exterior covering is a thick membrane, furniſhed with a great number of fibres, which deſcribe a vaſt variety of circles round it, communicating with each other by numerous ſhoots.

The ſecond is very thin and tranſparent; no particular veſſel is diſtinguiſhed in it. The third is compoſed of ſcaly threads, which are generally turned in a fpiral form, and come fo near each other as fcarce to leave any interval; thefe threads are curioufly united with the membrane which occupies the intervals, and form a tube which is always open, notwithftanding the flexure of the veffel. There are alfo many other peculiarities in it's ftructure, which cannot be well explained without more plates.

The principal tracheal veffels branch out into 236 fmaller ones, from which there fpring 1326 different ramifications.

The part of the caterpillar which naturalifts call the heart, without being certain that it performs the functions thereof, is of a nature very different from that of larger animals. It is almoft as long as the caterpillar itfelf, lies immediately under the fkin at the top of the back, entering into the head, and terminating near the mouth. It is large and fpacious towards the laft rings of the body, and diminifhes very much as it approaches the head, from the fourth to the twelfth divifion; it has on both fides, at each divifion, an appendage, which partly covers the mufcles of the back; but growing narrower as it approaches the lateral line, forms a number of irregular lozenge-fhaped bodies.

This mufcular tube has been called the heart of the caterpillar; firft, becaufe it is generally filled with a kind of lymph, which has been fuppofed to be the blood of the caterpillar; fecondly, becaufe in all caterpillars, whofe fkin is in fome degree tranfparent, continual, regular, and alternate dilations and contractions may be perceived along the fuperior line, beginning at the eleventh ring, and going on from ring to ring to the fourth, whence this veffel has been confidered as a file of hearts; but ftill ſtill this viſcera ſeems to have very little relation to the heart of larger animals; we find no veſſel opening into it, to anſwer to the aorta, or vena cava, &c. &c.

Near the eighth diviſion are two white oblong maſſes, that join the tube of the heart; they have been called reniform bodies, becauſe they are ſomething ſimilar to a kidney in their ſhape.

The corpus craſſum is, with reſpect to volume, the moſt conſiderable part of the whole caterpillar; it is the firſt and only ſubſtance that is ſeen on opening it, forming a kind of ſheath, which envelopes and covers all the entrails, and introducing itſelf into the head, enters all the muſcles of the body, filling the greateſt part of the empty ſpaces in the caterpillar. It is of a milk-white colour. In it's configuration it is very ſimilar to the human brain.

When the different maſſes of the corpus craſſum which covers the entrails are removed, the largeſt parts are the oeſophagus, the ventricle, and the large inteſtines.

The oeſophagus deſcends from the bottom of the mouth to about the fourth diviſion. The anterior part which is in the head is fleſhy, narrow, and fixed by different muſcles to the cruſtaceous parts thereof; the lower part, which paſſes into the body, is wider, and forms a kind of membranaceous bag, which is covered with very ſmall muſcles; near the ſtomach it is again narrower, and is as it were bridled by a ſtrong nerve, which is fixed to it at diſtant intervals.

The ventricle begins a little above the fourth diviſion, where the oeſophagus finiſhes, and terminates at the tenth diviſion; it is about ſeven times longer than it is broad; the anterior part, which is the broadeſt, is generally folded.

The folds diminiſh with the bulk, in proportion as it approaches the inteſtines. A great quantity of nerves cover the ſurface, it is ſurrounded by a number of aerial veſſels, and opens into a tube, which M. Lyonet calls the large inteſtine. There are three of theſe large tubes, each of which differs from the others ſo much, both in ſtructure and character, as to require a particular name to diſtinguiſh them; though this is not the place to enumerate theſe characteriſtic differences.

As moſt caterpillars are endowed with a power, or faculty, of ſpinning, they are provided with two veſſels where the ſubſtance is prepared, which, when drawn out, and extended in the air, becomes a ſilken thread; theſe two veſſels are termed the ſilk veſſels, or tubes; in the coſſus they are often above three inches long, and are diſtinguiſhed into three parts, the anterior, the intermediate, and poſterior. The coſſus has alſo two other veſſels, which are ſuppoſed to prepare and contain the liquor by which it diſſolves the wood on which it feeds. Thus have we endeavoured to give the reader an idea of the wonderful organization of this apparently imperfect animal. Aſſuredly, the 4000 * muſcles employed in the conſtruction of the coſſus cannot be conſidered without the deepeſt aſtoniſhment! their admirable coordination and junction with other parts equally numerous, yet all

* Lyonet ſur la chenille de ſaule, p. 584.

all harmonizing and acting together as if they were essentially one, naturally lead the mind to consider the nature and perfection of the theatre of creation; and to perceive that it is an exhibition of the highest wisdom, and that this wisdom, which in the minutest things gives evidence of such an immense attention to order and use, has, no doubt, framed the whole for some great purpose; but what that purpose is, we shall find it difficult to discover.

Though there is no doubt that even this difficulty may be removed, when mankind begin to consider the universe as one connected whole, manifesting and representing the action of an all-beneficent Creator on his creatures, according to the several degrees in which they are capable of receiving and displaying this action; or, in other words, that this transitory scene is the ultimate result of the state of purity, or error of those intelligences which act thereon. But it would lead us too far from the subject in hand, to enter into a discussion of this truly interesting subject. We must, therefore, content ourselves with recommending the reader to study nature; with the scriptures in his hand, he may be assured that he will not only find that they perfectly agree with each other; but he will also find, upon an attentive comparison of passages of scripture with each other, that those parts which he may have hitherto only considered as pleasing figures, descriptive imagery, and perhaps as the sublime and beautiful of eloquence, have a more distinct and close connection with the sublime and beautiful of nature; that they point out the natural, anatomical, and physical relation of the various parts of animated nature with man, and of man with superior intelligences.

He

Dr. Lieberkuhn adapted a microſcope to every object; they conſiſted of a ſhort braſs tube, at the eye end of which a concave ſilver ſpeculum was fixed, and in the center of the ſpeculum a magnifying lens: the object was placed in the middle of the tube, and had a ſmall adjuſtment to regulate it to the focus; at the other end of the tube there was a plano convex lens, to condenſe and render more uniform the light which was reflected from the mirror. But all this pains was not beſtowed upon trifling objects; his were generally the moſt curious anatomical preparations, a few of which, with their microſcopes, are (I believe) depoſited in the Britiſh Muſeum. It will be proper, in this place, to give ſome account of M. Leeuwenhoek's microſcopes, which were rendered famous throughout all Europe, on account of the numerous diſcoveries he had made with them, as well as from his afterwards bequeathing a part of them to the Royal Society. The microſcopes he uſed were all ſingle, and fitted up in a convenient ſimple manner; each of them conſiſted of a very ſmall double convex lens, let into a ſocket between two plates rivetted together, and pierced with a ſmall hole; the object was placed on a ſilver point or needle, which, by means of ſcrews adapted for that purpoſe, might be turned about, raiſed or depreſſed at pleaſure, and thus be brought nearer to, or be removed farther from the glaſs, as the eye of the obſerver, the nature of the object, and the convenient examination of it's parts required. M. Leeuwenhoek fixed his objects, if they were ſolid, to the foregoing point with glue; if they were fluid, he fitted them on a little plate of talc, or exceeding thin blown glaſs, which he afterwards glued to the needle, in the ſame manner as his other objects. The glaſſes were all exceeding clear, and of different magnifying powers, which were proportioned to the nature of the object, and the

He would find that this knowledge was not founded upon the testimony of a few obscure passages, but that every word of the sacred writings, when properly compared with others, will evince that they proceeded from the infinite source of wisdom, and contain such treasures from that fountain, as surpass the utmost effort of human ability to fathom; and yet that enough is laid open to satisfy every real inquirer after truth.

The following character of Mr. Lyonet's work, by M. Bonnet, cannot, I think, but prove agreeable to the reader. I give it in the original, as I am persuaded it would lose much of it's genuine force by a translation.

Je proposerai ici pour modèle à tous les anatomistes, ce cèlèbre scrutateur de la nature à la sagacité & au burin duquel nous devons le merveilleux Traité Anatomique de la chenille; ouvrage immortel dont nous n'avions pas même soupconnè la possibilité, & que je regarde comme la plus belle preuve de fait de l'existence d'une PREMIERE CAUSE INTELLIGENTE. Avec quel plaisir & quel etonnement ne lit-on point ces mots à la page xiii. de la Preface: "Comme je ne me suis proposé de publier qu'un simple "Traité d'Anatomie, l'on ne doit pas s'attendre à trouver ici de "grand details physiologiques; cette partie, si pleine d'incer- "titudes, pour être exposée comme il faut, auroit exigè nombre "d'expériences, que la répugnance que j'ai à faire souffrir les "animaux, ne m'a pas permis de tenter; répugnance, qui est "même allé si loin, que j'ai usé de la plus grande épargne par "rapport à mes sujets, & que je ne crois point que tout ce traité "ait coûté la vie a plus de huit ou neuf chenilles. Encore ai-je

" eu toujours soin de les noyer dans de l'eau avant que de les " ouvrir." Si GELON stipuloit pour l'humanite.* Quand il interdisoit aux Carthaginois vaincus, les sacrifices humains; LYONET stipuloit pour l'animalité quand il tracoit ainsi les devoirs de l'anatomiste, en se peignant si naivement lui-même.

DESCRIPTION OF FIG. 1, PLATE XIII.

OF THE LEPAS ANATIFERA, OR BARNACLE.

This is a very peculiar species of shell-fish; the shell is not composed of two pieces, or valves, as is the usual case, but of five; two of these are larger than the rest, to which are affixed two smaller ones; the fifth piece is long, slender, and crooked, running down lengthways, and covering the joinings of the other pieces. It is a tender and brittle shell-fish, in length about an inch, it's diameter about three quarters of an inch. The shell part is of a pale red, variegated with white; it adheres to a neck, or pedicle, of an inch long, and about a fifth of an inch in diameter; by which means it is affixed to old wood, to stones, and sea plants, or any other solid substance that lies under water. It can shorten or extend this neck at pleasure, which resembles a small gut, and is usually full of a glarious liquor; it is composed of two membranes, an external one, hard and brown, an internal one, soft, and of an orange colour. The larger portions of the shell open and shut in the manner of the bivalves; the others, being moveable by means of their membranous attachments, give way

* MONTESQUIEU, Esprit des Loix.

way to the opening of theſe, and to the motions of the body of the fiſh, in any direction. It is furniſhed with a cluſter of filaments, placed in a row on each ſide, ſometimes fourteen in number. They are a kind of arms, appropriated for catching it's prey, and therefore placed ſo as to ſurround the mouth of the animal, which is ſituated between them, and conſequently eaſily receives what they thruſt towards it. By the motion of theſe arms, which may be exerted in ſuch a manner, as to play either within or without the cavity of the ſhell, it forms a current of water, which brings with it the prey they feed upon. Fig. 1, Plate XIII. repreſents two of theſe arms, or horns, as ſeen with the microſcope. Fig. 2 repreſents the natural ſize of thoſe from which theſe drawings were made. Each horn conſiſts of ſeveral joints, and each joint is furniſhed on the concave ſide of the arm with a bruſh of long hairs. The arms, when viewed in the microſcope, ſeem rather opake; but they may be rendered tranſparent, and form a moſt beautiful object, by extracting out of the interior cavity a bundle of longitudinal fibres, which runs the whole length of the arm. Mr. Needham * thinks the motion and uſe of theſe arms illuſtrates the nature of that rotatory motion, which ſome writers have thought they diſcovered in the wheel animal.

In the midſt of the arms is a hollow trunk, conſiſting of a jointed hairy tube, which incloſes a long round tongue, that the animal can puſh occaſionally out of the tube or ſheath, and retract at pleaſure. The mouth of this animal is ſingular in it's kind, conſiſting of ſix laminæ, which go off with a bend, indented

* Needham's Microſcopical Obſervations.

dented like a ſaw on the convex edge, and by their circular diſpoſition are ſo ranged, that the teeth in the alternate elevation and depreſſion of each plate act againſt whatever intervenes between them. The plates are placed together in ſuch a manner, that to the naked eye they form an aperture not much unlike the mouth of a contracted purſe.

The weſtern iſles of Scotland, and ſome other parts of the Britiſh dominions, are abundantly ſtored, at certain times of the year, with a bird of the gooſe kind, commonly known in thoſe places by the name of the brent gooſe, or barnacle. Theſe birds rarely breed with us, but ſeek for their ſitting ſeaſon iſlands leſs frequented than thoſe where we find them in common. The ſeeing the birds ſo frequent, and yet never finding any of their neſts, induced ignorant people to believe they never had any, and that they were not bred like other birds.

About the very ſhores where theſe birds are moſt common, the lepas anatifera is alſo found in great abundance. The fiſhermen, who obſerved great quantities of theſe ſhells affixed to rotten wood, or dead trees, that were floating in the water, or lodged by it on the ſhore, were ſoon led to imagine that the filamentous ſubſtances which hung out of them reſembled feathers, and perſuaded themſelves that the geeſe, whoſe origin they could before by no means make out, were bred from them, inſtead of being hatched, like other birds, from eggs.* It was afterwards affirmed, that the ſhells themſelves originally grew on the trees, in the manner of their fruit; and from this aroſe the opinion that the barnacle, or brent gooſe, was the produce of a tree.

* Hill's Natural Hiſtory of Animals.

OF THE PROBOSCIS OF THE BEE, FIG. 3 AND 4, PLATE XIII.

The more we penetrate into the hidden receffes and internal parts of nature, the more we find it marked with perfection in form and defign. This pofition is fo clearly proved in the little apparatus we are now about to defcribe, that Swammerdam,* fpeaking of it, fays, that he cannot refrain from confeffing, to the glory of the immenfe and incomprehenfible Architect, that he had but very imperfectly defcribed and reprefented this little apparatus; for to reprefent it to the life in it's full perfection, as truly moft perfect it is, far exceeds the utmoft efforts of human knowledge.

Soon as the matin glory gilds the fkies,
Behold the little virtuofi rife!
Blithe for the tafk, they preen their early wing,
And forth to each appointed labour fpring.
Now nature boon exhales the morning fteam,
And glows and opens to the welcome beam;
The vivid tribes amid the fragrance fly,
And ev'ry art, and ev'ry bufinefs ply.
Each chymift now his fubtle trunk unfheathes,
Where from the flower the treafur'd odour breathes;
Here fip the liquid, there felect the gum,
And o'er the bloom with quiv'ring membrane hum.
Still with judicious fcrutiny they pry,
Where lodg'd the prime effential juices lie;
Each lufcious vegetation wide explore,
Plunder the fpring of every vital ftore:

The

* Swammerdam's Book of Nature, p. 195.

The dainty fuckle, and the fragrant thyme,
By chymical reduction, they fublime,
Their fweets with bland attempering fuction ftrain,
And curious thro' their neat alembicks drain;
Imbib'd reclufe, the pure fecretions glide,
And vital warmth concocts th' ambrofial tide.

BROOKE.

By the probofcis, or trunk, the bee not only procures itfelf neceffary fubfiftence, but it is alfo employed by the animal to collect the honey, which we appropriate to ourfelves as if it was made for us. It may be confidered in a general view as confifting of feven pieces; one of thefe, i i, b c, Fig. 3, Plate XIII. is placed in the middle; this is fuppofed to be pervious, and to conftitute what may be properly called the probofcis. The other fix fmaller parts, or fheaths, difpofed in three pairs, are placed on each fide the former. They not only affift it in extracting and gathering the honey from the flowers, but they alfo protect and ftrengthen it. The probofcis (i i, b c) itfelf is very curioufly divided; the divifions are elegant and regular, and are befet all round with briftly triangular hairs, diftributed in an elegant order: thefe divifions, though very numerous, appear at firft fight as a number of different articulations.

The two pieces a a of the exterior fheath are of a fubftance partly between bone and horn, and partly membranaceous; they are fet round with hairs, and are furnifhed with air veffels, which are diftributed through their whole texture; the upper ends f f of this fheath appear to be a little bent, but can be ftraitened by the bee when they are applied to the probofcis. At d d are two articu-

articulations, by means of which the pieces a a may be occasionally bent. The joints contribute towards bending the proboscis downwards, or rather underneath, against the head. These sheaths, together with the two interior ones e e, assist in defending, covering, and protecting it from injuries: it is also probable that they forward the descent of the honey, by pressing the proboscis. The parts k k of this sheath have been called by some writers the root.

The two parts e e of the interior sheath are placed higher than those of the exterior one; they originate at g g on the proboscis itself, and near that part, or articulation, by which the bee can upon occasion bend the proboscis; this sheath, therefore, always moves with the middle part i i, and is carried forward by it, the exterior sheath being left behind, because it's attachments and origin are below that of the proboscis. The pieces e e are very similar in structure to those of a a, only that each of them has on the upper part three joints; the lower one is much longer than the other two; they are all of them surrounded with short hairs. The smaller articulated pieces never lie close to the proboscis, nor cover it, but are only placed near it, the two upper joints projecting outwards, as in this figure, even when the whole apparatus is shut up as much as possible. Swammerdam thinks these joints are of essential use to the bee, acting as it were in the manner of fingers, and assist the proboscis, by opening the leaves of the flowers, and removing other obstructions from it: or like the two fore feet of the mole, by the help of which it pushes the earth from the sides both ways, that it may be able with it's sharp trunk to search for it's food more conveniently. There are two smaller pieces, or

4 sheaths,

ſheaths, m m, near the bottom of the proboſcis; theſe cannot be well ſeen without removing the ſheath e e.

The proboſcis is partly membranaceous, and partly of a griſtly nature; the lower part is formed in ſuch a manner, that it will ſwell out conſiderably, by which means the internal cavity may be prodigiouſly enlarged, and rendered capable of receiving a very large quantity of native and undigeſted honey, and larger than might be expected from it's ſize. When the proboſcis is ſhut up and inactive, it is very much flattened, and is three or four times broader than it is thick. The edges are always round; it grows tapering, though very gradually, towards the extremity. The lower and membranaceous part of the trunk has no hair on it, but is covered with little protuberant tranſparent pimples, that are placed in regular order, and at equal diſtances from each other, reſembling the little riſings obſervable on the ſkin of birds when the feathers have been plucked off. They are probably glandules, and may have a conſiderable ſhare in changing or preparing the honey that is ſwallowed or taken up by the proboſcis. Down the middle of the proboſcis there is a tube of a much harder nature than the ſides, it grows gradually ſmaller towards the top; at this place the proboſcis is very thick ſet with ſmall hairs; whether they are open tubes, or whether they only ſerve as ſo many claws, to keep it in it's proper place while in action, has not been determined.

The proboſcis terminates in a ſmall cylinder c, at the top of which there is a little globule, or nipple; the circumference of the upper part of this cylinder is beſet with hairs, which radiate from it; the bee can contract this cylindrical part, and the little membrane,

membrane, in which the hairs are fixed, into a much ſmaller compaſs, and draw it inwards.

The proboſcis is not cylindrical, but rather a kind of convex blade, terminating nearly in a point; and the ſheaths are ſo contrived as to cover little more than the upper part of it; they are a kind of angular groove, of which the upper ſide is the broadeſt. The exterior ſheaths lap over each other on the upper part, ſo that the outſide of the proboſcis is protected by a very ſtrong double caſe, a covering that was unneceſſary for the under part; becauſe when this inſtrument is in uſe the ſheaths are opened, but when it is inactive it is ſo folded that the under part is protected by the body of the bee. Within ſide the exterior ſheath, and near the bottom q, are two levers, which are fixed to the end of the proboſcis, and by which it is raiſed and lowered.

If a bee is attentively obſerved when it has placed itſelf upon a full-blown flower, the activity and addreſs with which it uſes this apparatus will be very conſpicuous. It lengthens the end of it, and applies it to the bottom of the petals, or leaves, of the flower, moving it continually in ten thouſand different ways, lengthening and ſhortening it, bending and turning it in all poſſible directions, to adapt it to the form of the leaves of the flower. Theſe various movements are executed with a promptitude that ſurpaſſes all deſcription.

Mr. Swammerdam thinks that the honey is, as it were, pumped or ſucked up by the bee through the hole at the end b of the proboſcis; he does not ſeem to have diſcovered the apertures which are on the cylindrical part, near the end b.

M. Reau-

M. Reaumur thinks it is uſed as a tongue to lap up the fluid which is conveyed down between the ſheath to the mouth of the bee. To prove this, he placed a bee in a glaſs tube, the inſide of which was rubbed over with honey, and little pieces thereof placed in different parts; he obſerved the trunk lying on the honey, the end thereof being ſtretched beyond the honeyed heap; ſhe bends it into the form of a bow, and inſerts the moſt convex part of this bow into the liquor, and then rubs the glaſs backwards and forwards with the ſame ſide of the proboſcis, ſo as very ſoon to clean that part of the glaſs to which ſhe applies it. It is afterwards conveyed to the throat by the various vermicular motions of the proboſcis. Thoſe who wiſh for a fuller account of this curious apparatus, will do well to conſult the intereſting memoirs of M. de Reaumur, who has, with a wonderful ſagacity, diſcovered the principal ſprings of this aſtoniſhing machine. He has there deſcribed more than twenty parts of which it is made, and almoſt given a complete anatomy of this little organ. Like a workman who takes to pieces a watch which he himſelf has made, he lays before us the ſeveral pieces, makes us remark their fitneſs, their adjuſtment, their uſes, the play of their ſprings, pivots, and pillars; for all theſe parts, and many more, are to be found in the proboſcis of the bee.

OF THE WINGS OF INSECTS.

The attentive obſerver will find a very pleaſing variety of objects in the wings of different inſects. The beauty of their colours, the delicacy of their ſtructure, the art with which they are connected to the body, the curious manner in which ſome are folded up, the admirable texture of their joints, impreſs on the mind the parts defigned to be examined. But none of thofe, which were prefented to the Royal Society, magnified fo much, as the glafs globules, which have been ufed in other microfcopes. He had obferved, in a letter of his to the Royal Society, that from upwards of forty years experience, he found that the moft confiderable difcoveries were to be made with fuch glaffes, as, magnifying but moderately, exhibited the object with the moft perfect brightnefs and diftinctnefs. Each inftrument was devoted to one or two objects: hence he had always fome hundreds by him. * There is fome reafon for fuppofing, that Leeuwenhoek was acquainted with a mode of viewing opake objects, fimilar to that invented by Dr. Lieberkuhn. †

About the year 1665, fmall glafs globules began to be occafionally applied to the fingle microfcope, inftead of convex lenfes. By thefe globules, an immenfe magnifying power is obtained. The invention of them has been generally attributed to M. Hartfoeker; it appears, however, to me, that we are indebted to the celebrated Dr. Hooke for this difcovery; for he defcribed the manner of making them in the preface to his Micrographia Illuftrata, which was publifhed in the year 1656. Now the firft account we have of any microfcopical difcovery by M. Hartfoeker, was that of the fpermatic animalculæ, made by him when he was eighteen years old; which brings us down to the year 1674, long after Dr. Hooke's publication.

As thefe glafs globules have been very ufeful in the hands of experienced obfervers, I fhall lay before my readers the different

* Philofophical Tranfactions, No. 380, No. 458.

† Prieftley's Hiftory of Optics, p. 220.

mind a deep ſenſe of that wiſdom, which is manifeſted in ſuch various ways through the whole works of creation.

The delicate tranſparent wings of many inſects are covered and protected by elytra, or caſes, which alſo in ſome meaſure act as wings.—Theſe

"——A two-fold apparatus ſhare,
Natives of earth, and habitants of air;
Like warriors ſtride, oppreſs'd with ſhining mail,
But furl'd beneath their ſilken pennons veil:
Deceiv'd, our fellow reptile we admire,
His bright endorſement, and compact attire;
When lo! the latent ſprings of motion play,
And riſing lids diſcloſe the rich inlay;
The tiſſued wing it's folded membrane frees,
And with blithe quavers fans the gathering breeze.*

The exterior caſes are harder and more opake than the under ones; they are generally highly poliſhed, and often enriched with various colours, adorned with ornamental flutings, and ſtudded with brilliants. All theſe ornaments are united in the curculio imperialis † (or diamond beetle), one of the moſt reſplendent creatures in nature; the head, the wings, the legs, &c. are curiouſly beſet with ſcales of a moſt brilliant view, outvying the ruby, ſaphire, and emerald. It is ſaid, that in the Brazils, from whence they come, it is almoſt impoſſible to look at them

* Brooke's Univerſal Beauty.

† Fabricius Spec. Inſ. 184. 129.—Drury. Inſ. 2 Tab. 33. Fig. 1.

them on a funny day, when they are flying in little fwarms, fo great is the glowing glory of their heightened colours.

The ftrength and hardnefs of the elytra are admirably adapted to the various purpo s of the infects to which they are appropriated, and at the fame time that they protect the tender wing, they ferve as a fhield to the body; the ribs, and other prominencies, on many of them, contribute to leffen the friction, and diminifh the preffure to which they are often expofed.

In moft of thefe infects the under wing is longer and larger than the exterior one, fo that it is obliged to be bent and folded up, in order to lie under the elytra; for this purpofe they are furnifhed with ftrong mufcles, and proper articulations, to difplay and conceal them at pleafure. Fig. 2, Plate XIV. reprefents the wing of the earwig * when unfolded, and of it's natural fize. Fig. 1 reprefents it as exhibited by the microfcope. We fhall defcribe this more particularly hereafter.

We have already treated of thofe decided differences in the wings of infects, which affift the natural hiftorian in ranging them into claffes; fo infinite are the varieties to be obferved in this curious organ, that only to enumerate them would occupy many pages; we muft, therefore, content ourfelves with a few general remarks, leaving it to fome future writer to difplay the wonders that are manifefted in their difpofition, ftructure, motions, and ornaments. In general, the wings are delicate and yet ftrong, furnifhed with ribs, or nerves, curioufly inofculated

Y y together,

* Forficula auricularia, Lin. Syft. Nat. vol 1, part 2, 686-1.

together, ſo as to ſtrengthen and convey nouriſhment to the ſeveral parts of the wing, while by the diverſity of their ramifications they add to it's beauty; many have their wings fortified with briſtly hairs, which they can erect at pleaſure, Plate XV. Fig. 1.

The wings of the moth and butterfly are moſtly farinaceous, being covered with a fine duſt, which renders them opake, and is alſo the cauſe of thoſe beautiful and variegated colours which ſo richly adorn them, that

"Not all the ſhew and mockery of ſtate,
The little, low, fine follies of the great;
Not all the wealth which eaſtern pageants wore,
What ſtill our idolizing worlds adore,
Can boaſt the leaſt inimitable grace
Which decks profuſive this illuſtrious race."

Ever ſince the microſcope was invented, this duſt has engaged the attention of the microſcopic obſerver. For by this inſtrument it is found to be a regular aſſemblage of organized ſcales, of various ſhapes and colours, ſome long and ſlender, ſome ſhort and broad, ſome notched at the edges, others ſmooth, generally furniſhed with a kind of foot ſtalk, by which they are fixed to the wing, ſee Fig. E F H I, of Plate XVI. Their ſhapes are not only very different in moths of various ſpecies, but of thoſe on the ſame moth ſome will be found to be nearly oval, while others are triangular; a variety of large ſtripes, or ribs, are to be diſcovered in theſe ſcales, and between theſe larger ramifications minuter lines may be ſeen; the larger ſtripes ſeem in general to riſe

rise from the exterior notches; some of these scales, or plates, are to be found so exceedingly slender, that it is not easy to discriminate them from hairs by the naked eye. The regular arrangement of these plates, one beside, and partly covering the other, as in the tiling of a house, is best seen by examining the wing in the opake microscope. The prodigious number of small scales which cover the wings of these beautiful insects, is a sure proof of their utility to them, because they are given by HIM who makes nothing in vain.

That the lively and variegated colours which adorn the wings of the moth and butterfly arise from the small scales, or plates, that are planted therein, is very evident from this, that if they are brushed off from it, the wing is perfectly transparent; but whence this profusion and difference of colour on the same wing? is a question as difficult to resolve as that of Prior, when he asks,

> "Why does one climate and one soil endue
> The blushing poppy with a crimson hue,
> Yet leave the lilly pale, and tinge the violet blue?"

The materials of the wings under these plates seem to be of a talcy nature; the wing is strengthened by several nerves, or ribs, which run through it; the largest fortifies the exterior edge of the wing, while a smaller one strengthens the interior edge. When the moth immerges from the chrysalis, the wings are soft and thick, and if they are examined at that time, they will be found to consist of two membranes, which may be raised up, and then ſeparated, by blowing between them with a ſmall tube. The veſſels, or ribs, lie between theſe ſkins.

As the wings of the moth and butterfly are light, they can ſupport themſelves for a long time in the air; their manner of flying is ungraceful, mounting and deſcending alternately, ſo that they generally move in a zigzag line, to the right and to the left, up and down; by this means they often eſcape the birds who chace them, as this undulating motion diſappoints them in their aim: hence they often may be ſeen to purſue a butterfly in vain for a conſiderable time.

Dr. Hooke * endeavoured to inveſtigate the nature of the motions of the wings of inſects; and although he was not able, from the experiments he made, to give a ſatisfactory account of them, yet as they may be uſeful to ſome future inquirer, and lead him more readily into the path of truth, I hope an extract therefrom will not prove unacceptable to the reader. To inveſtigate the mode or manner of moving their wings, he conſidered with attention thoſe ſpinning inſects that ſuſpend, or as it were poiſe themſelves, in one place in the air, without riſing or falling, or even moving backwards or forwards; by looking down on theſe he could, by a kind of faint ſhadow, perceive the utmoſt extremes of the vibratory motion of their wings; the ſhadow, while they were thus ſuſpended, was not very long, but was lengthened when they endeavoured to fly forwards. He next tried, by fixing the legs of a fly upon the top of the ſtalk of a feather, with glue, wax, &c. and then making it endeavour to fly away; he was thereby

* Hooke's Micrographia, p. 172.

thereby able to view it in any poſture. From hence he collected, that the extreme limits of the vibrations were uſually ſomewhat about the length of the body diſtant from each other, often ſhorter, and ſometimes longer. The foremoſt limit was generally a little above the back, and the hinder one ſomewhat beneath the belly; between theſe, to judge by the ſound, they ſeemed to move with an equal velocity. The manner of their moving them, if a juſt idea can be formed by the ſhadow of the wing, and a conſideration of it's nature and ſtructure, ſeemed to be this: the wing being ſuppoſed to be in the extreme limit, it is then nearly horizontal, the fore part only being a little depreſſed; in this ſituation the wing moves to the lower limit; before it arrives at this, the hinder part begins to move faſteſt; the area of the wing begins to dip behind, and in that poſture it ſeems to be moved to the upper limit back again. Theſe vibrations (judging by the ſound, and comparing them with a ſtring tuned in uniſon thereto) conſiſt of many hundreds, if not thouſands, in a ſecond of time. The powers of the governing faculty of the inſect, and the vivacity of it's ſenſations, whereby every organ is ſtimulated to act with ſo much velocity and regularity, ſurpaſs our preſent comprehenſion.

Fig. 1, Plate XV. is a repreſentation of the wing of the hemerobius perla (Lin. Syſt. Nat. vol. 1, part 2, page 911-2) of the natural ſize. Fig. 2 repreſents the ſame wing magnified. This elegant inſect has acquired the name of hemerobius from the ſhortneſs of it's life, as it ſeldom lives more than two or three days in it's fly ſtate: Linnæus has placed it in his fourth claſs, among thoſe inſects which have four tranſparent wings and no ſting. The wings are nearly of a length, and exactly ſimilar; they

they are compofed of delicate fine nerves, regularly and elegantly difpofed, as may be feen in the figure; they are beautifully adorned with hairs, and are flightly tinged with green. The body is of a fine green colour, and it's eyes appear like two delicate beads of burnifhed gold, from whence it is by many called the golden eye. This curious little infect lays it's eggs on the leaves of the plumb, rofe tree, &c. the eggs are fmall and white, and each of them fixed to a little pedicle, or foot ftalk, about half an inch long; they ftand off from the leaf, and appear much like the fructification of fome of the moffes. This fingular circumftance has been already noticed in page 265 of thefe effays. The larva which proceed from thefe eggs refemble that of the coccinella, or lady cow, but are much handfomer; it feeds like them on the aphides, or pucerons, fucking their blood, and forming itfelf a cafe with their dried bodies, in which it changes into the pupa ftate, from whence they afterwards immerge in the form of the fly here defcribed.

Fig. 2, Plate XIV. reprefents the wing of the forficula auricularia, or earwig, (Linn. Syft. Nat. vol. 1, part 2, page 686-1) of the natural fize. Fig. 1, the fame wing magnified. Though this infect is fo very common, yet few people know that they have wings, and fewer yet have feen them; they are of a curious and elegant texture, and wonderful ftructure. The upper part is cruftaceous and opake, while the other part is beautifully tranfparent. It folds up into a very fmall compafs, and lies nearly concealed under the elytra, which are not more than a fixth part of the wing in fize. They firft fold back the parts A B, and then fhut up the ribs like a fan; the ftrong mufcles ufed for this purpofe are feen at the upper part of the figure. The ribs are extended from

from the center to the outer edge, others are extended only from the edge about half way, but they are all united by a kind of band, at a ſmall but equal diſtance from the edge; the whole evidently contrived to ſtrengthen the wing, and facilitate the various motions thereof. The earwig is a very deſtructive animal, doing conſiderable injury to moſt kinds of wall fruit, to carnations, and other fine flowers, &c. and as they only feed in the night, they eſcape the ſearch of the gardener. Reeds open at both ends, and placed among fruit trees, are a good trap for them, as they croud into theſe open channels, and may be blown out into a tub of water. As they conceal themſelves in the daytime, thoſe that are curious in flowers place tobacco pipes, lobſters claws, &c. on the top of their garden ſticks, in order to catch them. This inſect differs very little in appearance in it's three different ſtates. De Geer aſſerts, that the female ſits on her eggs, and broods over the young ones as a hen does over her eggs.

OF THE EYES OF INSECTS.

The conſtruction and formation of the eyes of inſects differs conſiderably from that of other animals. In other creatures the eyes are moveable, and generally placed one on each ſide of the head, and two are ſufficient for all the purpoſes of viſion. But in inſects the eyes are fixed, and therefore would not ſerve to give them a view of any object but what was placed directly before them. We therefore find that they are provided with a number of eyes, which in ſome ſpecies, as in the ſpider, are ſingle, and placed at ſome diſtance from each other. But the greater part are

are furniſhed with a collection of an indefinite number of very ſmall ſingle eyes, placed in one common caſe or ſocket.

The two protuberances on the head, which are formed by this congeries of eyes, ſeem to the naked eye to conſiſt of a number of lines, croſſing with great regularity and exactneſs, at ſome little diſtance from each other, like the meſhes of a net, from whence they have been termed the reticular eyes. Thoſe of the libellula are peculiarly well adapted, on account of their ſize, for a microſcopic view of this ſubject. Theſe eyes are ſo perfectly ſmooth and poliſhed, that when viewed as an opake object, they will, like ſo many mirrors, reflect the images of all the ſurrounding objects. The figure of a candle may be ſeen multiplied almoſt to infinity on their ſurfaces, ſhifting it's beam to each eye according to the motion given it by the obſerver's hands. Other animals are obliged to turn their eyes towards any object, but theſe have eyes ready directed to it, on whatever ſide it may preſent itſelf. The genus of cancri have their eyes moveable, but for the moſt part reticulated like other inſects.

Though the reticulated eyes of flies are large, not only in proportion to the ſize of the creature, but abſolutely and in themſelves; yet the ſeveral ſmall eyes, of which they are compoſed, are remarkably minute in compariſon of thoſe of the butterfly claſs.

Moſt of the butterfly claſs have in each of their reticulated eyes many thouſand ſmall ones; but the fly claſs greatly exceed them in the number of theſe, as many of their eyes are three times as large as thoſe of the butterfly, and beſides that each ſmaller eye is vaſtly more minute.

4 Mr.

Mr. Hook computed 14,000 hemifpheres in the two eyes of a drone; Mr. Leeuwenhoeck reckoned 6236 in a filk-worm's two eyes in it's fly ftate; 3181 in each eye of a beetle, and 8000 in the two eyes of a common fly. The pearl eyes of the dragon fly appear with a common reading-glafs like fhagreen, and Mr. Leeuwenhoeck reckoned in each eye of this infect 12,544 lenfes, placed in an hexangular pofition, each lens having fix others round it. He alfo obferved in the center of each lens a minute tranfparent fpot, brighter than the reft, fuppofed to be the pupil, furrounded with three circles, and in appearance feven times lefs than the diameter of the whole lens. Mr. Puget counted 17,325 in the eye of a butterfly, which Malphigi concludes to be diftinct and feparate eyes. The Abbé Catalan, and others, have fince fhewn, that all the eminences difcoverable in the cornea of infects have the neceffary parts, and perform the offices of an eye. Leeuwenhoeck difcovered the bundles of optic nerves which ferve thefe fmall lenfes; and Reaumur fuppofes that thefe fupply the place of all that is wanted behind the lenfes, for the organization of an eye complete for vifion.

But it is in the works of Swammerdam that we are enabled to contemplate the aftonifhing organization of the eyes of infects. Under each mefh, or facet, there is a little pyramid of fibres, broad at the bafe, and growing fmaller as it proceeds inwards. The pyramids have the fame number of fides as each eye, and there are, therefore, as many hexagonal pyramids as there are fmall facets, or eyes, in the infect. An innumerable quantity of pulmonary tubes afcend thefe fibres; thefe tubes terminate in a fine tranfparent white fibrous membrane, of a convex fhape, which is alfo thick fet with pulmonary tubes; under this mem-different modes which have been deſcribed for making them, that he may be enabled thereby to verify or confute the diſcoveries that have been ſaid to be made with them.

Take a ſmall rod * of the cleareſt and cleaneſt glaſs you can procure, free, if poſſible, from blebs, veins, or ſandy particles; then by melting it in a lamp made with ſpirit of wine, or the pureſt and cleareſt ſallad oil, draw it out into exceeding fine and ſmall threads; take a ſmall piece of theſe threads, and melt the end thereof in the ſame flame, till you perceive it run into a ſmall drop or globule of the deſired ſize; let this globule cool, then fix it upon a thin plate of braſs or ſilver, ſo that the middle of it may be directly over the center of a very ſmall hole made in this plate, handling it till it is fixed, by the before-mentioned thread of glaſs. When the plate is properly fixed to your microſcope, and the object adjuſted to the focal diſtance of the globule, you will perceive the object diſtinctly and immenſly magnified. By this means, ſays Dr. Hooke, I have been able to diſtinguiſh the particles of bodies, not only a million of times ſmaller than a viſible point, but even to make thoſe viſible whereof a million of millions would hardly make up the bulk of the ſmalleſt viſible grain of ſand; ſo prodigiouſly do theſe exceeding ſmall globules enlarge our proſpect into the more hidden receſſes of nature.

Mr. Butterfield, in making of the globules, uſed a lamp with ſpirit of wine; but inſtead of a cotton wick, he uſed fine ſilver wire, doubled up and down like a ſkain of thread. † He pre-

B pared

* Lectures and Collections by Dr. Hooke.

† Philoſ. Tranſ. No. 141.

brane is another, which is more delicate and more tranfparent, but connected with it by means of pulmonary tubes; under this there is placed a fecond fpecies of fibres, tranfverfely applied, like fo many beams, to fupport the pyramidal fibres that are laid over them.

Each fide of the head of a fly, which is cut as it were into a multitude of fmall facets, is one of the reticulated eyes of the creature. Nature allots two of thefe reticulated eyes to each fly; and as they each contain fuch a vaft multitude of fmaller, but perfect eyes, one would imagine them to be very fufficient for all the occafions of the animal. There are, however, certain flies of the ephemera kind which have four of thefe reticulated eyes, two of which are placed as is ufual in the mufca, and are but of fmall extent; the other two have each the appearance of a fort of turban, and are placed one befide the other upon the upper part of the head.

Thefe have fomewhat the figure of a mufhroom, the head of it extended a little beyond the ftalk, and the upper convex furface cut into almoft an innumerable quantity of facets.

The firft pair of the reticular eyes of this fly, which are placed as thofe of the other flies, are in colour brown; thofe of the mufhroom form are of a very beautiful citron-colour, and as tranfparent as the moft pellucid reticular eyes of other flies; for, among the various fpecies, fome have thefe eyes much more tranfparent than others. The fly, thus remarkably furnifhed with eyes, is produced from a worm of the fame kind with the common fpecies of ephemerons; it's body is of a pale yellow, and

and it's wings white; the two inferior ones of thefe are fo fmall, that they are not eafily diftinguifhed.

Among the fly clafs thefe reticular eyes are, in different fpecies, of different colours; there are fome which have them brown, others yellow, others green, and others red, and this in all the different fhades of thofe colours. Some of them have alfo the glofs of metals highly polifhed, others afford us a view of changeable colours, and others have arrangements of different colours, fixed and invariable. The eyes of one fpecies of the gad-fly, fo troublefome to oxen, have ftreaks of red, green, and brown, placed alternately.

One would imagine, that as every fly has two of thefe reticular eyes, each compofed of fuch a multitude of real eyes, they could have no occafion for any more; but fo it has not appeared to the great Being that formed them, for many fpecies are furnifhed with more eyes, which differ both in conftruction and form from thofe that are reticulated.

The eyes already defcribed are properly called reticular ones; and to avoid confufion, it will be neceffary to defcribe thofe which differ from them by fome determinate name (they are now generally termed the ftemmata); thefe, when examined by the beft microfcopes, appear of a perfectly fmooth, gloffy, and polifhed furface, but plain and fimple, without the leaft appearance of a reticulated texture. They are alfo much fmaller than the reticulated eyes, and may therefore be called, by way of diftinction, the fmaller fmooth eyes, or the ftemmata.

Z z 2 M. De

M. De la Hire feems to have been the firft perfon who difcovered thefe fmooth eyes. He obferved three of them difpofed in a triangular form, on the back part of the heads of fome of thefe little creatures. He foon found that they were tranfparent, and thence naturally judged them to be of the fame nature of the cornea of our eyes, and really to ferve the fame office to the creature poffeffed of them.

We find three of thefe fmooth eyes placed triangularly on the back part of the head of vaft numbers of the genera of flies, as well of the two-winged as of the four-winged kinds; but there are alfo fome of both thefe claffes, in which they are wanting. All the fpecies of gnats, and of tipulæ, are without them. The heads of thefe are very fmall in proportion to the bulk of their body, and are in a manner covered by their reticular eyes. The want of the fmall eyes is amply made up by the fize and extent of the larger; but there are fome other kinds which want them, without having this advantage in their place. Of the two-winged flies with fhort bodies, the gad-flies want thefe eyes; and among the longer bodied and four-winged kinds, the flies produced from the puceron-eaters (hemerobius).

Notwithftanding, therefore, that many fpecies of flies have thefe eyes, there are yet fo many that want them, that Mr. De la Hire would not have judged thefe to be their only eyes, if he had made experiments on the reticulated ones, in the manner of Meff. Swammerdam and Reaumur. Mr. Swammerdam put upon the eyes of certain flies a covering of black, fteeped in oil; in this ftate they flew at random, and feemed to have no ftrength; and wherever they fettled they did not avoid the hand which would

6 take

take them. M. Reaumur made alſo ſome experiments upon the reticulated eyes of bees, which were all taken from the ſame hive. He ſpread upon them a covering of dark-coloured varniſh, and ſhut them up with ſome of their companions which had not been touched, in a large powder-box. At about eight or ten ſteps from the hive from whence they were taken, the cover of the box was taken off; thoſe which had their eyes clear immediately took their flight, and went to their habitation; thoſe whoſe eyes were varniſhed made no haſte to get out of the box; they had ſome difficulty to determine themſelves for flight, and the greateſt number directed it at random, and on different ſides, and went not far. To oblige ſome of them to fly farther, they were thrown into the air; they raiſed themſelves vertically till they were loſt, and not one of them ſeemed to know the way to it's hive.

To know what would happen if the ſtemmata were covered, he put varniſh upon them, in the ſame manner as was done to the reticulated eyes, and ſet them likewiſe at liberty, about three or four ſteps from the hive; not one ſeemed to know it's way, or even ſeek it. They flew on all ſides upon the plants, but did not fly far.

An inſect is, I believe, never found with both kinds of eyes but when it is in it's perfect ſtate. The moth, for inſtance, which has ſeveral thouſands of eyes in the reticulated form, has only ſix ſmall ſmooth eyes in the ſtate of the caterpillar. The wonderful anatomiſt of the coſſus has ſhewn, that the eyes of the latter are in the form of a cup, and that the cornea, which is the cover to this cup, is very tranſparent. He has been enabled to diſcover a true optic

optic nerve, that divides into fix branches, which are connected with each eye; each of thefe is accompanied with a pulmonary tube. This celebrated obferver, in fpeaking lightly of the reticulated eyes of the moth of the coffus, which are in number 22,000, fays, that each is probably a telefcope, confifting at leaft of three lenfes.

It is eafy to fhew with the eye of a fly, prepared as we have already defcribed in page 142, chapter iv. and then placed before the microfcope, that each of the portions of thefe reticular eyes have the power of refracting the light, and forming an image of a candle, or any other object, at their refpective foci. Mr. Martin affirms, that in a great number of obfervations he always found that the edge of the cornea of each eye was always thicker in the middle than at the edges, and that this fwelling out, or increafe of thicknefs, was equal on each fide, and exactly oppofite, amounting to a full proof that the cornea of an infect's eye is really a fyftem of a great number of exceeding fmall double and equally convex lenfes, of an hexagonal form, "and affording one of the moft ftriking inftances of Divine geometry and optics."

Fig. 3, Plate XVI. is a reprefentation of a fmall portion of the cornea of the libellula, as feen by the microfcope. The fides of the hexagons, in fome pofitions of the light, appear of a fine gold colour, and divided into three parallel lines. Fig. 4 is the fame piece of it's natural fize.

Fig. 5, Plate XVI. reprefents a piece of the cornea of a lobfter's eye; in thefe each of the eyes are fet as it were in a fquare frame. Fig. 6, the fame piece not magnified.

Mr.

Mr. William André has ſhewn, that theſe are not the only variations which are to be found in the eyes of theſe ſmall creatures; for thoſe of the monoculus polyphemus are made up of a great number of ſmall tranſparent amber-like cones. See his letter to Sir Joſeph Banks, in the Philoſophical Tranſactions, a ſhort extract from which I ſhall proceed to lay before the reader.

"The monoculus polyphemus, or king crab, is a cruſtaceous animal, found in all the ſeas ſurrounding the continent of America and the Weſt India iſlands, and which frequently grows to a very large ſize.

"If the ſhell of the monoculus were divided fairly in half, the large eyes would be nearly in the center of each piece, and the ſmall ones on the divided edge, near the fore-part of the ſhell. The large eyes are at a great diſtance from each other; but the ſmall ones are cloſe together. It will appear hereafter that the large eyes are made up of a great number of ſmall tranſparent amber-like cones, and that the ſmall ones are compoſed of one ſuch cone only; ſo that they may be divided into eyes with many cones, and eyes with a ſingle cone. The large eyes, or thoſe with many cones, appear as two tranſparent ſpots, about the ſize and nearly of the ſhape of a kidney-bean, the concave edges looking towards each other, and the convex towards the edge of the ſhell. If they be examined attentively, we may diſcern on their ſurface a number of ſmall depreſſions, which point out the center of each cone. The ſmall eyes, or thoſe with a ſingle cone, look like two ſmall tranſparent ſpots, not larger than a pin's head; theſe, from their minuteneſs, are eaſily overlooked.

"The

"The appearances which have been defcribed may be feen on the external furface of the fhell with the naked eye; but in order to proceed to a further inveftigation of the fubject, the cornea muft be removed from the fhell, and applied to a fingle microfcope with a very ftrong light.

"The internal furface of the large eyes, examined with the microfcope, is found to be thick fet with a great number of fmall tranfparent cones, of an amber colour, the bafes of which ftand downwards, and their points upwards next the eye of the obferver. The cones in general have an oblique direction, except fome in the middle of the cornea, about thirty in number, the direction of which is perpendicular.

"The center of every cone being the moft tranfparent part, and that through which the light paffes, on that account the perpendicular or central cones always appear beautifully illuminated at their points. In a word, they are all fo difpofed, as that a certain number of them receive the light from whatever point it may iffue, and tranfmit it to the immediate organ of fight, which we may reafonably fuppofe is placed underneath them; the cones are not all of the fame length; thofe on the edges of the cornea are the longeft, from whence they gradually diminifh as they approach the center, where they are not above half the length of thofe on the edges."

OF THE INSECT WHICH IS REPRESENTED AT FIG. 1, 2, 3, PLATE XVII.

This very beautiful and fingular infect was firft pointed out to me by Mr. Marfham, who had feen it in the cabinet of infects belonging to the Queen, in the royal obfervatory at Richmond. Her Majefty was pleafed to permit me to have the drawing taken from it, from which this plate was engraved. When Mr. Marfham firft faw it at Richmond, he confidered it as an undefcribed infect, and an unique in this country. But he has fince found that it is mentioned by Fabricius, in his Syftema Entomologiæ, as a new genus, under the name of leucofpis dorfigera; and there is one of the infects in the cabinet of the celebrated Linnæus, now in the poffeffion of J. E. Smith, M. D. F. R. S. Sulz, and other writers, have alfo defcribed it.

It appears at firft fight like a wafp, to which genus the folded wings would have given it a place, had not the remarkable fting, or tube, on the back removed it from thence. It is probably a fpecies between, and uniting the fphex and wafp, in fome degree partaking of the characters of both. The antennæ are black and cylindrical, increafing in thicknefs towards the extremity; the joint neareft the head is yellow, the head is black, the thorax is alfo black, and encompaffed round with a yellow line, and furnifhed with a crofs one of the fame colour, near the head. The fcutellum is yellow, the abdomen black, with two yellow bands, and a fpot of the fame colour on each fide between the bands. A deep black polifhed groove extends down the back, from the thorax to the anus, into which the fting turns and is depofited, leaving the anus very circular; a yellow line runs on each fide

 the

the ſting. The anus and the whole body, when viewed with a ſhallow magnifier, appear punctuated; theſe points, when examined in the microſcope, appear hexagonal, as in the plate; and in the center of each hexagon a ſmall hair is to be ſeen; the feet are yellow, the hinder thighs very thick and toothed, and alſo form a groove for the next joint; they are yellow, with black ſpots: it is found in Italy, Switzerland, France, and Germany. Fig. 1, Plate XVII. ſhews it very much magnified. Fig. 2 is a ſide view of it leſs magnified. Fig. 3 is the object of it's real ſize.

OF THE LOBSTER INSECT, DELINEATED FIG. 1 AND 6, PLATE XVIII.

This extraordinary little creature was found by my ingenious friend, Mr. John Adams, of Edmonton; he was at the New Inn, Waltham Abbey, where it was ſpied by ſome labouring men who were drinking their porter. The man who firſt perceived it thought it was of an unuſual form; this occaſioned a nicer inſpection, and it was ſuppoſed to be a louſe with unuſual long horns; others thought it was a mite. This occaſioned a debate, which drew the attention of my friend, who obtained the inſect from them for further obſervation. Mr. Martin has given ſome account of it in the third volume of "The Young Gentleman and Lady's Philoſophy." Mr. Adams favoured me with the inſect, that an accurate drawing might be taken from it, which I thought would be highly pleaſing, not only to the lovers of microſcopic obſervations, but alſo to the entomologiſt. It appears to be quite a diſtinct ſpecies from the phalangium cancroides of Linnæus, of which a good drawing has been given by Hook, Roeſel,

Roesel, Schæffer, &c. it has alſo been deſcribed by Scopoli, Geoffroy, &c.; not one, however, of theſe deſcriptions agrees with the animal under conſideration. The abdomen of this is more extended, the claws are larger and much more obtuſe, the body of the other being nearly orbicular, the claws ſlender, and finiſhing almoſt in a point, more tranſparent, and of a paler colour. It is very probable that there are ſeveral ſpecies nearly ſimilar. Mr. Marſham has two in his poſſeſſion, one like the drawings of Reaumur, the other not to be diſtinguiſhed from that which is repreſented in Plate XVIII. except that it wants the break, or dent, in the claws, which is ſo conſpicuous in this. He found his firmly fixed by it's claws to the thighs of a large fly, which he caught on a flower in Eſſex the firſt week in Auguſt, and from which he could not diſengage it without great difficulty, and tearing off the fly's leg, which he did on a piece of writing paper, and was much ſurprized to ſee the little creature ſpring forwards full a quarter of an inch, with great impetuoſity, and again ſeize it's prey, from which he had great trouble to diſengage it.

OF FIG. 3, 4, AND 5, PLATE XVIII.

The inſect which is repreſented at Fig. 3, Plate XVIII. was originally named phyſapus by Mr. de Geer, on account of the bladders at the feet. Linnæus terms it trips.

They live upon plants, and particularly in flowers. The one figured here is the black trips, with white wings; the antennæ have ſix articulations, the body is black, the wings whitiſh, long and hairy, the head ſmall, with two large reticular eyes. The pared his glafs by beating it to powder, and washing it very clean; he then took a little of this glafs upon the sharp point of a silver needle, wetted with spittle, and held it in the flame, turning it about till a glafs ball was formed; then taking it from the flame, he afterwards cleaned it with soft leather, and set it in a brafs cell.

No person has carried the use of these globules so far as T. Di Torrè, of Naples, nor been so dexterous in the execution of them; and if others have not been able to follow him in the same line, it may be fairly attributed to a want of that delicacy of touch for adjusting the objects to their focus, and that acuteness of vision which can only be acquired by long practice. P. Torrè has also described, more minutely than any other author, the mode of executing these globules, which, as it throws much light upon the preceding description by Dr. Hooke, will not, it is presumed, be unacceptable to the reader.

Three things are necessary for forming of these globules: 1. A lamp and bellows, such as are used by the glafs-blowers; 2. A piece of perfect tripoli; 3. A variety of small glafs rods. When the flame of the lamp is blown in an horizontal direction, it will be found to consist of two parts; from the base to about two-thirds of it's length, it is of a white colour; beyond this, it is transparent, and colourless. It is this transparent part which is to be used for melting the glafs, because by this it will not be in the least sullied; but it will be immediately soiled, if it touches the white part of the flame. The part of the glafs which is presented to the flame, ought to be exceeding clean, and great care should be taken that it be not touched by the fingers. If the antennæ are of an equal ſize throughout, and divided into ſix oval pieces, which are articulated together. The extremities of the feet are furniſhed with a membranaceous and flexible bladder, which it can throw out or draw in at pleaſure. It places and preſſes this bladder againſt the ſubſtances on which it is walking, and ſeems to fix itſelf thereby to them; the bladder ſometimes appears concave towards the bottom, the concavity diminiſhing in proportion as it is leſs preſſed.

They have four wings, two upper and two under ones; theſe laſt are with great difficulty perceived; they are fixed to the upper part of the breaſt, laying horizontally; both of them are rather pointed towards the edges, and have a ſtrong nerve running round them, which is ſet with a hair fringe, tufted at the extremity. The wings are repreſented by themſelves at Fig. 4; the inſect of the real ſize at Fig. 5. They are to be found in great plenty in the ſpring and ſummer, in the flowers of the dandelion, &c.

OF FIG. 2, PLATE XVIII.

This beautiful opake object is a piece of the ſkin of the lump fiſh. For a full deſcription of this ſingular creature, I muſt refer the reader to Pennant's Britiſh Zoology, vol. iv. page 117. There are no ſcales on the body, but a greater number of theſe tubercles, which are exhibited in this figure. When a good ſpecimen is procured, it forms a moſt delightful object for the opake microſcope. It is probable that the fiſh exudes an unctuous matter from theſe tubercles.

Fig.

Fig. 1, Plate XX. is a beautiful inſect of the hemiptera claſs, or that kind where the elytra are only in part cruſtaceous, and which do not form a longitudinal ſuture down the back, but fold over about one-third of their length towards the bottom, where it is alſo partly tranſparent. It is of the genus cimex, and called ſtriatus by Linnæus. It cannot boaſt a variety of colours, though what it has are bright and elegantly diſpoſed: the head, proboſcis, and thorax, are black. The thorax is ornamented with yellow ſpots, the middle one large, and occupying almoſt one-third of the poſterior part; the other two are on each ſide, and triangular. The ſcutellum has two yellow oblong ſpots, pointed at each end; the ground of the elytra is a bright yellow, ſpotted and ſtriped with black. The nerves are yellow, and there is a brilliant triangular ſpot of orange, which unites the cruſtaceous and membranaceous parts; the latter is brown and clouded. The feet are of a fine red, and the rings of the abdomen are black, edged with white. This pretty inſect is to be found in June, upon the elm-tree. It is repreſented at A of the natural ſize.

PLATE XX. FIG. 2.

A very common, though elegant, inſect of the coleoptra claſs, is repreſented as ſeen in the lucernal microſcope, and of it's natural ſize at B; it is called by Linnæus chryſomela aſparagi, from the larva feeding on the leaves of that plant. It's figure is oblong, the antennæ black, compoſed of many joints nearly oval. The head is a bright but deep blue, the thorax red and cylindrical, the elytra blue, with a yellow margin, with three ſpots of the ſame colour on each, one at the baſe of an oblong form, and two united with the margin; the legs are black, but the under ſide of the

the belly is of the fame blue colour with the elytra and head. This little animal, when viewed by the naked eye, fcarcely appears to deferve any notice; but when examined by the microfcope, it is one of the moft pleafing opake objects we have.

This infect is found in June, on the afparagus after it has run to feed. De Geer fays, that it is very fcarce in Sweden.

FIG. 3, PLATE XX.

The infect which comes at prefent under our infpection is peculiarly adapted to fhew the advantages of the microfcope, which alone will difcover the peculiarities of it's figure; this is fo remarkable, that the naturalifts appear undetermined as to it's genus. Geoffroy formed a new one for it, under the title of notuxus, in which he has been followed by Fabricius; even Linnæus himfelf could not determine at firft where to place it, for in the Fauna Suecica he makes it an attelabus, but in the laft edition of the Syftema Naturæ he has fixed it as a meloe, calling it the meloe monoceros; but ftill he adds, "genus difficile determinatur forte huic proximum." Both Geoffroy and Schæffer have given figures of it, but as they had not that kind of microfcope which would affift them, their figures are imperfect.

The head is black, and appears to be hid, or buried, under the thorax, which projects forwards like a horn; the antennæ are compofed of many articulations, and with the feet are of a dirty yellow. The hinder part of the thorax is reddifh, the fore-part black. The elytra are yellow, with a black longitudinal line down

down the future; there is a band of the same colour near the apex, and also a black point near the base: the whole animal is curiously covered with hair. Geoffroy says it is found on umbelliferous plants; the one here described was found in May; the natural size is seen at C.

Fig. 1 and 3, Plate XIX. represents two of the feet of the monoculus apus of Linnæus. They are curiously contrived to assist the animal in swimming, and form a very beautiful object for the microscope.

Fig. 2 and 4 are of the natural size.

OF THE SCALES OF FISH.

The outside coverings, or scales, of fishes afford an immense variety of beautiful objects for the microscope. They are formed in the most admirable manner, and arranged with inconceivable beauty and regularity; some are of a long shape, others nearly round, some square, varying in shape, not only in different species of fish, but even considerably on the same fish; those which are taken from one part not being entirely similar to those which are taken from another.

Leeuwenhoeck supposed each scale to consist of an infinity of scales, laid one over the other, or more simply of an infinity of strata, of which those next the body of the fish are the largest.

These strata exhibit a specimen of very beautiful workmanship; when viewed with the microscope, we find them to be constructed with

with wonderful art. In ſome ſcales we diſcover a prodigious number of concentric flutings, too fine, as well as too near each other, to be eaſily enumerated; they are probably formed by the edges of each ſtratum, denoting the limits thereof, and the different ſtages of the growth of the ſcale. Theſe flutings are often traverſed by others that proceed from the center of the ſcale, which is ſeldom in the middle thereof; theſe generally go in a ſtrait line from this center to the circumference.

Fig. 7, Plate X. repreſents a ſcale from a ſpecies of the parrot fiſh of the Weſt-Indies, conſiderably magnified. Fig. 8, the real ſize of the ſcale.

Fig. 9, Plate X. is a ſcale of the ſea perch, which is found on the Engliſh coaſt.

Fig. 10, the ſame ſcale of the natural ſize.

Fig. 7, Plate XIX. a ſcale from the haddock, as ſeen in the microſcope. Fig. 8, the ſame of the natural ſize.

Fig. 9, Plate XIX. a ſcale from a ſpecies of perch from the Weſt-Indies, magnified. Fig. 10, the ſcale of it's real ſize.

Fig. 11, a ſcale from the ſoal-fiſh, delineated as it appeared in the microſcope; the pointed part is that which ſtands without the ſkin, as may be ſeen in Fig. 5, which repreſents a piece of the ſkin of the ſoal, as viewed by the opake microſcope. Fig. 6 and 12, the ſame objects of their real ſize.

CHAP.

CHAP. VII.

THE NATURAL HISTORY OF THE HYDRA, OR FRESH-WATER POLYPE.

THE polypes defcribed in this chapter are frefh-water infects, of the genus of hydra, in the clafs of worms, and order of zoophytes. When they are cut or divided into a number of pieces, the feparated parts in a very little time become fo many perfect and diftinct animals; each piece having a power of producing a head, a tail, and the other organs neceffary for it's life and ftate.

They are generally known by the name of polype; but as this was thought by many to be improper, becaufe that, ftrictly fpeaking, they have no feet, Linnæus called the genus hydra, probably from their property of reproducing the parts which are cut off, a circumftance that naturally brings to mind the fabulous ftory of the Lernean hydra. Dr. Hill called them biota, on account of the ftrong principle of life with which every part is endued.

Leeuwenhoeck, whofe indefatigable induftry in his refearches after fmall infects permitted very few things to efcape his notice, difcovered discovered these animals, and gave some account of them in the Philosophical Transactions for the year 1703. There is also in the same volume a letter from an anonymous hand on this subject. We had, however, no regular account of them, their various habits, their different species, or of their wonderful properties, till the year 1740, when they first engaged the attention of Mr. Trembley, to whose assiduity and observations we are indebted for the knowledge of their nature and œconomy.

Before these discoveries of Mr. Trembley, Leibnitz and Boerhaave, by reflections on the various gradations in the scale of animated nature, had endeavoured to prove that there might be degrees of life between the animal and the plant, and that animals might be found which would propagate by slips, like plants. These conjectures were verified by Mr. Trembley, but not in consequence of any preconceived ideas in favour of such a supposition; on the contrary, it was only by repeated observations that he could destroy his own prejudices, and join these wonderful beings to the animal kingdom.

Though natural history is so fruitful in extraordinary facts, it has hitherto produced none so singular as the various properties of the different species of the hydra.

I shall endeavour, first, to trace the progress of this discovery, in which we shall see with what sage caution and accuracy Mr. Trembley, and other naturalists, examined this wonderful phænomenon, and what accumulated evidence was judged necessary to establish the facts.

We

We find Mr. Trembley writing in January, 1741, to Mr. Bonnet, that he did not know whether he ſhould call the object which then engaged his attention a plant or an animal. "I have ſtudied it, ſays he, ever ſince June laſt, and have found in it ſtriking characteriſtics of both plant and animal. It is a little aquatic being. At firſt ſight every one imagines it to be a plant; but if it be a plant, it is ſenſitive and ambulant; if it be an animal, it may be propagated by ſlips, or cuttings, like many plants." It was not till the month of March, in the ſame year, that he could ſatisfy himſelf as to their nature.

When Mr. Reaumur ſaw, for the firſt time, two polypes formed from one that he had divided into two parts, he could hardly believe his eyes; and even after having repeated the operation an hundred times, and again examined it an hundred more, he ſays, that the ſight was not become familiar to him.

The firſt account the Royal Society received of the ſurprizing properties of this inſect, was in a letter from M. Buffon (dated the 18th of July, 1741) to Martin Folkes, Eſq. their preſident, acquainting them with the diſcovery of a ſmall inſect called a polypus, which is found ſticking about the common duck-weed, and which, being cut in two, puts forth from the upper part a tail, and from the lower end a head, ſo as to become two animals inſtead of one. If it be cut into three parts, the middlemoſt puts out from one end a head, and from the other a tail, ſo as to become three diſtinct animals, all living like the firſt, and performing the various offices of their ſpecies: which obſervations are, adds M. Buffon, well averred.

3 B 2 There

There is no phænomenon in all natural hiſtory more aſtoniſhing than this, that man, at pleaſure, ſhould have a kind of creative power, and out of one life make two, each completely formed with all it's apparatus and functions, each with it's perceptions and powers of motion and ſelf-preſervation, each as complete in all reſpects as that from which it derived it's exiſtence, and equally enjoying the humble gratifications of it's nature.*

Mr. Folkes, in confirmation of the foregoing article, communicated to the ſociety a letter from C. Bentink, Eſq. at the Hague, dated September, deſcribing the inſects diſcovered by Mr. Trembley, adding, that he himſelf had ſeen them. In November a letter was read from Dr. Gronovius, of Leyden, giving an account of a water inſect, not yet known to or deſcribed by any author; afteref cribing it, he adds, " but what is more ſurprizing, if this animal is cut into five or ſix pieces, in a few hours there will be as many animals, exactly ſimilar to their parent." The accounts of this animal were ſo extraordinary, that they were not credited until Profeſſors Albinus and Muſſchenbrock were provided with animals, and found all that had been related thereof to be exactly true.

November 25, a letter from Cambridge was read at the Royal Society, in which the author endeavours to leſſen, by reaſon, the prejudices which then combated the belief of theſe facts. " Some of our friends, ſays the author, who are firmly attached to the general metaphyſical notions they have formerly learned, reaſon ſtrongly

* Goldſmith's Hiſtory of the Earth and Animated Nature.

ſtrongly againſt the poſſibility of ſuch a fact; but I have myſelf owned, on other occaſions, my diſtruſt of the truth, or certainty at leaſt, of ſome of thoſe principles, and I ſhall make no ſcruple of acknowledging, that I have already ſeen ſo many ſtrange things in nature, that I am become very diffident of all general aſſertions, and very cautious in affirming what may or may not poſſibly be. The moſt common operations, both of the animal and vegetable world, are all in themſelves aſtoniſhing, and nothing but daily experience and conſtant obſervation can make us ſee, without amazement, an animal bring forth another of the ſame kind, or a tree bloſſom and bear leaves and fruit.

“ The ſame obſervation and experience make it alſo familiar to us, that beſides the firſt way of propagating vegetables from their reſpective fruit and ſeed, they are alſo propagated from cuttings, and every one knows that a twig of a willow particularly, cut off and only ſtuck into the ground, does preſently take root and grow, and become as real and perfect a tree as the original one from which it was taken. Here then we find in the vegetable kingdom, quite common, the very thing of which we have an example before us in the animal kingdom, in this new-diſcovered inſect. The beſt philoſophers have long obſerved ſtrong analogies between theſe two claſſes of beings; and the more they have penetrated into nature, the more they have extended this analogy: now in ſuch a ſcale, who is the man that will be bold to ſay, juſt here animal life entirely ends, and here vegetable life begins? or, juſt ſo far, and no farther, one ſort of operation goes; and juſt here another ſort, quite different, takes it's place? or again, who will venture to ſay, life in every animal is a thing abſolutely different from that which we dignify by the ſame name

4 in

glaſs rod has contracted any ſpots, it muſt either be thrown away, or the parts that are ſpotted muſt be cut off.

The piece of tripoli which is to be uſed in forming the globules, ſhould be flat on one ſide, and ſo large, that it may be handled conveniently, and protect the fingers from the flame. A piece four or five inches long, and three or four inches thick, will anſwer very well. The beſt tripoli for this purpoſe, is of a white colour, with a fine grain, heavy and compact, and which, after it has been calcined, is of a red colour. This kind reſiſts the fire beſt, is not apt to break when calcined, and the melted glaſs does not adhere to it. To calcine this tripoli, cover it well all round with charcoal nearly red hot, leaving it thus till the charcoal is quite cold; it may then be taken out. Let ſeveral hemiſpherical cavities be made on the flat ſide of the tripoli; they ſhould be of different ſizes, nicely poliſhed, and neatly rounded at the edges, in order to facilitate the entrance of the flame. The large globules are to be placed in the large cavities, and the minuter ones in the ſmall cavities. The holes in the tripoli muſt never be touched with the finger. If it is neceſſary to clean them, it ſhould be done with white paper; the larger globules may be cleaned with waſh leather. The glaſs rods ſhould be of various ſizes, as of 1-10th, 1-20th, 1-30th of an inch in diameter, as clean and free from ſpecks and bubbles as poſſible.

TO MAKE SMALL GLASS MICROSCOPIC GLOBULES.

Take two rods of glaſs, one in each hand, place their extremities cloſe to each other, and in the pureſt part of the flame; when you perceive the ends to be fuſed, ſeparate them from each other;

in every vegetable?" Thus does the author endeavour to perſuade the prejudiced, and lead them to pay attention to the facts which were now laid open to their view, and which were further confirmed by a letter from Mr. Trembley, in January, 1740; which letter was ſtrengthened by an extract from the preface to the ſixth volume of Mr. de Reaumur's hiſtory of inſects. In March, 1742, Mr. Folkes gave an account of them to the Royal Society, from obſervations made on ſeveral polypes which had been ſent by Mr. Trembley from Holland to him. The inſects now began to be known, and were ſoon found in England, and the experiments that had been made on them abroad were publiſhed by M. Folkes,* my father,† and Mr. Baker: ‡ conviction now became too ſtrong for argument, and metaphyſical objections gave way to facts.

This animal is deſcribed in the following manner: §

HYDRA.

Animal baſi ſe affigens, vagum, gelatinoſum, lineare nudum, contractile. Os terminale, cirrhis ſetaceis cinctum. Prolibus lateralibus (autumno ovis) deciduis.

This animal fixes itſelf by it's baſe, it is gelatinous, linear naked, can contract itſelf, and change it's place. It's mouth, which

* Philoſophical Tranſactions.

† Micrographia Illuſtrata.

‡ Natural Hiſtory of the Polype.

§ Ellis's Nat. Hiſt. of Zoophytes, Lin. Syſt. Nat. p. 1320.

which is at one end, is ſurrounded by hair, like feelers. It ſends forth it's young ones from it's ſides, which drop off; but in the autumn it produces eggs from it's ſide.

1. Hydra viridis, tentaculis ſubdenis brevioribus.

Green polype, generally with about ten ſhort arms; it is repreſented at Fig. 5, Plate XXI.

2. Hydra fuſca, tentaculis ſuboctonis longiſſimis.

This polype has very long arms, often eight in number; it is repreſented at Plate XXI. Fig. 7. The arms are ſeveral times longer than the body.

3. Hydra griſea, tentaculis ſubſeptenis longioribus.

This polype has alſo generally long arms, in number about ſeven; it is of a yellowiſh colour, ſmall towards the bottom; it is repreſented at Fig. 6, Plate XXI.

4. Hydra pallens, tentaculis ſubſenis mediocribus.

The arms of this polype are generally about ſix in number, and of a moderate length.

5. Hydra hydatula, tentaculis quaternis obſoletis corpore veſicario, Fig. 1, 2, 3, 4, Plate XXI.

This

This polype has a veficular body, and four obfolete arms; is found in the abdomen of fheep, fwine, &c.

6. Hydra ftentorea, tentaculis ciliaribus corpore infundibuliformi.

This polype has been called tunnel fhaped; the mouth is furrounded with a row of hairs; it is reprefented at Fig. 27 and 28, Plate XXII.

7. Hydra focialis mutica torofa rugofa.

Bearded thick and wrinkled, Fig. 11, Plate XXI.

OF THE HYDRA VIRIDIS, HYDRA FUSCA, AND HYDRA GRISEA.

Thefe three fpecies of the hydra having been thofe on which the greateft number of experiments have been made, and of which we have the beft information, it is of thefe only we fhall fpeak in the following account, unlefs we give particular notice thereof to the reader.

There are few animals more difficult to defcribe than the hydra, as it has fcarce any thing conftant in it's form, varying continually in it's figure; they are often fo befet with young, as to appear ramofe and divaricated, the young ones conftituting as it were a part of the parent's body.

Whoever

Whoever has looked with care at the bottom of a wet ſhallow ditch, when the water is ſtagnant, and the ſun has been powerful, may remember to have ſeen many little tranſparent lumps, of a jelly-like appearance, about the ſize of a pea, and flatted on one ſide; the ſame appearances are alſo often to be ſeen on the under ſide of the leaves of thoſe weeds, or plants, that grow on the ſurface of the water; theſe are the hydra, gathered up into a quieſcent ſtate, and ſeemingly inanimate, becauſe either undiſturbed, or not excited by the calls of appetite to action. They are generally fixed by one end to ſome ſolid ſubſtance, at the other end there is a large opening, round about which the arms are placed as ſo many rays round a center, which center is the mouth.

They are ſlender and pellucid, formed of a kind of tender ſubſtance, in conſiſtence ſomething like the horns of a ſnail, and can contract the body into a very ſmall compaſs, or extend it to a conſiderable length. They can do the ſame with the arms; with theſe they ſeize minute worms and various kinds of aquatic inſects, bring them to the mouth and ſwallow them. After the food is digeſted, and the nutritive parts which are employed in ſuſtaining it's life are ſeparated from the reſt, they reject the remainder by the mouth.

The firſt polype which Mr. Trembley diſcovered was one of the hydra viridis, repreſented at Fig. 5, Plate XXI. Theſe are generally of a fine green colour. The indications of ſpontaneous motion were firſt perceived in the arms of theſe little creatures; they can extend or contract, bend and wind them divers ways. Upon the ſlighteſt touch they contract themſelves ſo much, as to appear little more than a grain, of a green ſubſtance, the arms disappearing entirely. He soon after found the hydra grisea, Fig. 6, and saw it eat, swallow, and digest worms much larger than itself. This discovery was soon followed by that of the hydra fusca, Fig. 7, Plate XXI.

The most general attitudes of these hydræ are those which are represented in Fig. 5 and 6, Plate XXI. They fix the posterior extremity *b* against a plant, or other substance, as *e f*; the body *a b*, and the arms *a c*, being extended in the water. There is a small difference in the attitudes of the three kinds which we are now describing.

The bodies of the hydra viridis, Fig. 5, and of the hydra grisea, Fig. 6, diminish from the anterior to the posterior extremity by an almost insensible gradation. The hydra fusca does not diminish in the same gradual manner, but from the anterior extremity *a* to the part *d*, which is often two-thirds of the length of their body, it is nearly of an equal size; from this part it becomes abruptly smaller, and goes on from thence of a regular size to the end. The number of arms in these three kinds are at least six, and at most twelve or thirteen, though eighteen may sometimes be found on the hydra grisea. They can contract their bodies till they are not above one-tenth of an inch in length; they can also stop at any intermediate degree, either of contraction or extension, from the greatest to the least. The species represented at Fig. 5 are generallly about half an inch long when stretched out. Those exhibited at Fig. 6 and 7 are about three-fourths of an inch, or one inch, in length, though some are to be found at times about an inch and an half long. The arms of the hydra viridis, Fig. 5, are seldom longer than their bodies; those

thoſe of Fig. 6 are commonly one inch long, while thoſe of Fig. 7 are generally about eight inches; whence Mr. Trembley has called it the long-armed polype.

The bulk of the hydræ decreaſes in proportion as they extend themſelves, and vice verſa. They may be made to contract themſelves, either by touching them, or agitating the water in which they are contained. They all contract themſelves ſo much when taken out of the water, as to appear only like a little lump of jelly. They can contract or extend their arms without extending or contracting the body, or the body without making any alteration in the arms: or they can contract or dilate only ſome of the arms, independent of the reſt: they can alſo bend their body and arms in all poſſible directions. Thoſe repreſented at Fig. 7, let their arms in general hang down, making different turns and returns, often directing ſome of them back again to the top of the water. They can alſo dilate the body at different places, ſometimes at one part, and then again at another; ſometimes they are thick ſet with folds, which, if careleſsly viewed, might be taken for rings.

They have a progreſſive motion, which is performed by that power by which they ſtretch out, contract, and turn themſelves every way. For ſuppoſe the hydra, or polype, *a b*, Fig. 16, Plate XXI. to be fixed by the tail *b*, having the body and arms *a* extended in the water, in order to advance, it draws itſelf together, by bending itſelf ſo as to bring the head and arms down to the ſubſtance on which it is to move; to do this, it fixes the head, or the arms, as in Fig. 17; when theſe are well fixed, it looſens the tail, and draws it towards the head, as in Fig. 18,

 which

which it again loofens, and refting on the tail, ftretches it out, as in Fig. 19. It is eafy to fee from this account, that their manner of walking is very analogous to that of various terreftrial and aquatic animals. They walk very flow, often ftopping in the middle of a ftep, turning and winding their body and arms every way. Their ftep is fometimes very fingular, as in the following inftance: fuppofe the polype *a b*, Fig. 20, to be fixed by the tail *b*, the body and arms being extended in the water, it firft bends the fore-part towards the fubftance on which it is moving, and fixes it thereto as at *a*, Fig. 21; it then loofens the lower end, and raifes it up perpendicular, as in Fig. 22; now bending the body to the other fide, it fixes the tail as in Fig. 23; then loofening the anterior end, it rifes up, as in Fig. 24.

They defcend at pleafure to the bottom of the water, and afcend again, either by the fides, or upon fome aquatic plants; they often hang from the furface of the water, refting as it were upon the tail; at other times they are fufpended by one arm from it. They walk alfo with eafe upon the furface of the water. If the extremity of the tail *b*, Fig. 7, be examined with a magnifying glafs, a fmall part of it will be found to be dry, and above the furface of the water, and as it were in a little concave fpace, of which the tail forms the bottom, fo that it feems to be fufpended on the furface of the water, on the fame principle that a fmall pin, or needle, is made to fwim.

Hence when a polype means to pafs from the fides of the glafs to the furface of the water, it has only to put that part out of the water by which it means to be fupported, and give it time to dry, which it always does upon thefe occafions. They attach themſelves ſo firmly by the tail to aquatic plants, ſtones, &c. as not to be eaſily driven from the place where they have fixed themſelves; they often further ſtrengthen theſe attachments, by means of one or two of their arms, which they throw out and fix to adjacent ſubſtances as ſo many anchors.

The mouth of the polype, or hydra, is ſituated at the fore-part of the body, in the middle between the ſhooting forth of the arms. The mouth aſſumes different appearances, according to the different purpoſes of the inſect; ſometimes it is lengthened out, and forms a little conical nipple, as at Fig. 13, Plate XXIII. A; ſometimes it appears truncated, as at Fig. 8, Plate XXI; at other times the interval between the arms appears cloſed, as at Fig. 2 and 12, Plate XXIII. A; or hollow, as at Fig. 11, Plate XXIII. A. If it is obſerved with a deep magnifier, in either of the two laſt caſes, a ſmall aperture may be diſcovered.

The mouth of the polype opens into the ſtomach, which is a kind of bag, or gut, that goes from head to tail; this may be perceived by the naked eye, when they are expoſed to a ſtrong light, or a candle placed on the oppoſite ſide to the eye; for the colour of the polype does not deſtroy the tranſparency thereof. The ſtomach will, however, be better ſeen, if the eye be aſſiſted by a deep magnifier; one of them is repreſented as highly magnified, at Fig. 8, Plate XXI. To be fully ſatisfied whether they were perforated throughout, Mr. Trembley cut one tranſverſely into three parts; each piece immediately contracted itſelf, and became very ſhort, and being placed in a ſhallow glaſs full of water, and viewed through the microſcope, they were found to be viſibly perforated. They are repreſented as they appear in the microſcope,

ſcope, at Fig. 6, 7, 8, Plate XXIII. A; it's mouth was at the anterior end *a*, Fig. 8, of one of theſe parts. The tail was at the end *b* of the third part, Fig. 6; as this piece was alſo perforated, it plainly appears, that the tail of the hydra is open. The perforation, which is thus continued from one end to the other, is called the ſtomach, becauſe it contains and digeſts the aliments. The ſkin which incloſes the bag, and forms the ſtomach, is the ſkin of the polype itſelf; ſo that the animal may be ſaid to conſiſt of but one ſkin, diſpoſed in the form of a tube, or gut, open at both ends. On opening the polype, no veſſels are to be diſtinguiſhed; and whatever be the nature of it's organization, it muſt reſide in the ſkin.

The ſkin muſt be ſo far organized, as to perform all the operations neceſſary for the nutrition and growth of the animal, without conſidering thoſe that are neceſſary for it's various motions. Whatever are the means the Author of nature has employed for theſe purpoſes, we are ignorant of them. If their ſkin is examined by a microſcope, it appears like ſhagreen, or as if it were covered with little grains; theſe are more or leſs ſeparated from each other, according to the degree in which the body is extended or contracted.

If the lips of a polype be cut tranſverſely, and placed ſo that the cut part of the ſkin may lie directly before the microſcope, the ſkin throughout it's whole thickneſs will be found to conſiſt of an infinite number of theſe grains. To know whether the inſide of the ſtomach was formed of ſimilar grains, ſeveral of them have been laid open and examined by the microſcope; the interior ſurface was then found to conſiſt of an immenſe number of them,

them, being as it were more ſhagreened than the exterior one, and leſs tranſparent. The grains are not ſtrongly united to each other, but may be ſeparated without much trouble. Fig. 10, Plate XXIII. A, repreſents a piece of ſkin thus laid open. To examine theſe particulars further, a piece of ſkin a, Fig. 9, was laid in a few drops of water, on a piece of glaſs, before the microſcope, and ſome of the grains were ſeparated from it, as at b c d, by preſſing them with the point of a pin; in endeavouring to open them, they ſpread themſelves into all parts of the water, and at laſt remained in heaps, as at e and f.

If a polype is carefully placed before the microſcope, without wounding it, you will ſeldom be diſappointed in ſeeing ſome of theſe grains detach themſelves from the ſuperficies thereof, and that even in the moſt healthy.

But if the grains ſeparate themſelves in large quantities, it is the ſymptom of a very dangerous diſorder; the ſurface of the polype thus attached becomes more and more irregular, and is no longer well terminated and defined as before. The grains fall off on all ſides, the body and arms contract and dilate, it becomes of a white ſhining colour, loſes it's form as at a, Fig. 4, Plate XXIII. A, and then diſſolving into a heap of grains, as at b, Fig. 5. The progreſs of this diſorder is moſt eaſily obſerved in the hydra viridis.

A very attentive and accurate examination ſhews that the ſkin is formed of a kind of glarous ſubſtance, a ſpecies of gum, which fills up the intervals between the grains, in which they are lodged, and by which they are attached (though weakly) together. It other; the heated glaſs following each rod, will be finer, in proportion to the length it is drawn to and the ſmallneſs of the rod; in this manner you may procure threads of glaſs of any degree of fineneſs. Direct the flame to the middle of the thread, and it will be inſtantly divided into two parts. When one of the threads is perfectly cool, place it at the extremity of the flame, by which it will be rendered round; and if the thread of glaſs be very fine, an exceeding ſmall globule will be formed. This thread may now be broke off from the rod, and a new one may be again drawn out as before, by the aſſiſtance of the other glaſs rod.

The ſmall ball is now to be ſeparated from the thread of glaſs; this is eaſily effected by the ſharp edge of a piece of flint. The ball ſhould be placed in a groove of paper, and another piece of paper be held over it, to prevent the ball from flying about and being loſt. A quantity of globules ought to be prepared in this manner; they are then to be cleaned, and afterwards placed in the cavities of the tripoli, by means of a delicate pair of nippers. The globules are now to be melted a ſecond time, in order to render them completely ſpherical; for this purpoſe, bring one of the cavities near the extremity of the flame, directing this towards the tripoli, which muſt be firſt heated; the cavity is then to be lowered, ſo that the flame may touch the glaſs, which, when it is red hot, will aſſume a perfect globular form; it muſt then be removed from the flame, and laid by; when cold, it ſhould be cleaned, by rubbing between two pieces of white paper. Let it now be ſet in a braſs cap, to try whether the figure be perfect. If the object is not well defined, the globule muſt be thrown away. Though, if it be large, it may be expoſed two or three times to the

It has been already obferved, that it is to thefe grains that it owes it's fhagreen-like appearance; it is from them alfo that it derives it's colour; for when they are feparated from the polype, they are the fame colour with it; whereas the glarous matter is without any diftinguifhing colour. The conftruction of the polype feems then to be confined to thefe glandular grains, to the vifcous matter, and the invifible fibres which act upon the glarous fubftance.

The ftructure of the arms of the polypes are very analogous to that of their body. When they are examined by the microfcope, either in a contracted or dilated ftate, their furface is fhagreened; if the arm be much contracted, it appears more fo than the body; on the contrary, it appears lefs fo in proportion as they are more extended, almoft quite fmooth when at their full extenfion; fo that in the hydra viridis the appearance of the arms is continually varying, and thefe variations are more fenfible towards the extremity of the arm than at it's origin, as at Fig. 10, Plate XXI. but more thinly fcattered, or farther afunder, in the parts further on, as at Fig. 9, Plate XXI. The extremity is often terminated by a knob, the hairs which are exhibited in Fig. 9, cannot be feen without a very deep magnifier, however they indicate a further degree of organization in this little animal.

All animals of this kind have a remarkable attachment to turn towards the light, and this might naturally induce the inquirer to look for their eyes; but how carefully foever this fearch has been purfued, and however excellent the microfcope with which every part has been examined, yet no appearance of this organ was found. Notwithftanding this, they conftantly turn themfelves towards the light; fo that if that part of the glafs in which we placed

placed them be turned from it, they will be found the next day to have removed themſelves to the ſide that is next the light, and the dark ſide will be quite depopulated.

OF THE FOOD OF THE HYDRÆ, AND THEIR METHOD OF SEIZING AND SWALLOWING THEIR PREY.

As the hydra fuſca, Fig. 7, Pl. XXI. has the longeſt arms, it's manner of feeding, and the different manœuvres it makes uſe of to ſeize and manage it's prey, are more remarkable than thoſe of the two other ſpecies; it will be, therefore, this kind only which will be principally ſpoken of under the preſent head. To view them properly, they ſhould be placed in a glaſs ſeven or eight inches deep. If the polype is fixed near the top of the glaſs, their arms for the moſt part hang down towards the bottom. This is a very convenient ſituation for giving them their food, and to obſerve how they manage it.

An hungry polype ſpreads it's arms as a fiſherman his nets; it extends them every way, ſo that they form a circle of conſiderable extent, every part of which is entirely within the reach of one of them; in this expanded poſture it lies in expectation of it's food; whatever comes within the verge of this circle is ſeized by one or another of it's arms. The arms are then contracted till the prey is brought to the mouth, when it is ſoon devoured. While the arms are contracting, and exerted vigorouſly, (to counteract the efforts the animal which it has ſeized makes in order to eſcape) they may be obſerved to ſwell like the muſcles of the human body when they are in a ſtate of exertion.

The polype does not always wait for it's prey, it feels for it, and in a manner follows it. It may be aſked, how can it do this when it has no eyes? or, do the glandular grains anſwer this purpoſe? Who can anſwer the queſtion? what are our own eyes but glandular grains of a larger ſize? If this ſhould be the caſe, our hydra would again exceed and realize the fables of the ancients, being an argus entirely compoſed of eyes. Be this as it may, they are certainly in poſſeſſion of ſome ſentiment by which they can perceive the approach of their prey, and which renders them attentive to all that may confirm or deſtroy this perception.

When the arms of a polype are extended, put a millepedes, or any kind of worm, into a glaſs, (ſee Fig. 1, Pl. XXIV. A) and with the point of a pencil puſh it towards one of the arms; as ſoon as it touches this it is ſeized; the worm, or millepedes, endeavours by quick and ſtrong efforts to diſengage itſelf, often ſwimming and dragging the arm from one ſide of the glaſs to the other. This violent motion of the prey obliges the polype to contract ſtrongly the arm, in doing which it often twiſts it in the form of a cork-ſcrew, as at o i, by which means it ſhortens it more rapidly; the ſtruggles of the devoted animal ſoon bring it in contact with another arm, theſe contracting further, the little creature is preſently engaged with all the arms, which contract ſo much as to convey it to the mouth, againſt which it is held and ſubdued.

When a polype has nothing to eat, it's mouth is generally open, but ſo ſmall that it can ſcarce be perceived without the aſſiſtance of a magnifying glaſs; but as ſoon as the arms have conveyed the prey to the mouth, it opens itſelf wider, and this in proportion to the ſize of the animal that is to be devoured; the lips gradually dilate, and adjust themselves accurately to the figure of the prey. The greatest part of the animals on which the polype feeds, are to it's mouth what an apple, the size of our heads, would be to the mouth of a man.

The worms, &c. which are seized by the polype are not always brought to the mouth in the same situation; if they are presented to it by one of their extremities, it is not requisite that the polype should open it's mouth considerably, and in effect it only opens it so wide, as precisely to give entrance to the worm, Fig. 5, Plate XXIV. A. If it be not too long for the stomach, it remains there extended; but if it be longer, the end which first enters is bent, so that when the worm is entirely swallowed, it may be seen lying folded in the stomach, Fig. 12, Plate XXIV. B.

If the middle, or any other part of the worm, be presented to the mouth of the polype, it seizes this part with the lips, extending them on both sides, and applying them against the worm, so that the mouth assumes the form of a boat, pointed at each end, Fig. 2, Plate XXIV. A; the polype gradually closes the two points of it's boat-like lips, and by this motion and suction swallows the worm, Fig. 4, Plate XXIV. A.

A worm is killed so soon by a polype, that Mr. Fontana thinks they must contain the most active and powerful venom; for it's lips scarce touch the worm but it expires, so great is the energy of the poison it conveys into it, though no wound can be observed in the dead animal.

As ſoon as the ſtomach is filled, it's capacity is enlarged, the body is ſhortened, Fig. 6, Plate XXIV. A, the arms are for the moſt part contracted, the polype hangs down without motion, and appears to be in a kind of ſtupor, and very different from it's extended ſhape; but in proportion as the food is digeſted, and it has voided the excrementitious parts, the body lengthens, and gradually recovers it's form.

The tranſparency of the polype permits us to ſee diſtinctly the worm which has been ſwallowed, Fig. 12, Plate XXIV. B, which gradually loſes it's form. It is at firſt macerated in the ſtomach of the polype, and when the nutritious juices are ſeparated from it, the remainder is diſcharged by the mouth, Fig. 13. It is with theſe as with other voracious animals, as they eat a great deal at once, ſo alſo they can faſt for a long time. The hiſtory of inſects furniſhes many examples of this kind.

One circumſtance is obſervable, which probably contributes much to the digeſtion of their food, namely, that the aliments are continually puſhed back from one extremity to the other of the ſtomach; this motion may be eaſily obſerved with a microſcope, in a polype which is not too full, and in which the food has been already divided into little fragments. For theſe obſervations, it is beſt to feed the polype with ſuch food as will give a lively-coloured juice; as for example, thoſe worms whoſe inteſtines are filled with red ſubſtances; for by this means we ſhall ſee that the nutritious juices are conveyed not only to the extremity of the body, but alſo into the arms, from whence it is probable that each of the arms form alſo a kind of gut, which communicates with that of the body. Some bits of a ſmall black ſnail, that is frequently

frequently to be found in our ditches, was given to a polype. The ſubſtance of this ſkin was ſoon reduced into a pulp, conſiſting of little black fragments; on examining the polype with the microſcope, theſe particles were perceived to be driven about the ſtomach, and to paſs from head to tail, and into their arms, even where theſe were as fine as a thread; they were afterwards forced into the ſtomach, and from thence to the tail, from whence they were again driven into the arms, and ſo on.

The grains take their tinge from the food which nouriſhes the polypes; theſe grains become red or black, if the polype be fed with juices that are either red or black; and they are more or leſs tinged with theſe different colours, in proportion to the ſtrength and quantity of the nutritive juices. It is alſo obſervable, that they loſe their colour if fed with aliments that are not of the ſame colour with themſelves.

The polypes feed on the greater part of thoſe inſects that are to be found in freſh water. They may be nouriſhed with worms, the larva of gnats, &c. they will alſo eat larger animals if they are cut into ſmall pieces, as ſnails, large aquatic inſects, ſmall fiſh, butchers meat, &c. Sometimes two polypes ſeize the ſame worm, and each begins to ſwallow it's own end, continuing ſo to do till their mouths meet, Fig. 8, Plate XXIV. A; in this poſition they remain for ſome time, at laſt the worm breaks, and each has it's ſhare; ſometimes the combat does not end here, for each continuing to diſpute the prize, one of the polypes opens it's mouth advantageouſly, and ſwallows the other with it's portion of the worm, ſee Fig. 14, Plate XXIV. A; this combat ends more fortunately for the devoured polype than might be at firſt expected,

pected, for the other often gets the prey out of it's ſtomach, but lets it out again found and ſafe, after having impriſoned it above an hour. From hence we learn, that the ſtomach of the polype, which ſo ſoon diſſolves the animal ſubſtances which are conveyed into it, is not capable of digeſting that of another polype.

Fig. 5, Plate XXIV. A, repreſents a polype with one-half of a millipedes in it's mouth, as at a; the other part without as at m. Fig. 1, Plate XXIV. A, repreſents one ſuſpended in water by a piece of packthread; c n, a millipedes ſeized by it, and drawn partly towards the mouth; i o the bendings in the arm; p an arm in ſearch of a ſmall aquatic inſect. Fig. 2, Plate XXIV. A, a polype ſtretching itſelf into a boat-like form, to take or ſwallow a worm lying ſideways. Fig. 4, Plate XXIV. A, the ſame polype with the worm ſwallowed and bent within it. Fig. 6, the ſame plate is a polype in the ſituation they generally aſſume when they have ſatisfied their voracious appetite. Fig. 7, one that has ſwallowed a ſmall monoculus. a, Fig. 9, one whoſe arms are loaded with monoculi. Fig. 10, a polype full of them from head to tail. Fig. 3, one that has only ſwallowed a few of them.

In this paragraph I ſhall ſpeak of ſome of the figures contained in Plate XXIV. B. Fig. 12, a worm ſeen within the ſkin of a polype. Fig. 13, diſgorging the excrementitious parts thereof. Fig. 11 repreſents one engaged with a very large worm.

Fig. 8, Plate XXIV. A, repreſents two polypes engaged in combat for a worm, of which both of them have ſwallowed a part.

Fig.

Fig. 12, Plate XXI. a polype that has ſwallowed a ſmall fiſh, and taken the ſhape thereof.

OF THE GENERATION OF THE HYDRÆ.

As the hydra fuſca and the hydra griſea are conſiderably larger than the hydra viridis, it is more eaſy to obſerve the manner of their producing their young. It is upon theſe, therefore, that moſt of the obſervations here recited have been made. If one of them be examined in ſummer, when the animals are moſt active and more particularly prepared for propagation, it will be found to burgeon forth from it's ſides ſeveral little tubercles, or knobs, which grow larger and larger every day; after two or three days inſpection, what at firſt appeared but a ſmall excreſcence, takes the figure of a ſmall animal, entirely reſembling it's parent.

When a young polype firſt begins to ſhoot, the excreſcence terminates in a point as at e, Fig. 24, Plate XXIV. B, ſo that it is rather of a conical figure, and of a deeper colour than that of the body. This cone ſoon becomes truncated, and in a little time appears cylindrical. The arms then begin to ſhoot from the anterior end c i, Fig. 24, Plate XXIV. B. The tail adheres to the body of the parent, but grows gradually ſmaller, till at laſt it only adheres by a point b, Fig. 23, Plate XXIV. B; it is then ready to be ſeparated; for this purpoſe the mother and young ones fix themſelves to the glaſs, or other ſubſtance upon which they may be ſituated. They have then only to give a ſudden jerk, and they are divided from each other. There are ſome trifling differences to be obſerved now and then in their performing this operation, which it would be too tedious to enumerate here.

here. A polype, a b, Fig. 20, with a young one, c d, places it's body in an arch of a circle a d b, againſt the ſides of the glaſs, the young one being fixed at the top d of the arch, with it's head alſo fixed againſt the glaſs; ſo that the mother, by contracting the body, and thus becoming ſtrait, looſens herſelf from the young one.

The young ones ſhoot in proportion to the warmth of the weather, and the nature of the food eaten by the mother; ſome have been obſerved to be perfectly formed in twenty-four hours, while others have required fifteen days for the ſame purpoſe; the firſt were produced in the midſt of ſummer, the latter in a cold ſeaſon.

The tail of the young polype communicates with and partakes of the food from the parent in the ſame manner as it's own arms do, and the food lies in the ſame manner as in the arms. When this fœtus is furniſhed with arms, it catches it's prey, ſwallows, digeſts, and diſtributes the juices thereof, even to the parent body; every good is common to each. Here then we have evident communication between the fœtus and the mother; this communication was further proved by the following experiment. A large polype (one of the hydra fuſca) was placed on a ſlip of paper, in a little water; the middle of the body of the young one was cut, and the ſuperior part of that end which remained fixed to the parent was found to be open. The parent polype was then cut on each ſide of the ſhoot. Thus a ſhort cylinder was obtained, which was open at both ends. This being viewed through a microſcope, the light was ſeen to come through the ſide ſlip, or young one, into the ſtomach of the old one. For further conviction, the cylindri-

cal

cal portion was cut lengthways; on obſerving theſe parts, not only the hole t of communication, Fig. 17, Plate XXIV. B, was diſtinctly ſeen, but one might ſee through the end o of the young one. On changing the ſituation of theſe two pieces of prepared polypi, and looking through the opening e, Fig. 18, the day-light was ſeen through the hole of communication i.

This communication between the parent polype and it's young ones may be ſeen on feeding them; for after the parent, a b, Fig. 22, Plate XXIV. B, has eaten, the body of the young ones ſwell, being filled with the aliments as if they themſelves had been eating. In the hydra fuſca the young ones do not proceed from the tail part b c, Fig. 16, Plate XXIII. B, but only from the part a c, with this exception, there is no particular part of the body before the reſt, on which they produce their young. Some of them have been ſo cloſely obſerved, and have ſo greatly multiplied, that there would be ſcarce any impropriety in ſaying they produced their young ones from all the exterior parts of the body. A polype puts forth often five or ſix young ones at the ſame time. Mr. Trembley has had ſome that have produced nine or ten at the ſame time, and when one dropped off another came in it's place.

Though Mr. Trembley had for two years thouſands of them under his eye, and conſidered them with the moſt ſcrupulous attention, he never obſerved any thing like copulation. To be more certain on this head, he took two young ones the inſtant they came from their parent, and placed them in ſeparate glaſſes; they both multiplied, not only themſelves, but their offspring, which were ſeparated and watched in the ſame manner to the

the flame. When a large globule is forming, it ſhould be gently agitated by ſhaking the tripoli, which will prevent it's becoming flat on one ſide. By attending to theſe directions, the greater part of the globules will be round and fit for uſe. In damp weather, notwithſtanding every precaution, it will often happen, that out of forty globules, four or five only will be fit for uſe.

Mr. Stephen Gray, of the Charter-Houſe, having obſerved ſome irregular particles within a glaſs globule, and finding that they appeared diſtinct and prodigiouſly magnified when held cloſe to his eye, concluded that if he placed a globule of water, in which there were any particles more opake than the water, near his eye, he ſhould ſee thoſe particles diſtinctly and highly magnified. This idea, when realized, far exceeded his expectation. His method was, to take on a pin a ſmall portion of water which he knew had in it ſome minute animalculæ; this he laid on the end of a ſmall piece of braſs wire, till there was formed ſomewhat more than an hemiſphere of water; on applying it then to the eye, he found the animalculæ moſt enormouſly magnified; for thoſe which were ſcarce diſcernible with his glaſs globules, with this appeared as large as ordinary ſized peas. They cannot be ſeen by day-light, except the room be darkened, but are ſeen to the greateſt advantage by candle-light. Montucla obſerves, that when any objects are incloſed within this tranſparent globule, the hinder part of it acts like a concave mirror, provided they be ſituated between that ſurface and the focus; and that by this means they are magnified three times and a half more than they would be in the uſual way. An extempore microſcope may be formed, by taking up a ſmall drop of water on the point of a pin, and placing it over a fine hole made in a piece of metal; but as the feventh generation; nay, they have even the faculty of multiplying while they adhere to the parent. The arms of the young ones do not fprout till the body has attained fome length.

Several excrefcencies, or buds, often appear at the fame time on a polype, which are fo many polypes growing from one trunk; whilft thefe are developing, they alfo bud, which buds again put forth little ones, the parent and the young ones forming a fingular kind of animal fociety, in which all participate of the fame life, and the fame wants. In this ftate the parent appears like a fhrub thick fet with branches. Several generations are often thus attached to one another, and all to the parent polype; after a time, this tree of polypes, or hydræ, is decompofed, and gives birth to new generations, or frefh genealogical trees. Here we fee a furprizing chain of exiftence continued, and numbers of animals naturally produced, without any union of fexes.

From Fig. 16, Plate XXIII. B, the reader may form an idea of the promptitude with which thefe creatures increafe and multiply; the whole group formed by the parent and it's young was about an inch and an half long, and one inch broad, the arms of the mother and her nineteen little ones hanging down towards the bottom of the veffel; the animal would eat about twelve monoculi per day, and the little ones about twenty among them, or rather more than thirty for the groupe.

OF THE RE-PRODUCTION OF POLYPES.

A polype cut tranfverfely, or longitudinally, in two or three parts, is not deftroyed, each part in a little time becomes a perfect polype. This species of fecundity is so great in these animals, that even a small portion of their skin will become a little polype, a new animal rising as it were from the ruins of the old, each small fragment yielding a polype. If the young ones are mutilated while they grow upon the parent, the mutilated parts are re-produced; the same changes succeed also in the parent. A truncated portion will put forth young before it is perfectly formed itself, or has acquired it's new head and tail; sometimes the head of the young one supplies the place of that which would grow out of the anterior part of the trunk.

If a polype is slit, beginning at the head, and proceeding to the middle of the body, a polype will be formed with two heads, and will eat at the same time with both. If the polype is slit into six or seven parts, it becomes a hydra, with six or seven heads. If these are again divided, we shall have one with fourteen; cut off these, and as many new ones will spring up in their place, and the heads thus cut off will become new polypes, of which so many new hydras may again be formed: so that in every respect it exceeds the fabulous relation of the Lernean hydra.

As if the wonders already related of the polype were not sufficient to engage our attention to these singular animals, new circumstances, as surprizing as the foregoing, present themselves to convince us of the imperfection of our ideas of animality, and of the greatness of the power of our Lord and Saviour, who is the source and origin of every degree of life, in all it's immense gradations, as unity is the origin of number, in all it's varied series, multiplied proportions and combinations; now as numbers may be considered as being recipient of unity, in order to make

 manifest

manifeſt the wonderful powers thereof, ſo the univerſe and it's parts are adapted to receive life from the ſource of all life, and thus become repreſentatives of his immenſity and eternity.

The polypes may be as it were grafted together. If the truncated portions of a polype are placed end to end, and then puſhed together with a gentle force, they will unite, and form a ſingle one. The union is at firſt made by a fine thread, and the portions are diſtinguiſhed by a narrow neck, which gradually fills up and diſappears, the food paſſing from one portion to another. Portions, not only of the ſame, but pieces of different polypes, may be thus united together. You may fix the head of one polype to the trunk of another. And that which is thus produced will grow, eat, and multiply like another.

There is ſtill another method of uniting theſe animals together, more wonderful in it's nature, and leſs analogous to any known principles of animation, and more difficult to perform. It is effected by introducing one within the other, forcing the body of one into the mouth of the other, and puſhing it down ſo that their heads may be brought together; in this ſtate it muſt be kept for ſome time; the two individuals are at laſt united, and grafted into each other; and the polype, which was at firſt double, is converted into one, with a large quantity of arms, and performs all it's functions, like another.

The hydra fuſca furniſhes us with another prodigy, to which we know nothing that is ſimilar, either in the animal or vegetable kingdom. They may be turned inſide out like a glove, and notwith-

notwithſtanding the apparent improbability of the circumſtance, they live and act as before. The lining, or coating, of the ſtomach now forms the epidermis, and the former epidermis now conſtitutes the coating of the ſtomach. A polype thus turned may often have young ones attached to it's ſide. If this is the caſe, after the operation they are of courſe incloſed in the ſtomach. Thoſe which have acquired a certain ſize extend themſelves towards the mouth, that they may get out when ſeparated from the body; thoſe which are but little grown turn themſelves inſide out, and by this means place themſelves again on the outſide of the parent polype.

The polype thus turned, combines itſelf a thouſand different ways. The fore-part often cloſes itſelf, and becomes a ſupernumerary tail. The polype which was at firſt ſtrait, now bends itſelf, ſo that the two tails reſemble the legs of a pair of compaſſes, which it can open and ſhut. The old mouth is at the joint as it were of the compaſſes; it cannot, however, act as one, ſo that a new one is formed near it, and in a little time you have a new ſpecies of hydra with ſeveral mouths.

Fig. 18, Plate XXIII. B, repreſents the upper part of a polype that has been divided into two parts, a the upper, c the lower part, the end c being ſomething larger than that of a common polype, and is ſenſibly perforated; in the ſummer time this part often walks and eats the ſame day it is cut.

Fig. 17, the other part of the ſame polype; the anterior end is very open, and the edges of it turned a little outwards, which afterwards folding inwards, cloſe the aperture. This end now

now appears fwelled, as at c, Fig. 21; the arms fhoot out from this end; at firft three or four points only begin to fhoot, as at c, Fig. 20, and while thefe increafe in fize, others appear between them; they can feize their prey, and eat before their arms have done growing. In the height of fummer, the arms will often begin to fhoot in twenty-four hours; but in cold weather it will be fifteen or twenty days before the head is formed.

Fig. 22 reprefents a polype that was cut clofe under the arms; this became alfo a complete animal in a little time.

The fides of a polype, that has been cut longitudinally, roll themfelves up in different ways, generally beginning at one of the extremities, rolling itfelf up in a heap, as at Fig. 19, Plate XXIII. B, with the outfide of the fkin inwards; it foon unrolls itfelf, and the cut fides form themfelves into a tube, whereof the edges a b and e i, Fig. 15, on both fides, meet each other and unite. Sometimes they begin to join at the tail end, at other times the whole fides gradually approach each other. The fides join fo clofe, that from the firft moment of their junction no fcar can be difcovered.

Fig. 14, Plate XXIII. B, reprefents a polype partly joined, as at i b, the part c a e not yet clofed.

Fig. 29, Plate XXIII. B, reprefents a polype, the heads of which have been repeatedly divided, by which means it becomes literally a hydra.

Fig. 24

Fig. 24 reprefents a polype that had been turned, endeavouring to turn itfelf back again, the fkin of the anterior part lying back upon the other; the arms varying in their direction, being fometimes turned towards the head, fee Fig. 24 and 26, Plate XXIII. B, at others towards the tail. The anterior extremity c, formed by the edges of the reverfed part a, remained open for fome days, and then began to clofe, new arms fhot out near the old ones, and feveral mouths were formed at thofe parts where the arms joined the body.

Fig. 23, 25, 27, 28, reprefent the different changes that took place in another polype that had been turned infide out, and the different revolutions it went through before it acquired a fixed ftate. a c always fhews the part the polype had turned back, and a b the part it could not turn back.

A polype, which has been partly turned back, remains but a little time in that fituation. a, Fig. 28, Plate XXIII. B, the part where the portion it had turned back joined to the body a b; this became ftrait, and formed a right angle with a b; the fame day another head appeared at e, and feveral arms, a o a n, began to fhoot from the mouth a; at the other fide of this mouth there were the old arms a d. The next day the portion a c was drawn near the body, and formed an acute angle with it, as at Fig. 25. Fig. 27 reprefents the fame fwelled, after having fwallowed a worm. Four days afterwards it's form had varied confiderably, as may be feen by comparing Fig. 25 and 28, having now one common mouth and two fmall polypes growing on it.

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We may now be permitted to make a few reflections on this singular animal. On considering the various properties that have been already described, we shall find in them many particulars that are very analogous to others that are continually carrying on around us; we perceive that there is a successive unfolding of new parts. In every organized frame there is a continual effort to extend it's sphere of action, and enlarge the operation of that portion of life which is communicated to it. This gradual evolution requires a secret and curious mechanism to regulate and modify by re-action the continued conatus of the forming principle within it. The polype is an organized whole, of which each part, each molecule, each atom, tends to produce another; it is, if we may so speak, one entire ovary, a compound of germ, or seed. In cutting a polype to pieces, the nourishing juices, which would have been employed in supporting the whole, are made to act upon each portion.

When a polype is divided longitudinally, it forms two half tubes; the opposite edges of these approach, and in a very short time form a perfect tube. The sides are made to touch each other by certain motions and contractions of the piece; but as soon as the edges come in contact, a slight adhesion takes place, the corresponding vessels unite, and new ones are unfolded, as in a vegetable graft; by this means, the points of connection and cohesion are multiplied, the motion of the fluids are re-established, and with them the vital œconomy. This is performed with more rapidity than in vegetables, because the polype is nearly gelatinous, and it's parts are extremely ductile; this ductility is supported and preserved by the element which it inhabits. The same reasoning

reaſoning applies equally to explain the formation of ſo many heads to a polype, as conſtitute it a real hydra.

A new polype is formed out of ſmall portions, or fragments, in a very different manner, the operations in nature being always varied, according as the circumſtances differ; each fragment is puffed up, the ſkin ſeparated, and an empty ſpace is formed within it; this part is to become the ſtomach of the riſing polype, which ſoon ſends forth arms, and is formed to the perfection proper to it's kind. We learn from this inſtance, that the ſkin of the polype is not ſo ſimple as was at firſt imagined; for we find it dividing itſelf into two membranes, and forming thereby a cavity fit to perform all the functions of a ſtomach; but why theſe membranes are ſeparated in the ſmall portions, and not in the larger, we cannot tell; but though we are ignorant of this, and many more circumſtances relative to the re-production of theſe little animals, yet the foregoing facts enable us to underſtand better the nature of the exiſtence of thoſe polypes which have been turned inſide out.

For as that part which formed the interior ſkin of the ſtomach, in the little fragments before-mentioned, became the exterior part of the animal, the inſide of the polype is conſequently ſo ſimilar to the exterior ſkin, that one may be ſubſtituted for the other, without injuring the vital functions; from hence we might, in ſome meaſure, have inferred the poſſibility of the polypes living after it has been turned inſide out, independent of the fact itſelf.

The viſcera of the animal are ſituated in the thickneſs of the ſkin, and abſorbing pores are placed both on the inſide and outside, so that the animal can live whether the skin is turned one way or the other. The Author of nature did not create the polype to be turned as we turn a glove; but he formed an animal whose viscera were lodged in the thickness of the skin, and with powers to resist the various accidents to which it was unavoidably exposed by the nature of it's life; and the organization necessary for this purpose was so constructed, that the skin might be turned without destroying life.

Every portion of a divided polype has, like the vegetable bud, all the viscera necessary to it's existence; it can, therefore, live by itself, and push forth a head and tail, when placed end to end against another piece. The vegetation consists in uniting the portions, the vessels of each part increase in length, and a communication is soon formed between them, which unites the whole. The ease with which the parts unite, is, as has been observed before, probably owing to their gelatinous nature; for we find many similar instances in tender substances. The solid parts of the embryo, as the fingers, unite in the womb; tender fruit and leaves may be also thus united.

A portion of these creatures is capable of devouring it's prey almost as soon as it is divided from the rest. In the structure of those animals which are most familiar to us, a particular place is appropriated for the developement and passage of the embryo. But on the body of an animal, which, like a tree, is covered with prolific gems, it is not surprizing that the young ones should proceed from it's sides, like branches from a tree. The mother and her young ones form but one whole; she nourishes them, and they contribute to her existence, as a tree supports and is reciprocally supported by it's branches and leaves.

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OF THE HYDRA PALLENS.

The hydra pallens has been defcribed only by M. Roefel, Infec. 3, Polyp. 465, Plate 76, 77; it is very feldom to be met with, is of a pale yellow colour, and grows fmaller gradually from the bottom, the tail is fomewhat round or knobbed, the arms are about the length of the body, of a white colour, and generally feven in number, apparently compofed of a chain of globules; it brings forth the young from all parts of it's body. Linnæus defines it as hydra pallens tentaculis fubfenis mediocribus. Pallas as hydra attenuata corpore flavefcente, furfum attenuato.

OF THE HYDRA HYDATULA.

The next in order is the hydra hydatula, which we have already defined from Linnæus as a hydra with four obfolete arms, and a veficular body: it is fpoken of by many medical writers, who are enumerated in the Syftema Naturæ, p. 1321. It is defcribed alfo by Hartman, mifc. nat. cur. dec. I. an. 7, obf. 206, dec. II. an. 4, obf. 73, as hydatis animata; alfo in the differt. de inf. viv. p. 50, n. 6, tænia hydatoidea. Pallas defines it as tænia hydatigena rugis imbricata corpore poftice bulla lymphaticæ terminato. The defcription I fhall give the reader will be extracted from the Philofophical Tranfactions, No. 193, by Dr. Tyfon, who names it lumbricus hydropicus.

In the diffection of a gazella, or antelope, Dr. Tyfon obferved feveral hydatides, or films, filled with water, about the bignefs of a pigeon's egg, and of an oval form, faftened to the omentum, and fome in the pelvis, between the bladder of urine and the rectum;

the refractive power of water is less than that of glass, these globules do not magnify so much as those of the same size, which are made of glass: this was also contrived by Mr. Gray. The same ingenious author invented another water microscope, consisting of two drops of water, separated in part by a thin brass plate, but touching near the center; which were thus rendered equivalent to a double convex lens, of unequal convexities.

Dr. Hooke describes a method of using the single microscope, which seems to have a great analogy to the foregoing methods of Mr. Gray. If you are desirous (he says) of obtaining a microscope with one single refraction, and consequently capable of procuring the greatest clearness and brightness any one kind of microscope is susceptible of; spread a little of the fluid you intend to examine on a glass plate, bring this under one of your microscopic globules, then move it gently upwards, till the fluid touches the globule, to which it will soon adhere, and that so firmly, as to bear being moved a little backwards or forwards. By looking through the globule, you will then have a perfect view of the animalculæ in the drop. *

Having laid before the reader the principal improvements that have been suggested or made in the single microscope, it remains only to point out those instruments of this kind, which, from the mode in which they are fitted up, seem best adapted for general use; the peculiar advantages of which, as well as the manner of using them, will be described in the third chapter of this work.

Fig.

* Hooke's Lectures and Conjectures, p. 98.

and he then ſuſpected them to be a particular ſort of inſect, bred in animal bodies, or at leaſt the embryos or eggs of them, 1. Becauſe he obſervėd them included in a membrane, like a matrix, ſo looſely, that by opening it with the finger, or a knife, the internal bladder, containing the ſerum or lympha, ſeemed no where to have any connection with it, but would very readily drop out, ſtill retaining it's liquor, without ſpilling any of it. 2. He obſerved that this internal bladder had a neck, or white body, more opake than the reſt of the bladder, and protuberant from it, with an orifice at it's extremity, by which, as with a mouth, it exhauſted the ſerum from the external membrane, and ſo ſupplied it's bladder, or ſtomach. 3. Upon bringing this neck near the candle, the neck moved and ſhortened itſelf. Fig. 1, Plate XXI. repreſents one of theſe watery bladders incloſed in it's external membrane, it's ſhape was nearly round, being only a little depreſſed, or flatted, as a drop of quickſilver will be by lying on a plane. In Fig. 2 the neck is better ſeen; the external membrane being taken off, an open orifice is found at it's extremity; it conſiſts of circular rings, or inciſures, which are more viſible when magnified, as in Fig. 3; it then appears granulated with a number of little eminencies all over the ſurface; the orifice at the extremity ſeems to be formed by retracting itſelf inwards, and upon trial it was found to be ſo; for in Fig. 4, the neck of this polype is repreſented magnified and drawn out it's whole length; on opening it there were found within the two ſtrings a a, which probably convey into the ſtomach the moiſture and nouriſhment, which the animal, by protruding it's neck, extracts from the external membrane.*

HYDRA

* Hydra hydatula habitat in abdomine mammalium, ovium, ſuum, murium, &c. inter peritoneum et inteſtina. Veſica lymphatica, pellucida, magnitudine pruni; petiolata.

HYDRA STENTOREA. FIG. 27 AND 28, PLATE XXII.

Tentaculis ciliaribus corpore infundibuliformi.

The arms of this hydra are rows of ſhort hairs, the body trumpet-ſhaped.

This ſpecies of hydra is very common, and has been deſcribed by almoſt every writer on theſe ſubjects; it is placed by Muller among the vorticellæ.

Vorticella ſtentorea caudata, elongata, tubæformis limbo ciliato. Muller animalcula infuſoria.

They are named by Mr. Baker and Mr. Trembley the funnel-like polype.

There are three ſpecies of them, which are of different colours, green, blue, and white. The white ones are the moſt common. It is neceſſary to obſerve them often, and in various attitudes, in order to obtain a tolerable idea of their ſtructure. They do not form cluſters, but adhere ſingly by their tail to whatever comes in their way; their anterior end is wider than the poſterior, and being round gives the animal ſomewhat of a funnel form, though it is not completely circular, having a ſort of ſlit, or gap, that interrupts the circle. The edge of this opening is furniſhed with a great number of little fimbrillæ, which by their briſk and continual

petiolata corpore cylindrico, in cujus apice os, quod corpore compreſſo, movet tentacula vix manifeſta. Lin. Syſt. Nat. p. 1321.

tinual motions, excite a current of water; the ſmall bodies that float or ſwim near this current, are forced by it into the mouth of the little animal. Mr. Trembley ſays, that he has often ſeen a number of very ſmall animalcula fall one after another into the mouth, ſome of which were afterwards let out again at another opening, which he was not able to deſcribe.

They can faſhion their mouths into ſeveral different forms. If any thing touches them they ſhrink back and contract themſelves. They live independent of each other, ſwimming freely through the water in ſearch of their prey, and fix to any thing they meet with.

Theſe animals multiply by dividing themſelves, not longitudinally, nor tranſverſely, but ſloping and diagonal wiſe; the proceedings in nature continually varying in every new form of life. Of the two polypes produced by the diviſion of one, the firſt has the old head and a new tail, the other the old tail with a new head.

To make the deſcription more clear, Mr. Trembley called that with the old head the ſuperior polype, that with the new head the inferior one. The firſt particular that is obſervable in theſe polypes, when they are going to divide, is the lips of the inferior one; a tranſverſe and oblique ſtripe indicates the part where it is going to divide; the new lips are formed at about two-thirds of the length of the polype, reckoning from the head; the diviſion is made in a ſloping line, that goes about half way round the parent animal; theſe lips are at firſt diſcerned by a ſlow motion, which engages the attention of the obſerver. They then inſenſibly approach

approach each other and close, whereby a swelling is formed on the side of the polype, which is soon found to be a new head. When the swelling is considerably increased, the two polypes may be plainly distinguished. The superior one being now connected with the inferior one only by it's lower extremity, is soon detached from it, and swims away to fix itself on some convenient substance; the inferior one remains fastened to the place where the original polype was fixed before the division.

From the various modes by which different species of polypes are multiplied, we are led to form more exalted ideas of nature, and to see that the little we discover is but an exceeding small part of her contents; we learn also to be more cautious in reasoning from analogy, and laying down the known for a model to the unknown, because we find that the operations in nature are varied ad infinitum.

The growth of the hydra fusca is very quick, but that of the hydra stentorea is much more so. The progress of the fœtus is always more rapid than that of the infant and adult animal; but in these organized atoms, the evolution is so rapid, as to appear almost like an immediate creation.

Fig. 28 represents the hydræ stentoreæ, or funnel-polype, fixed to the under side of a piece of some vegetable substance; they are in this figure of their natural size.

Fig. 27, the same polype magnified; the different forms they assume are also seen here, sometimes short and thick as at m m, long as at n, nearly globular as at o, extended to the full size as

at

at k, ſeen as contracted at i. The fimbrillæ, or little hairs, may be ſeen in moſt of the attitudes, except thoſe of l.

OF THE HYDRA SOCIALIS.

HYDRA SOCIALIS MUTICA TOROSA RUGOSA. Fig. 11, Pl. XXI.

Bearded thick and wrinkled.

This ſpecies of hydra has been deſcribed by many writers. It is the vorticella ſocialis of Muller, who defines it as vorticella caudata, aggregata, clavata; diſco obliquo Muller Animalcula infuſoria, p. 304. Pallas makes it a brachionus, Pall. Zooph. 53.

In Fig. 11 theſe animals are repreſented as conſiderably magnified; they appear like a circle, ſurrounded with crowns, or ciliated heads, tied by ſmall thin tails to a common center, from whence they advance towards the circumference, where they turn like a wheel, with a great deal of vivacity and ſwiftneſs, till they occaſion a kind of whirlpool, which brings into it's ſphere the proper food for the polype. When one of them has been in motion for a time, it ſtops, and another begins; ſometimes two or three may be perceived in motion together. They are often to be found ſeparate, with the tail ſticking in the mud. The body contracts and dilates very much, ſo as ſometimes to have the appearance of a cudgel, at others to aſſume almoſt a globular form. The young polypes of this ſpecies have been ſometimes taken for the hydra ſtentorea.

OF

OF THE VORTICELLÆ.

We now come to another divifion of thefe animals, to which later writers have given the name of vorticellæ, which we fhall therefore adopt, as we think it behoves every man to maintain that order in fcientific arrangement which is not inconfiftent with truth, except he can produce another arrangement more expreffive of the nature of the objects it is defigned to difcriminate.

The variety that may be obferved in thefe minute animals, confirms a principle, which the more it is looked into, the more it will be found to accord with the general operations in nature, namely, that there is always a pre-exiftent principle of life neceffary to the organization both of animals and vegetables; that the alimentary and other particles which are added to, or apparently belong to them, produce nothing of themfelves, they are incapable of forming the leaft fibre, but they are able to become conftituent parts of one organical whole, and the inftruments whereby the forming principle is manifefted, and rendered capable of acting upon certain orders of creatures.

VORTICELLA.

Animal, calyce vafculofo; ore contractili ciliato, terminali ftirps fixa.

A fmall animal, with a vafcular cup; the mouth is at one end ciliated, and capable of being contracted, the ftem fixed.

VORTICELLA ANASTATICA.

Vorticella anaftatica, compofita, floribus campanulatis ftirpe multiflora rigefcente, fee Fig. 13, 14, 15, 16, Plate XXI.

Vorticella anaftatica, compound, with bell-fhaped flowers, and a rigid ftem.

Cluftering polype, fecond fpecies, Trembley, Philof. Tranf. vol. xliv. part 2, p. 643.

Thefe polypes form a group refembling a clufter, or more properly an open flower; this flower, or clufter, is fupported by a ftem, which is fixed by it's lower extremity to fome of the aquatic plants, or extraneous bodies, that are found in the water; the upper extremity forms itfelf into eight or nine lateral branches, perfectly fimilar to each other; thefe have alfo fubordinate branches, whofe collective form much refembles that of a leaf. Every one of thefe affemblages is compofed of one principal branch, or nerve, which makes with the main ftem of the clufter an angle fomewhat greater than a right one; from both fides of this nerve the fmaller lateral branches proceed; thefe are fhorter the nearer their origin is to the principal branch.

At the extremity of the principal branch, and alfo of all the lateral ones there is a polype or vorticella. There are others on both fides of the lateral twigs, but at different diftances from their extremity. Thefe polypes are all exceeding fmall, and of a bell-like figure; near their mouth a quick motion may be difcerned, though not with a fufficient diftinctnefs to convey an adequate idea of of it's caufe; upon the branches of thefe clufters are round bodies, which will be more particularly defcribed prefently.

Every clufter has eight or nine of thefe branches, or leaves: they do not all proceed from the fame point, but the points from whence they fet out are not far afunder; each of thefe branches is bent a little inwards, fo that all of them taken together form a kind of fhallow cup. If the eye is placed right over the bafe of this cup, the appearance of the whole eight or nine branches is like unto that of a ftar, with fo many rays proceeding from the center. If the clufter is flightly touched, all the branches inftantly fold up, and form a fmall round mafs. The ftem which fupports the clufter contracts alfo at the fame time, folding up like a workman's meafuring rule, that confifts of three or four joints. This extraordinary affemblage conftitutes one organized whole, formed of a multitude of fimilar and particular ones. A new fpecies of fociety, in which all the individuals are members of each other in the ftricteft fenfe, and all participate of the fame life.

A few days after one of thefe clufters is formed, fmall round bodies, or bulbs, may be perceived to protrude in feveral places from the body of the branch; thefe grow very faft, and arrive at their greateft growth in two or three days. The bulbs detach themfelves from the branches out of which they fpring, and go away, fwimming till they can fettle upon fome fubftance which they meet with in the water, and to which they fix themfelves by a fhort pedicle; the bulbs are then round, only a little flatted on the under fide, the pedicle continues to lengthen gradually for about twenty-four hours, during the fame time the bulbs alfo change their figure, and become nearly oval. There are in a clufter but few of thefe bulbs compared with the number of the vorticellæ, neither do all the bulbs come out at the fame time. The bulb then divides lengthways into two fmaller ones, but which are ftill much larger than the vorticellæ themfelves. It is not long before thefe are feparated like the firft, and thus form four bulbs on the fame ftalk; thefe again divide themfelves, and form eight, which again fubdivide, and confequently make fixteen. They are all connected with the ftalk by a proper pedicle, but they are not all of an equal fize; the largeft continue to divide, and the fmalleft begin to open, and take the bell-formed fhape. Mr. Trembley obferved from one round bulb, in about twenty-four hours, by repeated divifions, one hundred and ten vorticellæ to be formed.

It has been afked with propriety, what plant, or what animal, could have led us to expect an exiftence and mode of propagation fimilar to that of the vorticella anaftatica?

Fig. 13 reprefents one branch of the vorticella anaftatica; on this branch, befides the vorticellæ which are of a bell-like form, fome of thofe round bodies from which they firft fpring, and by which they are fo remarkably diftinguifhed from many other fpecies, may be feen.

Fig. 14 reprefents one of the globular bodies, after it has parted from the clufter, and has fixed itfelf to fome other body, and after the globule itfelf and it's pedicle have begun to lengthen.

Fig. 15 reprefents the two bodies that were formed by the parting of that which is reprefented in Fig. 14.

Fig.

Fig. 16 repreſents four that were formed by the ſeparation of the two bulbs, repreſented in the foregoing figure.

VORTICELLA PYRARIA.

Compoſita, floribus muticis obovatis, tentaculis bigeminis ſtirpe ramoſa, Fig. 25 and 26, Plate XXII. Compound, with beardleſs oval florets, two double arms, the ſtem branched. Lin.

It is ſomewhat of a pear ſhape, the baſe is pellucid, the top truncated; the lateral arms, which are a pair on each ſide, cannot be diſtinguiſhed without ſome attention; they are ſometimes to be ſeen diſengaged from the pedicle, and rolling ſwiftly in a kind of circle.

VORTICELLA CRATÆGARIA.

Vorticella compoſita, floribus muticis globoſis, tentaculis binis, ſtirpe ramoſa, Fig. 40, Plate XXII. Compound, with globous naked florets, two tentacules, and a branched ſtem.

These vorticellæ are to be found in the month of April, both in the mud, and upon the tail of the monoculus quadricornis; they are generally heaped together in the manner in which they are repreſented in the figure; they are of a ſpherical form, and united to one common ſtalk. They are alſo often to be found without any pedicle, the body is rather contracted, the aperture is circular, and ſurrounded with a marked margin; it has two ſmall arms; with a deep magnifier, a vehement rotatory motion may be ſeen; they ſometimes ſeparate from the community, and go

Fig. 3. Plate VI. reprefents that which was ufed by M. Lyonnet for diffecting the coffus.

Fig. 1. Plate VII. B. The aquatic microfcope ufed by Mr. Ellis for inveftigating the nature of coralline, and recommended by Mr. Curtis to botanifts, in his Flora Londinenfis.

Fig. 1. Plate VI. A botanical microfcope, contrived by Dr. Withering.

Fig. 2. Plate VI. A botanical microfcope, by Mr. B. Martin.

Fig. 5. Plate VI. The tooth and pinion microfcope, which is now generally fubftituted in the room of Wilfon's.

Fig. 8. Plate VIII. A botanical magnifier.

Fig. 7. Plate VIII. A different kind of botanical magnifier.

A COMPOUND MICROSCOPE, as it confifts of two, three, or more glaffes, is more eafily varied, and is fufceptible of greater changes in it's conftruction, than the fingle microfcope. The number of the lenfes, of which it is formed, may be increafed or diminifhed, their refpective pofitions may be varied, and the form in which they are mounted be altered almoft ad infinitum. But among thefe varieties, fome will be found more deferving of attention than others; it is of thefe only we fhall fpeak in this place.

The

go forwards in a kind of ſpiral line, and then in a little time come back again to the reſt.

Fig. 40 repreſents a parcel of theſe vorticellæ united together.

Among the other authorities for this animal, M. Linnæus refers to Mr. Baker's deſcription of the mulberry inſect, "Employment for the Microſcope," p. 348, which, as it differs a little from the preceding account, we ſhall inſert here. That from which his drawing was made, and which he has deſcribed, was found in a ditch near Norwich; he called it the mulberry inſect, from the reſemblance it bore to that fruit; though the protuberances that ſtand out round it are more globular than thoſe of a mulberry; it is to be ſeen rolling about from one place to another, and is probably a congeries of animalcula; they are to be met with in different numbers of knobs, or protuberances, ſome having fifty or ſixty, others more or leſs down to four or five. The manner of moving is the ſame in all. They are generally of a pale yellow.

VORTICELLA OPERCULARIA, FIG. 29, PLATE XXII.

Vorticella compoſita, floribus muticis ovalibus, ſtirpe ramoſa. Compound, with naked oval florets, and a branched ſtem.

Theſe vorticellæ are of a lemon ſhape, and are generally found in cluſters, branching out from a ſtem, which moſtly adheres to ſome convenient ſubſtance.

That ſpecies of them which is deſcribed by Mr. Baker had a very ſhort pedicle, and the animals were much longer than thoſe which

which are reprefented at Fig. 29, Plate XXII. There was no main ftem, but all the pedicles were joined in one center, round which the animals extended themfelves as fo many radii, forming a very pleafing figure.

The mouths of thefe animalcula are not ciliated, but they are furnifhed with a round aperculum, or cover, connected by a long ligament, or mufcle, which extends downwards through the body, and is affixed within fide of it, near the tail. This ligament may be contracted or dilated, fo that the cover may be removed to fome diftance from the mouth; in this fituation feveral fhort hairs may be found to radiate from it; thefe have a vibratory motion, by which they excite a current of water, moft probably to draw in the proper nourifhment, after which they fhut or pull down the cover, which they again extend at pleafure; when the cover is pulled clofe down, the mouth contracts, and no hairs are to be feen.

Fig. 29 reprefents the vorticella opercularia, f the operculum removed at fome diftance from the mouth, at t, it is nearly clofe at r, the mouth contracted, the cover drawn in, and no hairs to be feen; u a part of the ftalk, from which fome of the animalcula are feparated.

VORTICELLA UMBELLARIA.

Vorticella compofita, floribus ciliatis globofis muticis, ftirpe umbellata, Fig. 30, Plate XXII. Compound, with ciliated globous naked florets, and an umbellated ftem.

Vorti-

Vorticella acinoſa, ſimplex, globoſa, granis nigricantibus, pedunculo rigido. Muller Animal Infuſ. p. 319.

We often find in divers places, upon water, plants, and other bodies in the water, a whitiſh ſubſtance, that looks like mould; plants, pieces of wood, ſnail ſhells, &c. are often entirely covered over with this ſubſtance. If we examine any of theſe by the microſcope, we ſhall find ſuch motions as will induce us to think them an aſſemblage of living animals, minute bodies, ſeverally fixed to the extremities of ſmall ſtems, or pedicles, many of which are often ſo united as to form together a ſort of branches, or cluſters, from whence they have been termed cluſtering polypes, or des polypes en bouquet.

Theſe cluſters are larger or ſmaller, according to the ſpecies of the vorticellæ which form them, and according to the concurrence of many other circumſtances. To get a clear idea of the figure of theſe animals, it is beſt to obſerve the ſmaller cluſters, as in the larger they are often rendered leſs diſtinct on account of the number.

The length of thoſe which are repreſented at Fig. 30, is about the 240th of an inch; they are of a bell-ſhape. The anterior part a c generally appears open, the poſterior part is fixed to a ſtem, or pedicle, b e; it is by the extremity of this pedicle that the vorticella faſtens itſelf to any ſubſtance. It appears in the microſcope of a browniſh colour, excepting at the ſmaller end b, where it is tranſparent, as well as the whole pedicle b e. When the anterior part a c is open, a very lively motion may be perceived about it's edges; and when it preſents itſelf in a particular manner, ſome-

6 thing

thing very much refembling the little wheels of a mill, moving with great velocity, may be difcovered on both fides of the edges of this anterior part.

Thefe vorticellæ are able to contract themfelves fuddenly. They may be made to do this, either by touching them, or moving the fubftance to which they are affixed. When they contract, the edges of the anterior parts are drawn quite into the body; on refuming their former pofture, the edges may be feen to come forth, and put themfelves in motion as before. Minute fubftances that float in the water are often forced down into thefe openings, and fometimes are thrown out again.

They are capable of fwimming about fingly, but their form is in that cafe confiderably different from that which they have when they are fixed. To fee regularly in what manner the clufters are formed, and in what way thefe little creatures multiply, it is beft to obferve one that is fixed by itfelf.

The pedicle of a fingle vorticella is at firft fhort, but it foon grows longer, and then begins to multiply, that is, to divide, or fplit itfelf in two lengthways. To effect this, the lips are firft drawn into the body, the anterior part clofes and becomes round, and lofes it's bell fhape, the motion about the lips ceafes, though a fmall degree of motion may be perceived within the body. The anterior end flattens gradually, and fpreads wider in proportion as it grows fmaller. It then gradually fplits down the middle, that is, from the middle of the head to the pedicle, fo that in a little time two feparate round bodies appear to be joined to the end of the pedicle, that before fupported but one.

The mouth, or anterior part of each of these bodies, now opens by degrees; and in proportion as they open, the lips of the new vorticella begin to display themselves. The motion before spoken of may then also be perceived. Indeed it is the best time of observing it; it is at first slow, but more rapid in proportion as the mouth opens, when it is as swift as that of the vorticella before it began to divide, and we may now look upon it as completely formed. A vorticella is generally about one hour in dividing itself.

The lower of the three drawings, Fig. 30, represents two vorticellæ joined by their posterior extremity to one pedicle; soon after the division, each vorticella begins to shew a pedicle of it's own.

Fig. 30 represents a cluster of eight vorticellæ; by this figure we may form some idea in what manner the pedicles are disposed as their number increases; there were at first only two at b, whose branches lengthened to d, and then each of them was divided into two, now forming four; these again lengthened and reached i, when they were again subdivided, as in the figure.

The reader will join with M. Bonnet in admiring the group of wonders afforded by a single spot of mouldiness. What unforeseen, varied, and interesting scenes are presented within so small a compass! what a theatre is exhibited to a thinking mind! But our abode is so recluse, that we have but a glimmering view of it: how great would our astonishment be, if the whole spectacle was disclosed to us at once, and we were enabled to penetrate into the interior structure of this wonderful assemblage of living atoms!

4 Our

Our eyes ſee only the groſs part of the decorations, whilſt the machines that execute them remain in impenetrable darkneſs! Who ſhall enlighten this profound obſcurity, or dive into an abyſs where reaſon is loſt, or draw from thence the treaſures of wiſdom concealed within it? Let us learn to be content with the ſmall portion that is communicated to us, and contemplate with gratitude the firſt traces of human underſtanding that are imparted to us in theſe diſcoveries.

VORTICELLA BERBERINA.

Vorticella compoſita, floribus ovalibus muticis, ſtirpe ramoſa. Compound, with oval beardleſs florets.

This is a ſpecies of the vorticellæ, which reſemble the preceding one in many reſpects, particularly in being multiplied in the ſame manner, that is, by dividing, or ſplitting, according to it's length.

They are more ſlender than the vorticella umbellaria; the branches of the cluſters are tranſparent. When many of them are together, they appear of a changeable violet colour; the cluſters are not unlike a ſprig of ſpun glaſs. The motion of the lips is not ſo eaſily diſtinguiſhed as in the foregoing ſpecies, though it may be obſerved in theſe whilſt they are opening and completing their formation. For at theſe times the motion is but ſlow, whereas it becomes afterwards very quick in thoſe that are arrived at a ſtate of perfection.

All the clufter vorticellæ detach themfelves from time to time from the ftem, and from thefe they fwim about till they fix again upon fome convenient fubftance; the branches, when deferted, bear no more vorticellæ.

VORTICELLA DIGITALIS.

Vorticella compofita, floribus cylindricis, unifulcatis femiclaufis, ftirpe ramofa, Fig. 31, Pl. XXII. Compound, with cylindrical florets.

Vorticella compofita, cylindrica, cryftallina, apice truncata et fiffa, pedunculo fiftulofo ramofa. Muller Animal Infuf. p. 327.

This fpecies of the vorticella is very fcarce, it feems only to have been feen by Roefel, who found it on the monoculus quadricornis, till 1784, when it was difcovered by Mr. Muller, who had fought for it feveral years before in vain.

The body is cylindrical, cryftalline, and appears almoft empty; it has three pellucid points difpofed lengthways, the apex is truncated in an oblique direction, the margin bent back. The upper part contracts itfelf, and the margin then affumes a conical fhape, with a convex furface; there are in general but few branches from the principal ftem, and thefe are fhort and thick; it excites an undulatory motion, but no hairs, nor any rotatory motion, have been difcovered. Fig. 31, o and n, reprefents the vorticella adhering to the monoculus quadricornis.

VORTI-

VORTICELLA CONVALLARIA.

Simplex, gregaria, flore campanulata mutico, tentaculis bigeminis, ftirpe fixa, Fig. 39, Pl. XXII. Simple, but gregarious, the florets bell-fhaped, with two pair of little arms, and a fixed ftem.

Vorticella fimplex, campanulata, pedunculo retortili. Muller Animal Infuf.

Thefe vorticellæ, or bell animals, as they are termed by Mr. Baker, are generally found adhering to fome fubftance in the water; they are reprefented here as found by M. Roefel, fixed to a curious cornu ammonis, with points projecting from the back. To the naked eye they appear only as fo many little white points, but under a microfcope, as little bells, agitating the water to a confiderable diftance. The ftems of thefe have a particular motion, they draw themfelves up, and fhorten all at once, taking the form of a fpiral wire, or fcrew; in a moment after they again refume their former fhape, ftretching themfelves out ftrait as before. Many of them may be feen at times adhering to each other by their tails; the cilia, which are two on each fide of the mouths, are very feldom to be perceived.

VORTICELLA URCEOLARIS. FIG. 33, 34, 35, PLATE XXII.

Simplex, pedunculata, ore dentato. Single, with a fhort tail, and toothed mouth.

Brachionus capfularis tefta ovata apice fexdentata bafi incifa, cauda longa bicufpi. Muller Animal Infuf. p. 356.

To

To the naked eye it appears as a white moveable point; but when examined by the microfcope, a tail, projecting from the lower part, is difcovered, and a double rotatory inftrument is feen, which it can conceal or difcover at pleafure. It has been feen and defcribed by moft microfcopical writers; but as Mr. Baker's feems to us to be the moft perfect, we fhall principally follow his account of it.

He difcovered three fpecies of them, two of which are included under the vorticella urceolaris. Fig. 33, 34, 35, are of the firft fpecies; Fig. 36, 37, 38, are of the fecond kind. The firft fort, when extended, is about twice as long as it is broad. It is contained in a fhell; the fore-part of this is armed with four fharp teeth, or points; the oppofite fide has no teeth, but is waved, or bent, in two places, like the form of a Turkifh bow. At the bottom there is a hole, through which it pufhes the tail. It faftens itfelf by this tail to any convenient fubftance, when it intends to ufe it's rotatory organs; but when it is floating in the water, and at all other times when not adhering to any body, it wags the tail backwards and forwards fomething like a dog.

We may confider it as divided into a head, thorax, and abdomen; each of which may be extended and contracted confiderably: it can by dilating all three protrude the head beyond the fhell, or by contracting them, draw the whole body within the fame.

The head when extended divides itfelf into two branches, between which another part, a kind of probofcis, is pufhed out; at the end of this are two fibrils, that appear when they are at reft reſt like a broad point, but which can be moved to and from each other very briſkly with a vibratory motion, ſee Fig. 33.

The form and ſituation of the two branches is ſometimes changed, the ends thereof becoming more round, and the vibratory motion is altered to a rotatory one: this alteration is repreſented at Fig. 34: the head alſo appears in this figure. The thorax is annexed to the lower part of the head, it is muſcular; within it there is a moving inteſtine, which has been ſuppoſed to be either the lungs or the heart of the little creature, ſee b, Fig. 33 and 34.

A communication is formed between the thorax and the abdomen by means of a ſhort veſſel c, whoſe alternate contractions and dilatations occaſion the abdomen to riſe and fall alternately, having at the ſame time a ſort of periſtaltic motion. The food is conveyed through this veſſel into the abdomen, where it is digeſted; it is then diſcharged by the anus, which is placed near the tail.

The tail has three joints, and is cleft or divided at the extremity, by which means it can better faſten itſelf to ſuitable objects. It is in general projected from the lower end of the ſhell, moving nimbly to and fro, ſerving the animal as a rudder when it is ſwimming to direct it's courſe.

When the water in which the little animal is placed is nearly dried away, or when it has a mind to compoſe itſelf to reſt, it contracts the head and fore-part of the body, and brings them down into the ſhell, and pulls the tail upwards, ſo that the whole of

The three firſt compound microſcopes that attract our notice, are thoſe of Dr. Hooke, Euſtachio Divini, and Philip Bonnani. Dr. Hooke gives an account of his in the preface to his Micrographia, which was publiſhed in the year 1656; it was about three inches in diameter, ſeven long, and furniſhed with four draw-out tubes, by which it might be lengthened as occaſion required: it had three glaſſes, a ſmall object glaſs, a middle glaſs, and a deep eye glaſs: Dr. Hooke uſed all the glaſſes when he wanted to take in a conſiderable part of an object at once, as by the middle glaſs a number of radiating pencils were conveyed to the eye, which would otherwiſe have been loſt: but when he wanted to examine with accuracy the ſmall parts of any ſubſtance, he took out the middle glaſs, and only made uſe of the eye and object lenſes; for the fewer the refractions are, the clearer and more bright the object appears.

An account of Euſtachio Divini's microſcope was read at the Royal Society, in 1668.* It conſiſted of an object lens, a middle glaſs, and two eye glaſſes, which were plano convex lenſes, and were placed ſo that they touched each other in the center of their convex ſurfaces; by which means the glaſs takes in more of an object, the field is larger, the extremities of it leſs curved, and the magnifying power greater. The tube, in which the glaſſes were incloſed, was as large as a man's leg, and the eye glaſſes as broad as the palm of the hand. It had four ſeveral lengths; when ſhut up, it was ſixteen inches long, and magnified the diameter of an object forty-one times; at the ſecond length, ninety times; at the third length, one hundred and eleven times; at

* Philoſ. Tranſ. No. 42.

of this minute creature is contained within the ſhell, ſee Fig. 35. The ſhell is ſo tranſparent that the terminations cannot be eaſily diſtinguiſhed when the animal is extended; but whatever is tranſacted within the ſhell, is as plain as if there was no ſubſtance between the eye and the interior parts.

Fig. 36, 37, 38, exhibit the appearance of another ſpecies of theſe animals, which differs from the foregoing kind. This has alſo a head, a thorax and abdomen, but then they are not ſeparated by a gut or intermediate veſſel, as in the former, but are joined immediately together, and at the place where in the firſt kind a moveable inteſtine was ſeen; in this a muſcle, moſt probably the heart, may be diſcovered; it has a regular ſyſtole and diaſtole: this part is intended to be ſhewn at a, Fig. 36, 37, 38. Like the other it draws the head and tail within the ſhell, which then appears to have ſix teeth or ſpikes on one ſide, and two on the other: it very ſeldom protrudes it's head ſo far out as the other; ſometimes the fibrillæ may be ſeen within the margin of the ſhell.

Both ſpecies carry their young in an oval integument or bag, faſtened externally to the lower part of the ſhell, ſomewhere about the tail; theſe bags are ſometimes opake at one end, and ſeemingly empty at the other, ſee Fig. 34: ſometimes the middle is opake, with a tranſparent margin, ſee Fig. 36.

It is highly entertaining to ſee a young one burſt it's integument, and gradually force it's way out; in performing this operation, it is much aſſiſted by the motion of the tail of the parent. The head part comes out firſt, it then ſets it's rotatory organ in motion,

motion by which it is completely difengaged, leaving the integument behind, which the vorticella freed itfelf from by repeated ftrokes with it's tail. A young one almoft difengaged is feen at b, Fig. 38; another embryo, c, was left adhering to the fhell.

There are four more fpecies of the vorticella mentioned by Linnæus, which are the vorticella encrinus, the vorticella polypina, the vorticella ftellata, and the vorticella ovifera, which do not come properly within our plan. The vorticella polypina will be defcribed hereafter. There is, however, another little animal, of which we have given a figure in Plate XXII. and which Linnæus, in a former edition of the Syftema Naturæ, placed among the hydræ, but which he has fince removed, and placed amongft the tubularia; and as I do not feel myfelf competent to controvert the propriety or impropriety of the former or prefent arrangement, the little creature muft here take a folitary fituation, and ftand without a companion.

TUBULARIA CAMPANULATA. FIG. 32, PLATE XXII.

Reptans, tubis campanulatis. Creeping, with campanulated tubes.

It is called by Mr. Baker the bell-flowered, or plumed animal.

Thefe little creatures dwell in colonies together, from ten to fifteen in number, living in a kind of flimy mucilaginous cafe, which, when expanded in the water, has fome refemblance to a bell with it's mouth upwards. Thefe bells, or colonies, are to be be found adhering to the large leaves of duck-weed and other aquatic plants.

The bell, or cafe, which thefe animals inhabit, being very tranfparent, all the motions of it's inhabitants may be difcerned diftinctly through it. There are feveral ramifications, or fmaller bells, proceeding from the larger one; in each of thefe there is an inhabitant. The opening at the top of thefe bells is juft large enough for the creature's head and a fmall part of it's body to be thruft out from it, the reft remaining in the cafe, into which it alfo draws the head on the leaft alarm.

Befides the particular and feparate motions which each of thefe creatures is able to exert within it's cafe, and independent of the reft, the whole colony has a power of altering the pofition of the bell, and removing it from one place to another. Thefe animalcula feem not to like to dwell in focieties whofe number exceeds fifteen; when the colony happens to increafe in number, the bell may be obferved to fplit gradually, beginning from about the middle of the upper extremity, and proceeding downwards towards the bottom, till they at laft feparate and become two colonies, independent of each other.

The arms are very near each other; fixty may often be counted in one plume, having each the figure of an Italic *f*, one of whofe hooked ends is faftened to the head; and all together, when expanded, compofe a figure fomewhat like a horfefhoe, convex on the fide next the body, but gradually opening and turning outwards, fo as to leave a confiderable diftance within the outer extremities

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tremities of the arms. When the arms are thus extended, the creature, by giving them a vibratory motion, can produce a current in the water, which brings the animalcula, and other minute bodies that are floating near it, into it's mouth, ſituated between the arms. The food, if agreeable to the creature, is ſwallowed; if not, it is rejected by a contrary motion. As the ſkin is tranſparent, the animal may be ſeen very plain when it has retired within the tube.

The body is about one-eighth of an inch long, without reckoning the plume, which is about the ſame length. It is cylindrical, and the ſkin is very tranſparent. The plume is only a continuation of this tranſparent ſkin, it is very broad in proportion to the body, and of a remarkable figure; the baſe is of the ſhape of a horſeſhoe, from this baſe the arms project, they bend rather outwards. The plume which they form gives them a reſemblance to ſome flowers. The arms may be compared, from their fineneſs and tranſparency, to very fine threads of glaſs. The baſe of the plume is grooved, and is fixed to the animal by the middle of the horſeſhoe which it forms, and it is here that there is an opening which ſerves as a mouth to the animal. The inteſtines are eaſily diſtinguiſhed through it's tranſparent ſkin; when it has juſt been eating, they are of a deep brown colour. Three principal parts may be diſtinguiſhed, the oeſophagus e h i, the ſtomach f g, and the rectum f a.

The plumed polype is very voracious, devouring a great number of ſmall animals. The arms, when obſerved attentively with the microſcope, will be found to bend from moment to moment within ſide of the plume, and then riſe up again;

 then

then another arm performs the ſame; thus by the continual motion of it's arms, it puts the water into violent agitation, and brings into it's mouth the food whereby it is nouriſhed.

In the inſide of theſe animals a ſmall oblong whitiſh body is formed, which is carried to the outſide, and remains fixed in a perpendicular direction to the body; many of theſe are formed daily, and of theſe oval bodies new animals are produced, exactly ſimilar to the parent.

If theſe minute bodies are eggs, they are of a ſingular kind, being deſtitute of any covering, and are neither membranaceous nor cruſtaceous; we cannot with propriety ſay the young ones are hatched from them; we can, however, perceive theſe oviform bodies to gradually unfold themſelves. The developement is accompliſhed in a few minutes, and an animalculum appears like the parent.

Mr. Trembley amaſſed a large quantity of theſe eggs, and carried them from England with him, keeping them quite dry; on putting them into water, they gradually developed, and became as perfect as the tubularia from which they proceeded.

There is a very great ſimilarity in the conſtruction of this little creature, and many of the marine polypes, who, like it, exiſt in tubes of the ſame growth with themſelves.

Fig. 32 repreſents three tubulariæ campanulatæ, or plumed polypes, very much magnified, namely, b f a c d d e h g i, which is out of it's cell; I B A C, which is within it's cell, and the young one, t u u s, which is out of it's cell; e h the oeſophagus, f g the ſtomach, a f the rectum, a c d d e the plume, conſiſting of the baſe e a c, which is but little ſeen, and the arms ad ad ad which proceed from the edges of this baſe; I B A C one of the animals drawn into it's cell, I A B the ſkin reverſed, in which the plume is contained; g o o threads which are fixed at one end to the inteſtines of the animal, by the other to the bottom of the cell.

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R. HINDMARSH,
Printer.
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CHAP. VIII.

OF THE ANIMALCULA INFUSORIA.

OUR knowledge of the microfcopic world is at prefent very contracted, but we know enough to give us high conceptions of it's concealed wonders, and to fill us with profound aftonifhment at the infinite variety of forms that are made recipient of life. A few of the inhabitants of this world have been difcovered. The figure and apparent habits of life of thefe, refemble fo little thofe with which we are more acquainted, that it is often difficult to find terms to exprefs what is prefented to the eye. It is highly probable that there are many gradations of exiftence far below the minuteft of thofe which we obferve with the microfcope; and though by this we are enabled to difcover myriads of different creatures roving in the leaft drop of water, as if it were a fea, yet it is not unreafonable to fuppofe that HE who has filled the immenfity of extent with funs and worlds, has peopled every particle of fluids with more minute beings than any apparatus of our's can perceive, agreeable to the fublime ideas of the poet:

Gradual

Gradual from theſe what num'rous kinds deſcend,
Evading even the microſcopic eye!
Full nature ſwarms with life; one wond'rous maſs
Of animals, or atoms organized,
Waiting the vital breath, when parent heaven
Shall bid his ſpirit blow. The hoary fen,
In putrid ſteams, emits the living cloud
Of peſtilence; thro' ſubterranean cells,
Where ſearching ſun-beams ſcarce can find a way,
Earth animated heaves. The flowery leaf
Wants not it's ſoft inhabitants. Secure,
Within it's winding citadel, the ſtone
Holds multitudes. But chief the foreſt boughs,
That dance unnumber'd to the playful breeze,
The downy orchard, and the melting pulp
Of mellow fruit, the nameleſs nations feed
Of evaneſcent inſects. Where the pool
Stands mantled o'er with green, inviſible,
Amid the floating verdure, millions ſtray.
Each liquid too, whether it pierces, ſoothes,
Inflames, refreſhes, or exalts the taſte,
With various forms abounds. Nor is the ſtream
Of pureſt cryſtal, nor the lucid air,
Tho' one tranſparent vacancy it ſeems,
Void of their unſeen people. Theſe, conceal'd
By the kind art of forming heaven, eſcape
The groſſer eye of man:

* * * * * * * *
* * * * * * * *
* * * * * * * *

Let

Let no presuming impious railer tax
Creative Wisdom, as if aught was form'd
In vain, or not for admirable ends.
Shall little haughty Ignorance pronounce
His works unwise, of which the smallest part
Exceeds the narrow vision of her mind?
As if upon a full proportion'd dome,
On swelling columns heav'd, the pride of art!
A critic fly, whose feeble ray scarce spreads
An inch around, with blind presumption bold,
Should dare to tax the structure of the whole.
And lives the man, whose universal eye
Has swept at once th' unbounded scheme of things;
Mark'd their dependance so, and firm accord,
As with unfaultering accent to conclude
That this availeth nought? Has any seen
The mighty chain of beings lessening down
From infinite perfection to the brink
Of dreary nothing, desolate abyss!
From which astonish'd thought, recoiling, turns?
Till then alone let zealous praise ascend,
And hymns of holy wonder, to that Power,
Whose wisdom shines as lovely on our minds,
As on our smiling eyes his servant sun.

THOMPSON.

Animal-

Animalculum fignifies a little animal, and therefore the term might be applied to every animal which is confiderably inferior in fize to ourfelves. It has been cuftomary, however, to diftinguifh by this name only thofe animals that are of a fize fo diminutive that their true figure cannot be difcerned without the affiftance of glaffes, and is more efpecially applied to fuch as are altogether invifible to the naked eye, and cannot be perceived even to exift but by the aid of microfcopes.

By thefe we are brought into a new world, and numberlefs animals are difcovered, which, from their minutenefs, muft otherwife for ever have efcaped our obfervation: and how many kinds of thefe invifibles there may be, is yet unknown; as they are difcerned of all fizes, from thofe which are barely invifible to the naked eye, to fuch as refift the action of the microfcope, as the fixed ftars do that of the telefcope, and with the greateft powers hitherto invented, appear only as fo many moving points.

The fmalleft living creatures our inftruments can fhew, are thofe that inhabit the waters; for though animalcula, equally minute, may fly in the air, or creep upon the earth, it is fcarce poffible to get a view of them; whereas, water being tranfparent, and confining the creatures within it, we are enabled, by applying a drop of it to our glaffes, to difcover with eafe a great part of it's contents.

It has been long known, that if feeds, herbs, or other vegetable fubftances, are infufed in water, the water will foon be filled with an indefinite number of little animals. We find them, in general, moving in all directions with equal eafe and rapidity, at the fourth length, one hundred and forty-three times. It does not appear that E. Divini varied the object lenses.

Philip Bonnani published an account of his two microscopes in 1698;* both were compound; the first was similar to that which Mr. Martin published as new, in his Micrographia Nova,† in 1712. His second was like the former, composed of three glasses, one for the eye, a middle glass, and an object lens: they were mounted in a cylindrical tube, which was placed in an horizontal position; behind the stage was a small tube, with a convex lens at each end; beyond this was a lamp; the whole capable of various adjustments, and regulated by a pinion and rack; the small tube was used to condense the light on the object, and spread it uniformly over it according to it's nature, and the magnifying power that was used.

If the reader attentively considers the construction of the foregoing microscopes, and compares them with more modern ones, he will be led to think with me, that the compound microscope has received very little improvement since the time of Bonnani. Taken separately, the foregoing constructions are equal to some of the most famed modern microscopes. If their advantages are combined, they are far superior to that of M. Dellebarre, notwithstanding the pompous eulogium affixed thereto by Mess. De L'Academie Royale des Sciences.‡

C From

* Bonnani Observationes circa viventia, &c.

† Micrographia Nova, by B. Martin, 4to.

‡ Memoires sur les Differences de la Construction et des Effets du Microscope, de M. L. F. Dellebarre, 1777.

ſometimes obliquely, ſometimes ſtrait forwards, at other times circularly, one while rolling and turning round, and then running backwards and forwards through the whole dimenſions of the drop, as if in ſport; at other times attacking with avidity the little heaps of matter they meet with in their way. They know how to avoid with dexterity any obſtacles that would interrupt their motion, and even to avoid one another; you may ſee hundreds in motion in a drop of water, that never ſtrike againſt each other; ſometimes they will ſuddenly change the direction in which they are moving, and take one diametrically oppoſite thereto. By inclining the glaſs on which the drop of water is laid, it may be made to move in any direction; the animalcula in the drop will ſwim as eaſily againſt the ſtream as with it.

If the water begins to evaporate, and the drop to grow ſmaller, they flock impetuouſly towards the remaining fluid; an anxious deſire of attaining this momentary reſpite of life is very viſible, as well as an uncommon agitation of the organs by which they imbibe the water. Theſe motions grow languid as the water fails, till they at laſt ceaſe. If they are left dry for a little time, it is impoſſible to re-animate them by giving them freſh water.

Animalcula and inſects will ſupport a great degree of cold, but both one and the other periſh when it is carried beyond a certain point. The ſame degree of heat that deſtroys the exiſtence of inſects, is fatal to animalcula; as there are animalcula produced in water at the freezing point, ſo there are inſects which live in ſnow.

If

If the ſmalleſt drop of urine is put into a drop of water, where theſe animalcula are roving about, apparently happy and eaſy, they inſtantly fly to the other ſide, but the acid ſoon communicating itſelf to this part, their ſtruggles to eſcape are increaſed, but the evil alſo increaſing, they are thrown into convulſions, and ſoon expire.

Among animalcula, as in every other part of nature, there is always a certain proportion preſerved between the ſize of the individuals and their number. There are always feweſt amongſt the larger kinds, but they increaſe in number as they diminiſh in ſize, till of the laſt or loweſt to which our powers of magnifying will reach, there are myriads to one of the larger. Like other animals, they increaſe in ſize from their birth till they have attained their full growth. When deprived of food, they grow thin and periſh, and different degrees of organization are to be diſcovered in their ſtructure.

The birth and propagation of theſe microſcopic beings is as regular as that of the largeſt animals of our globe; for though their extreme minuteneſs prevents us, in moſt caſes, from ſeeing the germ from which they ſpring, yet we are well aſſured, from numerous obſervations, that the manner in which they multiply is regulated by conſtant and invariable laws.

We have ſeen that different ſpecies of the hydra and vorticella multiply and increaſe by natural diviſions and ſubdiviſions of the parent's body; this manner of propagation is very common among the animalcula in infuſions, though with many remarkable varieties. Some multiply by a tranſverſe diviſion, a contraction takes place in the middle, forming a kind of neck, that becomes ſmaller every inſtant, till they are enabled by a ſlight degree of motion to ſeparate from each other. Theſe animalcula, in general, ſtudiouſly avoid each other; but when they are in the labour of multiplication, and the diviſion is in great forwardneſs, it is not uncommon to ſee one of them precipitate itſelf on the neck of the dividing animalcula, and thus accelerate the ſeparation.

Another ſpecies, when it is on the point of multiplying, fixes itſelf to the bottom of the infuſion; it then forms an oblong figure, afterwards becomes round, and begins to turn rapidly, as if upon an internal center, continually changing the direction of it's rotatory motion; after ſome time, we may perceive two lines on the ſpherule, forming a kind of croſs; ſoon after which, the animalculum divides into four, which grow, and are again ſubdivided.

Some multiply by a longitudinal diviſion, which in one kind begins in the fore-part, and others in the hind-part; from another kind a ſmall fragment is ſeen to detach itſelf, which very ſoon acquires the form of the parent animalculum. Laſtly, ſome propagate in the ſame manner as thoſe we deem more perfect animals.

From what has been ſaid, it appears clearly that their motions are not purely mechanical, but are produced by an internal ſpontaneous principle, and that they muſt therefore be placed among the claſs of living animals, for they poſſeſs the ſtrongeſt marks, and the moſt decided characters of animation; and conſequently, that there is no foundation for the ſuppoſition of a chaotic and neutral kingdom, which can only have derived it's origin from a very tranſient and ſuperficial view of theſe animalcula.

It

It may also be further observed, that as we see that the motions of the limbs, &c. of the larger animals are produced by the mechanical construction of the body, and the action of the soul thereon, and are forced by the ocular demonstration which arises from anatomical dissection, to acknowledge this mechanism which is adapted to produce the various motions necessary to the animal; and as when we have recourse to the microscope, we find those pieces which had appeared to the naked eye as the primary mechanical causes of the particular motions, to consist themselves of lesser parts, which are the causes of motion, extension, &c. in the larger; when the structure can therefore be traced no further by the eye or glasses, we have no right to conclude, that the parts which are invisible are not equally the subject of mechanism: for this would be only to assert in other words, that a thing may exist because we see and feel it, and have no existence when it is not the object of our senses.

The same train of reasoning may be applied to microscopic insects and animalcula; we see them move, but because the muscles and members which occasion these motions are invisible, shall we infer that they have not muscles, with organs appropriated to the motion of the whole and it's parts? To say that they exist not, because we cannot perceive them, would not be a rational conclusion. Our senses are indeed given us, that we may comprehend some effects; but then we have also a mind with reason bestowed upon us, that from the things which we do perceive with our senses, we may deduce the nature of those causes and effects which are imperceptible to the corporeal eye.

Messrs.

Meſſrs. Buffon, Needham, and Baron Munckhauſen, have conſidered this part of animated nature in ſo different a light from other writers, that we cannot with propriety entirely paſs them over. Mr. Needham imagined that there was a vegetative force in every microſcopical point of water, and every viſible filament of which the whole vegetable contexture conſiſts; that the ſeveral ſpecies of microſcopic animals may ſubſide, reſolve again into gelatinous filaments, and again give leſſer animals, and ſo on, till they can be no further purſued by glaſſes. That agreeable to this idea, every animal, or vegetable ſubſtance, advances as faſt as it can in it's revolution, to return by a ſlow deſcent to one common principle, whence it's atoms may return again, and aſcend to a new life. That notwithſtanding this, the ſpecific ſeed of one animal can never give another of a different ſpecies, on account of the preparation it muſt receive to conſtitute it this ſpecific ſeed.

M. Buffon aſſerts, that what have been called ſpermatic animals, are not creatures really poſſeſſing life, but ſomething proper to compoſe a living creature, diſtinguiſhing them by the name of organic particles, and that the moving bodies which are to be found in the infuſions, either of animal or vegetable ſubſtances, are of the ſame nature.

Baron Munckhauſen ſuppoſed that the ſeeds of muſhrooms were firſt animals, and then vegetables; and this becauſe he had obſerved ſome of the globules in the infuſions of muſhrooms, after moving ſome time, to begin to vegetate.

It

It might be sufficient in the first instance to observe, that Meff. Needham and Buffon, by having recourse to a vegetative force, and organic particles, to account for the existence, and explain the nature of animalcula, and the difficulties of generation, have substituted words in the place of things, and that we are no gainers by the substitution, unless they explain the nature of these powers. But to this we may add, that all those who have examined the subject with accuracy and attention, as Bonnet, De Saussure, Baker, Wrisberg, Spalanzane, Haller, Ellis, Muller, Leder Muller, Corti, Roffredi, &c. disagree with the foregoing gentlemen, proving that they had deceived themselves by inaccurate experiments, and that one of them, M. Buffon, had not seen the spermatic animals he supposed himself to be describing, insomuch that Mr. Needham was at last induced to give up his favorite hypothesis.

To this we may add, that though we can by no means pretend to account for the appearance of most animalcula, yet we cannot help observing, that our ignorance of the cause of any phænomenon is no argument against it's existence. Though we are not, for instance, able to account in a satisfactory manner for the origin of the native Americans, yet we suppose M. Buffon himself would reckon it absurd to maintain, that the Spaniards on their arrival there found only ORGANIC PARTICLES moving about in disorder. The case is the very same with the eels in paste, to whose animation he objects. They are exceedingly small in comparison with us; but, with the solar microscope, Mr. Baker has made them assume a more respectable appearance; so as to have a diameter of an inch and an half, and a proportionable length. They swam up and down very

5 briskly;

briſkly; the motion of their inteſtines was very viſible; when the water dried up, they died with apparent agonies, and their mouths opened very wide. Now, were we to find a creature of the ſize of this magnified eel gaſping in a place where water had lately been, we certainly ſhould never conclude it to be merely an ORGANIC PARTICLE, or fortuitous aſſemblage of them, but a fiſh. Why then ſhould we conclude otherwiſe with regard to the eel in it's natural ſtate, than that it is a little fiſh? In reaſoning on this ſubject, we ought ever to remember, that however eſſential the diſtinction of bodies into great and ſmall may appear to us, they are not ſo to the Deity, with whom, as Mr. Baker well expreſſes himſelf, " an atom is a world, and a world but as an atom."—Were the Deity to exert his power a little and give a natural philoſopher a view of a quantity of paſte filled with eels, from each of whoſe bodies the light was reflected as in the ſolar microſcope; our philoſopher, inſtead of imagining them to be mere organic particles, (as the paſte would appear like a little mountain,) he would probably look upon the whole as an aſſemblage of ſerpents, and be afraid to come near them. Whenever, therefore, we diſcover beings to appearance endowed with a principle of ſelf-preſervation, or whatever we make the characteriſtic of animals, neither the ſmallneſs of their ſize, nor the impoſſibility of our knowing how they came there, ought to cauſe us to doubt of their being animated.*

I ſhall here inſert ſome extracts of the experiments made by Mr. Ellis at the deſire of M. Linnæus, and which are a full refutation of thoſe made by M. Needham and B. Munckhauſen. By thoſe

* Encyclopædia Britannica, vol. 1, p. 456.

thoſe he made on the infuſions of muſhrooms in water, it appeared evidently that the ſeeds were put in motion by minute animals, which aroſe on the decompoſition of the muſhroom; theſe, by pecking at the ſeeds, which are little round reddiſh bodies, moved them about with great agility in a variety of directions, while the little animals themſelves were ſcarce viſible till the food they had eaten diſcovered them.

The ramified filaments, and jointed or coralloid bodies, which the microſcope diſcovers to us on the ſurface of moſt vegetable and animal infuſions, when they become putrid, and which were ſuppoſed by Mr. Needham to be zoophytes, were found by Mr. Ellis to be of that genus of fungi called mucor, many of which have been figured by Michelius, and deſcribed by Linnæus. Their vegetation is ſo quick, that they may be ſeen to grow and feed under the eye of the obſerver; other inſtances of ſimilar miſtakes in Mr. Needham's experiments may be ſeen in Mr. Ellis's paper, Philoſ. Tranſ. vol. lix. p. 138.

A ſpecies of mucor ariſes alſo from the bodies of inſects putrefying in water; this ſpecies ſends forth a maſs of tranſparent filamentous roots, from whence ariſe hollow ſeed veſſels; on the top there is a hole, from which minute globules often iſſue in abundance, and with conſiderable elaſtic force, which move about in the water. It will, however, be found, with a little attention, that the water is full of very minute animalcula, which attack theſe ſeeds, and thus prolong their motion; but after a ſmall ſpace of time they riſe to the ſurface, and remain there without any motion; a freſh quantity riſes up, and floating to the edge of the water, remains there inactive; but no appearance

3 L can

can be obferved of detached and feparated parts becoming what is called microfcopic animalcula. Indeed, it is furprizing that Mr. Needham fhould ever take the filaments of the moiftened grains for any thing elfe than a vegetable production, a true fpecies of mouldinefs.

On the 25th of May, Fahrenheit's thermometer 70°, Mr. Ellis boiled a potatoe in the New River water till it was reduced to a mealy confiftence. He put part of it, with an equal proportion of the boiling liquor, into a cylindrical glafs veffel, that held fomething lefs than half a wine pint, and covered it clofe immediately with a glafs cover. At the fame time he fliced an unboiled potatoe, and, as near as he could judge, put the fame quantity into a glafs veffel of the fame kind, with the fame proportion of New River water not boiled, and covered it with a glafs cover, and placed both veffels clofe to each other.

On the 26th of May, twenty-four hours afterwards, he examined a fmall drop of each by the firft magnifier of Wilfon's microfcope, whofe focal diftance is reckoned at $\frac{1}{50}$ part of an inch; and, to his amazement, they were both full of animalcula of a linear fhape, very diftinguifhable, moving to and fro with great celerity; fo that there appeared to be more particles of animal than vegetable life in each drop.

This experiment he repeatedly tried, and always found it to fucceed in proportion to the heat of the circumambient air; fo that even in winter, if the liquors are kept properly warm, at leaft in two or three days the experiment will fucceed.

The

The animalcula are infinitely ſmaller than ſpermatic animals, and of a very different ſhape; the truth of which every accurate obſerver will ſoon be convinced of, whoſe curioſity may lead him to compare them, and he is perſuaded they will find they are no way akin.

Having learnt from Mr. De Sauſſure, of Geneva, that he found one kind of theſe animalcula infuſoria that increaſe by dividing acroſs into nearly two equal parts, and that the infuſion was made from hemp-ſeed, he procured a quantity of this ſeed, ſome of it he put into New River water, ſome into diſtilled water, and ſome into very hard pump water; the reſult was, that in proportion to the heat of the weather, or the warmth in which they were kept, there was an appearance of millions of minute animalcula in all the infuſions; and, ſome time after, ſome oval ones made their appearance; theſe were much larger than the firſt, which ſtill continued; theſe wriggled to and fro in an undulatory motion, turning themſelves round very quick all the time that they moved forwards.

Mr. Ellis found out, by mere accident, a method to make their fins appear very diſtinctly, eſpecially in the larger kind of animalcula, which are common to moſt vegetable infuſions, ſuch as the terebella. This has a longiſh body, with a cavity or groove at one end, like a gimlet: by applying a ſmall ſtalk of the horſeſhoe geranium, (or geranium zonale of Linnæus) freſh broken, to a drop of water in which theſe animalcula are ſwimming, we ſhall find that they will become torpid inſtantly, contracting themſelves into an oblong oval ſhape, with their fins extended like ſo many briſtles all round their bodies. The fins are

From this period, to the year 1736, the microſcope appears not to have received any conſiderable alteration, but the ſcience itſelf to have been at a ſtand. The improvements which were making in the reflecting teleſcope, naturally led thoſe who had turned their thoughts this way, to expect a ſimilar ſervice for microſcopes on the ſame principles: accordingly we find two plans of this kind; the firſt was that of Dr. Robert Barker. This inſtrument is entirely the ſame as the reflecting teleſcope, excepting the diſtance of the two ſpeculums, which is lengthened, in order to adapt it to thoſe pencils of rays which enter the teleſcope diverging; whereas, from very diſtant objects, they come in a direction nearly parallel. But this was ſoon laid aſide, not only as it was more difficult to manage, but alſo becauſe it was unfit for any but very ſmall or tranſparent objects: for the object being between the ſpeculum and the image, would, if it were large and opake, prevent a due reflection of light on the object.

The ſecond was contrived by Dr. Smith.* In this there were two reflecting mirrors, one concave, and the other convex; the image was viewed by a lens. This microſcope, though far from being executed in the beſt manner, performed, ſays Dr. Smith, very well, ſo that he did not doubt but what it would have excelled others, if it had been properly finiſhed.

As ſome years are more favorable to the fruits of the earth, ſo alſo ſome periods are more favorable to particular ſciences, being rich in diſcovery, and cultivated with ardor. Thus, in the year

6 1738,

* Dr. Smith's Optics, Remarks, p. 94.

in length about half the diameter of the middle of their bodies. Before he difcovered this expedient, he tried to kill them by different kinds of falts and fpirits; but though they were deftroyed by this means, their fins were fo contracted, that he could not diftinguifh them in the leaft. After lying in this ftate of torpidity for two or three minutes, if a drop of clean water be applied to them, they will recover their fhape, and fwim about immediately, rendering their fins again invifible.

It is one of the wonders of the modern philofophy to have invented means for bringing creatures, fo imperceptible as the various animalcula, under our cognizance and infpection. One might well have deemed an object that was a thoufand times too little to affect our fenfe, as perfectly removed from human difcovery; yet we have extended our fight over animals to whom thefe would be mountains. In reality, the greater number of microfcopic animalcula are of fo fmall a fize, that through a lens, whofe focal diftance is the tenth part of an inch, they only appear as fo many points; that is, their parts cannot be diftinguifhed, fo that they appear from the vertex of that lens under an angle not exceeding the minute of a degree. If we inveftigate the magnitude of fuch an object, it will be found nearly equal to $\frac{3}{100000}$ of an inch long. Suppofing, therefore, thefe animalcula to be of a cubic figure, that is, of the fame length, breadth, and thicknefs, their magnitude would be expreffed by the cube of the fraction $\frac{3}{100000}$, that is, by the number $\frac{27}{1000000000000000}$, that is, each animalculum is equal to fo many parts of a fquare inch. This contemplation of animalcula has rendered the idea of indefinitely fmall bodies very familiar to us; a mite was formerly thought the limit of littlenefs, but we are not now furprized to be be told of animals many millions of times ſmaller than a mite; for there are ſome animalcula ſo ſmall, that, upon calculation, the whole earth is not found large enough to be a third proportional to theſe little animals, and the wha e in the ocean.* Theſe conſiderations are ſtill further heightened, by reflecting on the internal ſtructure of animalcula, for each muſt have all the proportion, ſymmetry, and adjuſtment of that organized texture, which is indiſpenſibly neceſſary for the ſeveral functions of life, and each muſt be furniſhed with proper organs, tubes, &c. for ſecreting the fluids, digeſting it's food, and propagating it's ſpecies.

Having thus given a general idea of the properties of animalcula, we now proceed to deſcribe the various individuals, following the arrangements of O. F. Müller,† and giving the reader the diſcriminating characters by which he has diſtinguiſhed them, abridging, enlarging, or altering the deſcriptions, to render them in ſome inſtances more exact, in others leſs tedious, and upon the whole I hope, more intereſting to the reader.

A METHODICAL DIVISION OF THE ANIMALCULA INFUSORIA.

I. Thoſe that have no external organs.

1. Monas: punctiforme. A mere point.

2. Proteus: mutabile. Mutable.

3. Volvox:

* Cyclopedia Britannica, Art. Animalcule.

† Müller Animalcula Infuſoria, Fluviatilia et Marina.

3. Volvox: fphæricum. Spherical.

4. Enchelis: cylindraceum. Cylindrical.

5. Vibrio: elongatum. Long.

* Membranaceous.

6. Cyclidium: ovale. Oval.

7. Paramæcium: oblongum: Oblong.

8. Kolpoda: finuatum. Sinuous.

9. Gonium: angulatum. With angles.

10. Burfaria. Hollow like a purfe.

II. Thofe that have external organs.

* Naked, or not inclofed in a fhell.

1. Cercaria: caudatum. With a tail.

2. Trichoda: crinitum.

3. Kerona: corniculatum. With horns.

4. Himantopus: cirratum. Cirrated.

5. Leu-

5. Leucophra: ciliatum undique. Every part ciliated.

6. Vorticella: ciliatum apice. The apex ciliated.

* Covered with a shell.

7. Brachionus: ciliatum apice. The apex ciliated.

I. MONAS.

Vermis inconspicuus, simplissimus, pellucidus, punctiformis. An invisible,* pellucid, simple, punctiform worm.

1. Monas Termo.

Monas gelatinosa. Gelatinous Mona.

Animalcules semblable a des points, spall. op. phys. I. p. Bullæ continuo motu, Bonanni obs. p. 174.

Among the various animalcula which are discovered by the microscope, this is the most minute, and the most simple; a small jelly-like point, eluding the powers of the compound microscope, and being but imperfectly seen by the single; these, and some others of the mona kind, are so delicate and slender, that it is no wonder they often escape the sight of many who have examined infusions with attention; in a full light they totally disappear

* By invisible we only mean that they are too small to be discerned by the naked eye.

difappear, their thin and tranfparent forms blending as it were with the water in which they fwim.

Small drops of infufed water are often fo full of thefe, that it is not eafy to difcover the leaft empty fpace, fo that the water itfelf feems changed into another fubftance lefs tranfparent, but confifting of an innumerable number of globular points, thick fown together. In this a motion may be perceived, fomething fimilar to that which is obferved when the fun's rays fhine on the water, the animalcula being violently agitated, or in a commotion like unto a hive of bees. It is very common in ditch water, and in almoft all infufions, both of animal and vegetable fubftances.

2. Monas Atomus.

Monas albida puncto, variabili inftructa, Plate XXV. Fig. 1. White mona, with a variable point.

This animalculum appears as a white point, which, when it is highly magnified, is fomewhat of an egg fhape; the fmaller end is generally marked with a black point, the fituation of this is fometimes varied, and found at the other end of the animalculum; fometimes two black points are to be feen croffing the middle of the body.

It was found in fea water that had been kept the whole winter; it was not, however, very fœtid; there were no other animalcula in the fame water.

3. Monas

3. Monas Punctum.

Monas nigra. A black mona.

A very minute point, ſolid, opake and black, round and long. They are diſperſed in the infuſion, and move with a ſlow wavering motion; were found in a fœtid infuſion of pears.

4. Monas Ocellus.

Monas hyalina puncto centrali notata. Tranſparent like talc, with a point in the middle.

The margin black, and a black point in the middle; it moves irregularly, is found in ditches covered with conferva, and frequently with the cyclidium milium.

5. Monas Lens.

Monas hyalina. Tranſparent mona, of a talcy appearance.

This is among the number of the ſmaller animalcula, nearly of a round figure, and ſo pellucid, that it is not poſſible to diſcover the leaſt veſtige of inteſtines. Though they may often be ſeen ſeparate, yet they are more generally collected together, forming a kind of veſicular or membranaceous maſs. Contrary to the cuſtom of other animalcula, they ſeek the edges of the evaporating water, the conſequence of which is almoſt immediate death. When the water is nearly evaporated, a few dark ſhades are perceived, probably occaſioned by the wrinkling of the body.

A ſlow tremulous motion, confined to one ſpot, may be perceived at intervals; this in a little time becomes more lively, and ſoon pervades the whole drop.

It's motions are, in general, very quick; two united together may ſometimes be ſeen ſwimming among the reſt; while in this ſituation they have been miſtaken by ſome writers for a different ſpecies, whereas it is the ſame generating another by diviſion.

It is to be found in all water, though but ſeldom in that which is pure; they are in great plenty in the ſummer in ditch water, alſo in infuſions of animal or vegetable ſubſtances, made either of freſh or ſalt water, myriads being contained in a drop; numbers, of various ſizes, are to be found in the filth of the teeth.

The animalcula of this and the firſt ſpecies are ſo numerous as to exceed all calculation, though they are contained in a very confined ſpace.

6. Monas Mica.

Monas, circulo notata. Mona, marked with a circle.

This lucid little point may be diſcovered with the third lens of the common ſingle microſcope, when the magnifying power is increaſed; it appears either of an oval or ſpherical figure, for it aſſumes either at pleaſure. It is tranſparent, and has a ſmall ellipſe inſcribed as it were within it's circumference; this ellipſe is moveable, being ſometimes in the middle, ſometimes a little towards the fore-part, at others nearer the hind-part.

5 There

There is a confiderable variety in it's motions; it often turns round for a long time in the fame place; an appearance like two kidneys may fometimes be perceived in the middle of the body, and the animalculum is beautifully encompaffed with a kind of halo, arifing, moft probably, from invifible and vibrating hairs.

They are to be found in the pureft waters.

7. Monas Tranquilla.

Monas ovata, hyalina, margine nigro. Egg-fhaped, tranfparent mona, with a black margin.

Thefe animated points feem to be nearly fixed to one fpot, where they have a vacillatory motion. They are frequently furrounded with a halo, and differ in their figure, being fometimes rather fpherical, at others quadrangular. The black margin is not always to be found, and fometimes one would almoft be tempted to think it had a tail. It is found in urine which has been kept for a time. The urine is covered, after it has remained in the veffel, with a dark-coloured pellicule, in which thefe animals live: although the urine was preferved for feveral months, no new animalcula were obferved therein. It has been already fhewn, that a drop of urine is in general fatal to other animalcula, yet we find that it has animated beings of a peculiar kind, appropriated to, and living in it.

8. Monas Lamellula.

Monas, hyalina compreſſa. Flat tranſparent monas.

This is moſtly found in ſalt water. It is of a whitiſh colour, more than twice as long as it is broad, tranſparent, with a dark margin, the motion vacillatory; it often appears as if double.

9. Monas Pulviſculus.

Monas hyalina, margini virente. Tranſparent mona, with a green margin.

Little ſpherical pellucid grains, of different ſizes, the circumference green, a green bent line paſſes through the middle of ſome, probably indicating that they are near ſeparating, or dividing, into two diſtinct animalculum; ſometimes three or four, at others ſix and ſeven, or even more, are collected together. They rove about with a wavering motion, and are moſtly found in the month of March in marſhy grounds.

10. Monas Uva.

Monas hyalina gregaria. Tranſparent gregarious monas.

It is not eaſy to decide on the nature of theſe little aſſemblages of corpuſcles, which ſometimes conſiſt of five, at other times of four, and frequently of many more; the corpuſcles are of different ſizes, according to the number collected in one group. When collected

collected in a heap, the only motion they have is a kind of revolution, or rolling round. The fmaller particles feparate from the larger, often dividing into as many portions as there are conftituent particles in the group; when feparated, they move about with incredible fwiftnefs.

To try whether this was a group of animalcula collected together by chance, or whether it was their natural ftate to be thus grouped together, the following experiment was made. A fingle corpufcle was taken the moment it was feparated from the heap, and placed in a glafs by itfelf; it foon increafed in fize, and when it had attained nearly the fame bulk as the group from which it was feparated, the furface began to affume a wrinkled appearance, which gradually changed till it became exactly fimilar to the parent group. This new-formed group was again decompofed, like the preceding one, and in a little time the feparated particles became as large as that from which they proceeded.

It is found in a variety of infufions.

II. PROTEUS.

Vermis inconfpicuus, fimpliciffimus, pellucidus, mutabilis. An invifible, very fimple, pellucid worm, of a variable form.

11. Proteus Diffluens.

Proteus in ramulos diffluens, Fig. 2 and 3, Plate XXV. Proteus, branching itfelf out in a variety of directions.

A very

1738, Mr. Lieburkuhn's invention of the folar microfcope was communicated to the public: the vaft magnifying power which was obtained by this inftrument, the coloffal grandeur with which it exhibited the minima of nature, the pleafure which arofe from being able to difplay the fame object to a number of obfervers at the fame time, by affording a new fource of rational amufement, increafed the number of microfcopic obfervers, who were further ftimulated to the fame purfuits by Mr. Trembley's famous difcovery of the polype: the wonderful properties of this little animal, together with the works of Mr. Trembley, Baker, and my father, revived the reputation of this inftrument. *

Every optician now exercifed his talents in improving (as he called it) the microfcope; in other words, in varying it's conftruction, and rendering it different from that fold by his neighbour. Their principal object feemed to be, only to fubdivide the inftrument, and make it lie in as fmall a compafs as poffible; by which means, they not only rendered it complex, and troublefome in ufe, but loft fight alfo of the extenfive field, great light, and other excellent properties of the more ancient inftruments; and in fome meafure, fhut themfelves out from further improvements on the microfcope. Every mechanical inftrument is fufceptible of almoft infinite combinations and changes, which are attended with their relative advantages and difadvantages: thus, what is gained in power, is loft in time; " he that loves to be confined to a fmall houfe, muft lofe the benefit of air and exercife."

 The

* Trembley Memoires fur les Polypes. Baker's Microfcope made Eafy; Attempt towards an Hiftory of the Polype; Employment for the Microfcope. Adams's Micrographia Illuftrata. Joblot's Obfervations d'Hiftoire Naturelle.

A very ſingular animalculum, appearing only as a grey mucous maſs; it is filled with a number of black globules, of different ſizes, and is continually changing it's figure. Being formed of a gelatinous pellucid ſubſtance, the ſhape is eaſily altered, and it puſhes out branches of different lengths and breadths. The globules which are within divide and paſs immediately into the new-formed parts, always following the various changes of form in the animalcula. The changes that are obſerved in the form of this little creature, do not ariſe from any extraneous cauſe, but are entirely dependent on it's internal powers.

It is to be met with but very ſeldom; the indefatigable Muller only ſaw it twice, although he examined ſuch an immenſe variety of infuſions.

It is to be found in fenny ſituations.

12. Proteus Tenax.

Proteus in ſpiculum diffluens, Fig. 4 and 5, Plate XXV. Proteus, running out into a fine point.

A gelatinous pellucid body, ſtored with black molecules; it changes it's form like the preceding, but always in a regular order, firſt extending itſelf out in a ſtrait line, the lower part terminating in an acute bright point, without any inteſtines, and the globules being all collected in the upper part, it next draws the pointed end up towards the middle of the body, ſwelling it into a round form. The contraction goes on for ſome time, after which the lower

lower part is ſwelled out as it is repreſented in Fig. 4; the point is afterwards projected from this ventricoſe part. It paſſes through five different forms before it arrives at that which is ſeen at Fig. 4. It ſcarcely moves from one ſpot, only bending about ſideways. It is to be found in river water, where the C nitida grows,—a the tail, c the head, d the protuberant ſwelling.

III. VOLVOX.

Volvox inconſpicuus ſimpliciſſimus, pellucidus, ſphæricus. An inviſible, very ſimple, pellucid, ſphærical worm.

13. Volvox Punctum.

Volvox ſphæricus, nigricans, puncto lucido. Spherical, of a black colour, with a lucid point.

A ſmall globule; one hemiſphere is opake and black, the other has a pellucid cryſtalline appearance; a vehement motion is obſervable in the dark part. It moves in a tremulous manner, and often paſſes through the drop, turning round as if upon an axis. Many may be often ſeen joined together in their paſſage through the water, they ſometimes move as in a little whirlpool, and then ſeparate. It is found in great numbers on the ſurface of fœtid ſea water.

14. Vol-

14. Volvox Granulum.

Volvox fphæricus, viridis, peripheria hyalina. Sphærical and green, the circumference of a bright colour.

There feems to be a kind of green opake nucleus in this animalculum; the circumference is tranfparent. It is to be found generally in the month of June, in marfhy places; it moves but flowly.

15. Volvox Globulus.

Volvox globofus, poftice fubobfcurus. Globular volvox, the hinder part fomewhat obfcure.

This globular animalculum is ten times larger than the mona lens; it verges fometimes a little towards the oval in it's form. The inteftines are juft vifible, and make the hinder part of the body appear opake; it has commonly a flow fluttering kind of motion, but if it is difturbed the motion is more rapid.

It is found in moft infufions of vegetables.

16. Volvox Pilula.

Volvox fphæricus, interaneis immobilibus virefcentibus. Small round volvox, with immoveable green inteftines.

This is a fmall tranfparent animalculum; it's inteftines are immoveable, of a green colour, and are placed near the middle of the

the body, the edges often yellow; a ſmall obtuſe inciſion may be diſcovered on the edge, which is, perhaps, the mouth of the animalculum. This little creature appears to be encompaſſed with a kind of halo, or circle. If this is occaſioned by the vibratory motion of any fringe of hairs, they are inviſible to the eye, even when aſſiſted by the microſcope.

It ſeems to have a kind of rotatory motion, at one time ſlow, at another quick, and is to be found in water where the lemna minor grows, ſometimes as late as the month of December.

17. Volvox Grandinella.

Volvox ſphæricus, opacus, interaneis immobilibus. Spherical and opake, with immoveable inteſtines.

This is much ſmaller than the preceding, and is marked with ſeveral circular lines; no motion is to be perceived among the interior molecules. It ſometimes moves about in a ſtrait line, ſometimes it's courſe is irregular, at others it keeps in the ſame ſpot, with a tremulous motion.

18. Volvox Socialis.

Volvox ſphæricus, moleculis cryſtallinis, æqualibus diſtantibus, Spherical volvox, with cryſtalline molecules, placed at equal diſtances from one another.

When very much magnified, this animalculum feems to have fome relation to the vorticella focialis, as feen with the naked eye. It confifts of cryftalline molecules, difpofed in a fphere, and filling up the whole circumference; they are all of an equal fize. Whether they are included in a common membrane, or whether they are united by one common ftalk, as in the vorticella focialis, has not been difcovered. We are alfo ignorant of the exact figure of the little particles of which it is compofed; when a very large magnifying power is ufed, fome black points may be difcerned in the center of the cryftalline molecules. The motion is fometimes rotatory, fometimes from right to left, and the contrary. It is found where the chara vulgaris has been kept.

19. Volvox Sphæricula.

Volvox fphæricus, moleculis fimilaribus rotundis. Spherical volvox, with round molecules.

This fpherule is formed of pellucid homogeneous points, of different fizes. It moves flowly about a quarter of a circle from right to left, and then back again from left to right.

20. Volvox Lunula.

Volvox hemifphæricus, moleculis fimilaribus lunatis. An hemifpherical volvox, with lunular molecules. Fig. 7, Plate XXV.

Is

Is a ſmall roundiſh tranſparent body, compoſed of innumerable molecules, homogeneous, pellucid, and of the ſhape of the moon in it's firſt quarter, without any common margin.

It is in a continual twofold motion; the one of the whole maſs turning ſlowly round, the other of the molecules one among the other. They are found in marſhy places in the beginning of ſpring.

21. Volvox Globator.

Volvox ſphæricus membranaceus. Spherical membranaceous volvox.

This is a tranſparent globule, of a greeniſh colour; the fœtus is compoſed of ſmaller greeniſh globules. It becomes whiter and brighter with age, moves ſlowly round it's axis, and may be perceived by the naked eye.

But to the microſcope the ſuperficies of this pellucid membrane appears covered with molecules, as if it were granulated, which has occaſioned ſome obſervers to imagine it to be hairy; the round pellucid molecules that are fixed in the center are generally largeſt in thoſe that are young. The exterior molecules may be wiped off, leaving the membrane naked.

When the young ones are of a proper ſize, the membrane opens, and they paſs through the fiſſure; after this, the mother melts away. They ſometimes change their ſpherical figure, the ſuperficies being flattened in different places.

3 N 2 Moſt

Moſt authors ſpeak of finding eight leſſer globules within the larger; but Muller ſays, that he has counted thirty or forty of different ſizes. This wonderful incapſulation of it's progeny is well known; indeed it often exhibits itſelf big with children and grandchildren.

Leeuwenhoeck was the firſt who noticed this curious animalculum, and depicted it; a circumſtance which has not been mentioned by Baker and other microſcopic writers who have deſcribed it. It may be found in great plenty in ſtagnant waters in ſpring and ſummer, and in infuſions of hemp-ſeed and tremella.

It is thus deſcribed by Mr. Baker. This ſingular minute water animal, ſeen before the microſcope, appears to be exactly globular, without either head, tail, or fins. It moves in all directions, forwards or backwards, up or down, rolling over and over like a bowl, ſpinning horizontally like a top, or gliding along ſmoothly without turning itſelf at all. Sometimes it's motions are very ſlow, at other times very ſwift; and when it pleaſes it can turn round as upon an axis very nimble, without moving out of it's place. The body is tranſparent, except where the circular ſpots are placed, which are probably it's young. The ſurface of the body in ſome is as it were dotted all over with little points, and in others as if granulated like ſhagreen. Mr. Baker thought alſo that in general it appeared as if it was ſet round with ſhort moveable hairs.

By another writer they are thus deſcribed. Theſe animalcula are at firſt very ſmall, but grow ſo large as to be diſcerned with the naked eye; they are of a yellowiſh green colour, globular figure, and in fubftance membranaceous and tranfparent; in the midft of this fubftance feveral fmall globes may be perceived; each of thefe are fmaller animalcula, which have alfo their diaphanous membrane, and contain within themfelves ftill fmaller generations, which may be diftinguifhed by the affiftance of very powerful glaffes. The larger globules may be feen to efcape from the parent, and then increafe in fize, as we have already obferved.

22. Volvox Morum.

Volvox membranaceus orbicularis, centro moleculis fphæricis viridibus. Membranaceous orbicular, with fpherical green molecules in the center.

This animalculum has fome refemblance to the volvox uva, but is fufficiently diftinguifhed by the furrounding bright orbicular membrane. The middle part is full of clear green globules. The globules feldom move, though a quivering motion may fometimes be perceived at the center. It has a flow rotatory motion, and is found amongft the lemna, in the months of October and December.

23. Volvox Uva.

Volvox globofus, moleculis fphæricis virefcentibus nudis. Globular volvox, compofed of green fpherical globules, which are not inclofed in a common membrane.

This

This animalculum feems to be a kind of medium between the volvox pillula and the gonium pectorale, being like the one compofed of green fpherules, and in form refembling the other.

It confifts of a congeries of equal globules of a greenifh colour, with a bright fpot in the middle; the whole mafs is fometimes of a fpherical form, fometimes oval, without any common membrane; a kind of halo may be perceived round it, but whether this is occafioned by the motion of any invifible hairs has not been difcovered. The mafs generally moves from right to left, and from left to right; fcarce any motion can be difcovered in the globules themfelves. It was found in the month of Auguft, in water where the lemna polyrrhiza was growing. Two maffes of thefe globules have been feen joined together. They contain from four to fifty of the globules, of which a folitary one may now and then be found.

24. Volvox Vegetans.

Volvox ramulis fimplicibus & dichitomis, rofula globulari terminatis. A volvox with fimple dichitomous branches, terminating in a little bunch of globules.

It confifts of a number of floccofe opake branches, which are invifible to the naked eye; at the apex of thefe there is a little congeries of very minute oval pellucid corpufcles. Muller at firft thought it to be a fpecies of microfcopic and river fertularia; but afterwards he found the bunches quitting the branches, and fwimming about in the water with a proper fpontaneous motion. Many old branches were found deferted of their globules, while the

the younger branches were furnished with them. It was found in river water in November 1779 and 1780.

IV. ENCHELIS.

Vermis inconfpicuus, fimpliciffimus, cylindraceus. An invifible, fimple, cylindric worm.

25. Enchelis Viridis.

Enchelis fubcylindrica, antice oblique truncata. Green enchelis, of a fubcylindric figure, the fore-part truncated.

This is an opake, green, fubcylindric animalculum, with an obtufe tail, the fore-part terminating in an acute truncated angle; the inteftines obfcure and indiftinct.

It is continually varying in it's motion, turning from right to left.

26. Enchelis Punctifera.

Enchelis viridis, fubcylindracea, antice obtufa, poftice acuminata, Fig. 8, Plate XXV. Green enchelis, fubcylindric, the fore-part obtufe, the hinder-part pointed.

It is an opake animalculum, of a green colour; there is a fmall pellucid fpot in the fore-part a, in which two black points may be feen; a kind of double band, c c, croffes the middle of the body. The hinder part is pellucid and pointed; an incifion is

The microſcope, nearly at the ſame period, gave riſe to M. Buffon's famous ſyſtem of organic molecules, and M. Needham's incomprehenſible ideas concerning a vegetative force and the vitality of matter. M. Buffon has dreſſed up his ſyſtem with all the charms of eloquence, preſenting it to the mind in the moſt agreeable and lively colours, exerting the depths of erudition in the moſt intereſting and ſeducing manner, to eſtabliſh his hypotheſis, making us almoſt ready to adopt it againſt the dictates of reaſon, and the evidence of facts. But whether this great man was miſled by the warmth of his imagination, his attachment to a favorite ſyſtem, or the uſe of imperfect inſtruments, it appears but too evident, that he was not acquainted with the objects whoſe nature he attempted to inveſtigate; and it is probable, that he never ſaw * thoſe which he ſuppoſed he was deſcribing, continually confounding the animalculæ produced from the putrifying decompoſition of animal ſubſtances, with the ſpermatic animalculæ, although they are two kinds of beings, differing in form and nature; ſo that the beautiful fabric attempted to be raiſed on his hypotheſis, vaniſhes before the light of truth and well conducted experiments.

After this period, the mind, either ſatisfied with the diſcoveries already made, (which will be particularly deſcribed hereafter) or tired by it's own exertions, ſought for repoſe in other purſuits; ſo that for ſeveral years this inſtrument was again, in ſome meaſure,

* Porro Buffonius, ut cum illuſtris viri venia dicam omnino non videtur, vermiculos ſeminales vidiſſe. Diuturnitas enim vitæ quam ſuis corpuſculis tribuit, oſtendit non eſſe noſtra animalcula (id eſt, ſpermatica) quibus brevis et paucarum horarum vita eſt. Haller Phyſiol. tom. 7.

is difcoverable at the apex of the fore-part, which feems to be the mouth. When in motion, the whole of it appears opake and green. Is found in marfhes.

27. Enchelis Defes.

Enchelis viridis, cylindrica, fubacuminata gelatinofa. Green, cylindrical, gelatinous, the ends fomewhat pointed.

The body is round, the colour a very dark green, fo that it is quite opake; the fore-part is bluntly rounded off, the hinder part is fomewhat tapering, but finifhes with a rounded end. From it's opacity, no internal parts can be difcovered; there is a degree of tranfparency near the ends.

It is exceeding idle, moving very flowly; to be found, though rarely, in an infufion of lemnæ.

28. Enchelis Similis.

Enchelis obovato-opaca, interaneis mobilibus. Enchelis of an egg-fhape, opake, with moveable inteftines.

It is an opake body, with a pellucid margin; both extremities are obtufe, but the upper one much more fo than the under one; it is filled with moveable fpherules. It's motion is generally quick, either to the right or the left; it is probably furnifhed with hairs, becaufe, when moving rapidly, the margin appears ftriated. It is found in water that has been kept for months.

29. En-

29. Enchelis Serotina.

Enchelis ovato-cylindracea, interaneis immobilibus. Enchelis partly oval, partly cylindrical, the interior parts immoveable.

An oval animalculum, round, the fore-part ſmaller than the hind-part, the margin of a black colour; it is replete with grey veſicular molecules, and moves ſlowly.

30. Enchelis Nebuloſa.

Enchelis ovato-cylindracea, interaneis manifeſtis mobilibus. Oval and cylindric enchelis, with viſible moveable inteſtines.

The body is ſhaped like an egg, the fore-part narrow, and often filled with opake confuſed inteſtines; in moving, it elevates the fore-part of the body. It is found in the ſame water as the cyclidium glaucoma, but is three times larger, and an hundred times more ſcarce.

31. Enchelis Seminulum.

Enchelis cylindracea æqualis. Enchelis equally cylindric.

It is a cylindrical animalculum, twice as long as it is broad, the fore and hind-part of the ſame ſize; the inteſtines in the fore-part are pellucid, thoſe in the hinder-part obſcure. It moves by aſcending and deſcending alternately. It may be ſeen ſometimes ſwimming about with the extremities joined together. Found in water that has been kept for ſome days.

32. Enchelis Intermedia.

Enchelis cylindracea, hyalina, margine nigricante. Cylindrical enchelis, tranſparent, with a blackiſh margin.

This animalculum forms an intermediate kind between the monas punctum, the enchelis ſeminulum, and the cyclidium milium. It is one of the ſmalleſt among the animalcula. The body is tranſparent, it has no viſible inteſtines, the fore and hind-part are of an equal ſize, the edge of a deeper colour than the reſt of the body; a point is to be ſeen in the middle of ſome of them, in others it is as if a line paſſed through the middle.

33. Enchelis Ovulum.

Enchelis cylindrico-ovata hyalina. Egg-ſhaped tranſparent enchelis.

A tranſparent, round, egg-ſhaped animalculum; nothing is diſcovered within ſide, even by the third magnifier; but with an increaſed power ſome long foldings may be ſeen on the ſuperficies, and here and there a few bright molecules.

34. Enchelis Pirum.

Enchelis inverſe conica, poſtice hyalina. Pear-form enchelis, the hinder-part tranſparent.

This

This enchelis is lively and pellucid, the fore-part is protuberant, and filled with molecules, the hinder-part ſmaller and empty; it has moveable molecular inteſtines. It's motion is rapid, paſſing backwards and forwards through the diameter of the drop. When at reſt, it ſeems to have a little ſwelling, or tubercle, on the middle of the body.

35. Enchelis Tremula.

Enchelis ovato-cylindracea, gelatina. Oval enchelis, cylindrical, gelatinous.

This is alſo to be placed amongſt the moſt minute animalcula; the end of it is rather pointed, and has a tremulous motion; it almoſt induces one to think it has a tail. Two of theſe little creatures may at times be perceived to adhere together. It was found in an infuſion with the paramæcia aurelia, and many other animalcula.

36. Enchelis Conſtricta.

Enchelis obovata, cryſtallina, medio coarctata. Suboval enchelis, cryſtalline, with a ſtricture in the middle.

An animalculum of an oval ſhape, the middle part drawn in, as if a ſtring was tied round it. It is of a very ſmall ſize, and is found in ſalt water.

37. Enchelis Pulvifculus.

Enchelis eliptica, interaneorum congerie viridi. Of an eliptic fhape, with a congeries of green inteftines.

It is a round animalculum, pellucid, the fore-part obtufe, the hind-part rather fharp, marked with green fpots; myriads may fometimes be feen wandering about in one drop; it is found among the green matter on the fides of the veffels in which water has been kept for fome time.

38. Enchelis Fufus.

Enchelis cylindracea, utraque extremitate anguftiore truncata. Cylindrical enchelis, both ends truncated.

The body is round and transparent, the fore and hind-part fmaller than the reft of the body, and equally fo, the ends a little truncated. In the infide a long and fomewhat winding inteftine, a fky-coloured bright fluid, and fome black molecules tranfverfely fituated, may be difcerned.

It's motions are languid; was found in pure water.

39. Enchelis Fritillus.

A cylindric enchelis, the fore-part truncated.

This

This is one of the most transparent animalcula; the hinder-part of an obtuse convexity, the fore-part truncated. Muller suspects that there is a rotatory organ in the fore-part. No intestines can be seen. It runs backwards and forwards through the drop in a diametrical line, with a wavering motion; sometimes turns round for a moment, but presently enters on it's usual course. Is found in an infusion of grass and hay.

40. Enchelis Caudata.

Enchelis elongata, antice obtusa, postice in caudam hyalinam attenuata, Fig. 9, Plate XXV. Enchelis with a long body, the fore-part obtuse, the hinder-part diminishing into a kind of tail.

The body is of a grey colour, pellucid, with globular molecules divided from each other, and dispersed through the whole body; the fore-part, a, thick and obtuse, the hind-part, b, crystalline and small, the end truncated. It is but seldom met with.

41. Enchelis Epistomium.

Enchelis cylindrico-elongata, apice gracili subgloboso. Enchelis with a long cylindric body, the fore-part slender and roundish.

It

It is among the fmaller animalcula; the body is cylindrical and bright, the hind-part obtufe, the fore-part fmaller, and terminating in a globule; a black line may now and then be perceived down the middle of it.

42. Enchelis Gemmata.

Enchelis cylindracea, ferie globulorum duplici, in collum hyalinum producta. Enchelis with a cylindrical body, the upper part prolonged into a tranfparent neck, a double feries of globules running down the body. It's motion is flow, and generally in a ftrait line; it is found in ditch-water where the lemna thrives.

43. Enchelis Retrograda.

Enchelis hyalina, antice anguftata, apice globulari. Tranfparent enchelis, the fore-part rather fmaller, and terminating in a fmall globule, Fig. 11 and 12, Plate XXV.

It has a gelatinous tranfparent body; no vifible inteftines, though a pellucid globule is difcoverable near the hinder part; the body is thickeft in the middle, and grows fmaller towards each end. It generally moves fide-ways, fometimes in a retrograde manner; and if it is obftructed in it's motion, draws itfelf up as it is reprefented at Fig. 11.

44. Enchelis Feftinans.

Enchelis cylindrica oblonga, obtufa, antice hyalina. Oblong cylindrical enchelis; the ends obtufe, the fore-part tranfparent.

The

The body is round, of an equal ſize throughout, and both ends obtuſe; more than half the length is without any viſible inteſtines, the lower end full of veſicular, pellucid, minute globules; a large globular veſicle is alſo to be found in the fore-part; it moves quickly from one ſide to the other, in a vacillatory manner. It was found in ſea-water.

45. Enchelis Farcimen.

Enchelis cylindracea curvata utrinque truncata. A cylindric enchelis, crooked and truncated at both ends.

The body of this is cylindrical, about four times longer than it is wide, even, truncated at both ends, the inteſtines opake, and not to be diſtinguiſhed; it turns the extremities oppoſite ways, ſo as to form the figure of an S. It is to be found in water that has ſtood for ſome time, though but ſeldom. Joblot found it in an infuſion of blue bottles; it moves in an undulatory manner, but very ſlowly.

46. Enchelis Index.

Enchelis inverſe conica, apicis altero angulo producto. Enchelis in the form of an inverted cone, one edge of the apex produced out ſo as to form an angle with the other part.

The body rather opake, of a grey colour, and of a long conical figure; the lower end obtuſe, the fore-part thick, one ſide of this part projecting like a finger from the edge; two very ſmall projections proceed alſo ſometimes from the lower end.

This animalculum has the power of retracting these projections, and making both ends appear obtuse. It moves about but slowly, and was found in water with the lemna minor.

47. Enchelis Truncus.

Enchelis cylindrica, subcapitata. Fig. 10. Plate XXV. Cylindrical enchelis with a kind of head.

This is the largest of this kind of animalcula; the body is cylindrical, mucose, grey, long and rather opake, the fore-part globular, the hind-part obtuse. Something like three teeth (c) may be sometimes seen to proceed from one of the sides; it can alter it's shape considerably. Globules of different sizes may be seen within the body. It rolls about slowly from right to left.

48. Enchelis Larva.

Enchelis elongata, medio papillula utrinque notata. A long enchelis, with two little nipples projecting from the middle of the body, one on each side.

It is long, round, and filled with grey molecules; the fore-part is obtuse and pellucid; a kind of neck, or small contraction, is formed at some little distance from this end. The lower part pointed, about the middle of the body there are two small projections.

49. En-

49. Enchelis Spatula.

Enchelis cylindrica ſtriata, apice hyalino-ſpatulata. A cylindrical ſtriated enchelis, the fore-part tranſparent, and of the ſhape of a ſpatula.

This animalculum is perfectly cylindrical, very pellucid, of a cryſtalline appearance; it is marked with very fine longitudinal furrows, and has generally two tranſparent globules, one placed below the middle, the other near the extremity of the body; on the other ſide are five ſmaller ones, which are oval. The top is dilated, with the corners rounded like the ſpatula of the apothecaries. It has a wavering kind of motion, folding the ſpatula variouſly, yet retaining the form in general. Muller mentions his ſeeing it once draw the ſpatula into the body, and keep it there for two hours, when it again appeared.

50. Enchelis Pupula.

A cylindric enchelis, the fore-part papillary.

The fore-part is protuberantly round, and rather opake, the hind-part pellucid, both extremities obtuſe, furniſhed with a papillary finger-ſhaped head, the hinder-part marked with a tranſparent circle, or circular aperture. The fore-part filled up with moveable molecules, which are more ſcarce in the hinder-part. It has a rotatory motion on a longitudinal axis, and moves through the water in an oblique direction. It is to be found in dunghill water in November and December.

ſure, laid aſide. In 1770, Dr. Hill * publiſhed a treatiſe, in which he endeavours to explain the conſtruction of timber by the microſcope, and ſhew the number, the nature, and office of it's ſeveral parts, their various arrangements and proportions in the different kinds; and point out a way of judging, from the ſtructure of trees, the uſes they will beſt ſerve in the affairs of life. So important a ſubject ſoon revived the ardor for microſcopic purſuits, which ſeems to have been increaſing ever ſince. About the ſame time, my father contrived an inſtrument for cutting the tranſverſe ſections of wood, in order that the texture thereof might be rendered more viſible in the microſcope, and conſequently be better underſtood; this inſtrument was afterwards improved by Mr. Cumming. Another inſtrument for the ſame purpoſe, more certain in it's effects, and more eaſily managed, is repreſented in fig. 1, plate 9; it will be deſcribed in one of the following chapters. Dr. Hooke and Mr. Cuſtance now endeavoured to bring back the microſcope nearer to the old ſtandard, to increaſe the field by the multiplication of the eye glaſſes, and to augment the light on the object, by condenſing lenſes; and in this they happily ſucceeded: Mr. Cuſtance was unrivalled in his dexterity in preparing, and accuracy in cutting thin tranſverſe ſections of wood.

In 1771, my father publiſhed a fourth edition of his Micrographia, in which he deſcribed the principal inventions then in uſe; particularly a contrivance of his own, for applying the ſolar microſcope to the camera obſcura, and illuminating it at night by a lamp,

* Dr. Hill on the Conſtruction of Timber.

51. Enchelis Pupa.

Enchelis ventricoſo-cylindrica, apice in papillam producta. Enchelis forming a kind of ventricoſe cylinder, with a ſmall nipple proceeding from the apex.

It is not unlike the preceding animalculum, but is much larger; the anterior end not ſo obtuſe, the nipple gradually formed from the fore-part, all but this end is opake, and filled with obſcure particles: it has no tranſparent circle, as was obſerved in the enchelis pupula. It is exceeding ſlothful.

V. VIBRIO.

Vermis inconſpicuus, ſimpliciſſimus, teres, elongatus. An inviſible worm, very ſimple, round, and rather long.

52. Vibrio Lineola.

Vibrio linearis minutiſſimus. Very ſmall linear vibrio.

This is one of the moſt minute animalcula, ſurpaſſing in ſlenderneſs the monas termo. The greateſt magnifier exhibits little more than a tremulous motion of myriads of little oblong obſcure points. In a few days it almoſt fills the whole ſubſtance of the water in vegetable infuſions.

53. Vibrio

53. Vibrio Rugula.

Vibrio linearis flexuofus. Vibrio like a bent line.

Myriads of this fpecies may be found; it is between the vibrio lineola and the vibrio undula.

It appears as a little line, which is fometimes drawn up in an undulated fhape, and moves backwards and forwards in a ftrait line, often without bending the body at all.

54. Vibrio Bacillus.

Vibrio linearis, æqualis utrinque truncata. Linear vibrio, equally truncated at both ends.

This is an exceeding fmall creature, but vifible with the third lens; in a certain pofition of the light tranfparent. It is gelatinous, and not half fo large as the monas lens, though fix, and fometimes ten times longer; it is every-where of an equal fize, and has no vifible inteftines; it's action is languid, the ferpentine flexures of the body are with great difficulty perceived.

Muller made two infufions of hay in the fame water, and at the fame time in the one he put the hay whole, in the other it was cut in fmall pieces; in the firft there was none of the vibrio bacillus, but many of the monas lens and kolpoda cucullus; in the latter, many of vibrio bacillus, and few of the monæ.

55. Vibrio Undula.

Vibrio filiformis flexuofus. A filiform flexuous vibrio.

A perfect undulating little line, round, gelatinous, without any visible inteftines. It is never ftrait; when at reft it refembles the letter V, when in motion the letter M, or a bending line like that which geefe form in their flight through the air; it's motions are fo rapid, that the eye can fcarce follow them. It generally refts upon the top of the water, fometimes it fixes itfelf obliquely by one extremity, and whirls itfelf round.

This is the little creature that Leeuwenhoeck fays exceeds in flendernefs the tail of the animalculum feminale, which he has defcribed in Fig. 5, Epif. Phyf. 41, being an hundred times lefs than a muftard-feed, and on which he makes the following very juft obfervation: That as thefe very fmall animalcula can contract and varioufly fold their little tails, we muft conclude that tendons and mufcles are as neceffary to them as to other animals; if to this we add the organs of fenfation, and thofe of the inteftines, the mind is loft in the aftonifhment which arifes from the impreffion of infinite, in the indefinitely fmall.

56. Vibrio Serpens.

Vibrio filiformis, ambagibus in angulum obtufum productis. A filiform vibrio, the windings or flexures obtufe.

A flen-

A ſlender gelatinous little animal, in the form of a long ſerpentine line, all the bendings being nearly equal in ſize, and at equal diſtances; it generally moves in a ſtrait line; an inteſtine may be diſcovered down the middle. It is to be found in river water, but is not commonly to be met with.

57. Vibrio Spirillum.

Vibrio filiformis, ambagibus in angulum acutum tornatis. Filiform vibrio, twiſted ſomething like a ſpiral wire, or cork-ſcrew; the bending acute.

It is an exceeding minute ſingular little creature, twiſted in a ſpiral form; the ſhape of theſe bendings remains the ſame even when the animal is in motion, not occaſioned by any internal force, but are it's natural ſhape. It moves generally in a ſtrait line, vibrating the hind and fore-part. It was found in 1782, in an infuſion of the ſonchi arvenſis.

58. Vibrio Vermiculus.

Vibrio tortuoſus gelatinus. This little vibrio is twiſted and gelatinous.

The body is white, or rather of a milky appearance, cylindric, long, the apex obtuſe, rather growing ſmaller, and twiſted towards the hind-part. It's motion is languid and undulatory, like that of the common worm; it ſometimes moves quicker, but with ſeeming labour. When it bends itſelf alternately from one ſide to the other, a black long line may be diſcovered, ſometimes whole, ſometimes broken: when at reſt, it occaſionally twiſts into various folds.

It may be obſerved eaſily with the firſt lens of the ſingle microſcope, and is probably the ſame animalculum mentioned by Leeuwenhoeck in all his works, as found in the dung of frogs, and in the ſpawn of the male libellula. It is to be found in marſhy water in November, though but ſeldom.

59. Vibrio Inteſtinum.

Vibrio gelatinoſus, teres, antice anguſtatus. This vibrio is gelatinous, round, the fore-part ſmall.

It is cylindric, milk-coloured, and ſlender towards the top, both ends obtuſe; no traces of inteſtines to be diſcovered, though four or five ſpherical eggs are perceived at the extremity of the hind-part. It can draw the fore-part ſo much inwards as to give it a truncated and dilated appearance, ſomething like a ſpatula. It's motion is ſlow and progreſſive. They are found in marſhy waters.

60. Vibrio Bipunctatus.

Vibrio linearis, æqualis, utraque extremitate truncata, globulis binis mediis. Linear vibrio, of an equal ſize throughout, both ends truncated, and two ſmall globules in the middle of the body.

It is of a ſmall ſize, and rather leſs than the following animalculum, the body of a pellucid talc-like appearance, the fore and hind-

hind-part truncated; in the middle are two (ſometimes there is only one) pellucid globules, placed lengthways. It moſt commonly moves forwards in a ſtrait line; it's movements are ſlow. It was found in ſtinking ſalt water.

61. Vibrio Tripunctatus.

Vibrio linearis, utrinque attenuatus, globulis tribus, extremis minoribus. Linear vibrio, both the ends ſmaller than the middle, furniſhed with three globular points, the two which are at the extremities being ſmaller than that at the middle.

The body is pellucid, talcy, each of the ends rather tapering, furniſhed with three pellucid globules, the middle one is the largeſt, the ſpace between theſe globules is generally filled with a green matter; in ſome there is nothing of the green ſubſtance near the extremities, but only about the middle. It ſeldom moves far, and then it's motion is rectilinear, backwards and forwards.

62. Vibrio Paxilifer.

Vibrio flaveſcens paleis gregariis multifariam ordinatis, Fig. 13, 14, 15, Plate XXV. Yellow, gregarious, ſtraw-like vibrio.

This is a wonderful animalculum, or rather a congeries of animalcula. It is inviſible to the naked eye, and conſiſts of a tranſparent membrane, with yellow inteſtines, and two or three viſible points; they are generally found collected together in different parcels,

parcels, from seven to forty in number, and ranged in a variety of forms, sometimes in a strait line, as in Fig. 14, then forming the concave Figure 13, at others moving in a zig-zag direction, as in Fig. 15; when at rest, they are generally in a quadrangular form, and found in great plenty with the ulva latissima.

As this animalculum seems to have some affinity with the hair-like animal of Mr. Baker, I think the reader will be better pleased to see his description of it introduced in this place, than to have it raised into a new and distinct species.

This little animal is extremely slender, and not uncommonly one hundred and fifty times longer than broad. It's resemblance to an hair induced Mr. Baker to call it the hair-like insect. The body, or middle part, which is nearly strait, appears in some composed of such parallel rings as the windpipe of land animals consists of, but seems in others scaled, or rather made up of rings that obliquely cross each other. It's two ends are bent, or hooked, pretty nearly in the same degree, but in a direction contrary each to the other; and as no eyes can be discerned, it is difficult to judge which is the head or tail.

It's progressive motion differs from that of all animals hitherto described, for notwithstanding the body is composed of many rings and joints, it seems unable to bend them, or move directly forwards; but when it is inclinable to change it's quarters, it can move from right to left, or left to right, and proceed at the same time backwards or forwards obliquely; and this it performs by turning upon one end as a center, and describing with the other the quarter of a circle, then it does the same with the other end, and

and ſo alternately, whereby it's progreſſion is in a diagonal line, or from corner to corner; as whoever will take the trouble to ſhift the points of a pair of compaſſes in that manner, may immediately be ſatisfied.

All it's motions are extremely ſlow, and require much patience and attention in the obſerver. It has neither feet, nor fins, nor hairs, but appears perfectly ſmooth and tranſparent, with the head bending one way, and the tail another, ſo as to be like a long Italic *S*; nor is any internal motion, or particularly opake part, to be perceived, which may determine one to ſuppoſe it the ſtomach, or other of the inteſtines.

Theſe creatures are ſo ſmall, that millions of millions might be contained in an inch ſquare. When viewed ſingly, or ſeparated from one another, they are exceedingly tranſparent, and of a lovely green; but, like all other tranſparent bodies, when numbers of them are brought together they become opake, and loſe their green colour in proportion as the quantity increaſes, till at laſt they appear entirely black.

Notwithſtanding the extreme minuteneſs of theſe animalcula, they ſeem to be fond of ſociety; for on viewing for ſome time a parcel of them taken up at random, they will be ſeen to diſperſe themſelves in a kind of regular order. If a multitude of them are put into a jar of water, they will form themſelves into a regular body, and aſcend ſlowly to the top, where, after they have remained ſome time expoſed to the air, their green colour changes to a beautiful ſky-blue. When they are weary of this ſituation, they form themſelves into a kind of rope, which ſlowly deſcends as low as they intend.

A ſmall quantity of the matter containing theſe creatures having been put into a jar of water, it ſo happened, that one part went down immediately to the bottom, whilſt the other continued floating on the top. After ſome time, each of theſe ſwarms of animalcula began to grow weary of it's ſituation, and had a mind to change it's quarters. Both armies, therefore, ſet out at the ſame time, the one proceeding upwards, and the other downwards; ſo that after ſome hours journey they met in the middle. A deſire of knowing how they would behave on this occaſion engaged the obſerver to watch them carefully, and to his ſurprize he ſaw the army that was marching upwards open to the right and left, to make room for thoſe that were deſcending. Thus without confuſion or intermixture, each held on it's way, the army that was going up marching in two columns to the top, and the other proceeding in one column to the bottom, as if each had been under the direction of wiſe leaders.

63. Vibrio Lunula.

Vibrio arcuatus, utraque extremitate æquali, Fig. 16. Bow-ſhaped vibrio, both ends of an equal ſize.

The body reſembles much the ſhape of the moon at the firſt quarter; it is of a green colour, and has generally from ſeven to ten globules diſpoſed lengthways; the ſmaller ones are of a very pale colour, a pale green vacuity may ſometimes be ſeen in the middle: ſome little varieties may be obſerved amongſt them, which

which are not eaſy to be deſcribed; it will be enough to have given the reader their general and diſtinguiſhing characteriſtics.

64. Vibrio Verminus.

Vibrio linearis compreſſus, antice quam poſtice anguſtior. Linear compreſſed vibrio, the fore-part narrower than the hind-part.

A round tranſparent animalculum, or rather a long cryſtalline membrane, the hind-part broader than the fore-part, the apex ſubtruncated, the baſe obtuſe, no perceptible inteſtines, in the middle are two ſpherical veſicules, and a third towards the lower edge. It moves quickly, with an undulatory motion, backwards and forwards; they ſeem to be joined in a very ſingular manner, and are found in great plenty in ſalt water that had been kept ſome days, and was fœtid.

65. Vibrio Mallæus.

Vibrio linearis baſi globuli, apice linea tranſverſa. A linear vibrio, with a globule at the baſe, and tranſverſe line at the apex.

This is a white pellucid animalculum, reſembling the letter T, with a globule affixed to the baſe.

It is in motion and at reſt every moment alternately; when in motion it reſembles the letter V, when at reſt the letter T. They are found plentifully in ſpring water.

 66. Vibrio

a lamp, by which means a picture of microscopic objects might be exhibited in winter evenings.

It appears * from the testimony of M. Æpinus, that M. Lieburkuhn had considerably improved the solar microscope, by adapting it to view opake objects. This contrivance was by some means lost. The knowledge, however, that such an effect had been produced, led Æpinus to attend to the subject himself, in which he in some measure succeeded, and would, no doubt, have brought it to perfection, if he had increased the size of his illuminating mirror. Some further improvements were made on this instrument by M. Ziehr; but the most perfect instrument of the kind, is that of Mr. B. Martin, who published an account of it in the year 1774. † The common solar microscope does not shew the surface of any object, whereas the opake solar microscope not only magnifies the object, but exhibits on a screen an expanded picture of it's surface, with all it's colours, in a most beautiful manner.

About the year 1774, I invented the improved lucernal microscope; this instrument does not in the least fatigue the eye; it shews all opake objects in a most beautiful manner; and transparent objects may be examined by it in various ways, so that no part of an object is left unexplored; and the outlines of all may be taken with ease, even by those who are most unskilled in drawing.

M. L.

* Priestley's Hist. of Optics, p. 743.

† Martin's Description and Use of an Opake Solar Microscope.

66. Vibrio Acus.

Vibrio linearis, colli, apice obtufo, cauda fetacea. Linear vibrio, with a neck, the upper extremity obtufe, the lower one terminating in a fetaceous tail.

This vibrio is of the fhape of a fewing needle; the neck round, partly tranfparent, and marked in the middle with a red point; the trunk cylindrical, the edges obfcure, the middle bright, and nearly of a triangular appearance, the tail is fine like a briftle. A motion may be obferved in the infide of this little creature. It does not bend the body when in motion.

67. Vibrio Sagitta.

Vibrio fublinearis, colli, apice truncato atro, cauda fetacea. Somewhat linear in it's appearance, a well-marked neck, the apex truncated and open, the tail fetaceous.

The body is very long and flexible, broadeft towards the middle, which is alfo filled with grey molecules; the fore-part is drawn out into a ftrait tranfparent neck, the upper end of it thick and black. The motion of this animalculum feems to be produced by the contraction and extenfion of the neck. It is found in falt water.

68. Vibrio

68. Vibrio Gordius.

Vibrio æqualis, caudæ apice tuberculato. Vibrio of an equal ſize throughout, the tail terminated by a little tubercle.

A round animalculum; the fore-part for about one-ſixth of the whole length is tranſparent, and furniſhed with a ſky-coloured alimentary tube; the lower part is bright and pointed, the middle full of ſmall globules; a ſmall knob terminates the tail. Found in an infuſion made with ſalt water.

69. Vibrio Serpentulus.

Vibrio æqualis utrinque ſubacuminatus. This vibrio is of an equal ſize, rather pointed at both ends.

It is very ſimilar to the vibrio anguillula, differing principally in the ſhape of the ends, which in this are pointed. It does not adhere to objects by the pointed tail; it is furniſhed with a long row of the moſt minute points.

It's motion is ſerpentine, ſometimes to be met with perfectly ſtrait and ſtill, and is found in infuſions of vegetables after ſome weeks ſtanding; it is of a whitiſh colour, the whole body is frequently convoluted, and drawn into different figures.

70. Vibrio

70. Vibrio Coluber.

Vibrio filiformis, ſeta caudali geneculata. Filiform vibrio, the tail ſetaceous, and bending up nearly to form a right angle with the body.

In this vibrio the mouth, the oeſophagus, the molecules in the inteſtines, and the twiſting thereof, are very conſpicuous. The tail is exceeding ſmall, and bent ſo as to form a conſiderable angle with the body. It is found in river water.

71. Vibrio Anguillula.

Vibrio æqualis ſubrigidus. Vibrio of an equal ſize throughout, and ſomewhat hard.

This animalculum may be divided into four varieties, if not diſtinct ſpecies, namely, the anguillula aceti, glutinis farinoſi, aquæ dulcis, et aquæ marini.

Anguillula Aceti. Vinegar Eel.

Chaos redivivum, Lin. Syſt. Nat. 1326.
Leeuwenhoeck Op. Omn. p. 3, n. 1, f, l, o.
Joblot Obſ. Micr. 1, p. 2, pl. 2.
Hook's Micr. p. 25, fig. 2.
Borelli Obſ. Micr. 1, p. 7.

Power's

Power's Micr. Obf. p. 38.
Baker's Empl. for Micr. p. 10, fig. 8 and 9.
——— Micr. Expl. p. 81, pl. 5, fig. 10.
Adams Micr. Illuf. pl. 32, fig. 197, A, B, C, D.
Rozier Journal Phyfique, Mars 1775, Janv. & Mars 1776.
Spallanzani Opus, Phy. part 1, p. 83.

Anguillula Glutinis. Pafte Eel.

Chaos redivivum, Lin. Syft. Nat. 1326.
Ledermuller Micr.
Baker Micr. Exp. p. 82.
Roz. Journal Phyfique, Mars 1775, Mars 1776.
Adams Micr. Illuf.

The body is filiform, or like a thread, round, pellucid, replete with little grains in the middle, both extremities very pellucid and empty, the fore-part a little truncated, the hind-part terminating in a very fhort briftly point. It is the fame in every age and fize.

Anguillula Fluviatalis.

Coreulum vermiculo fimile Lin. amæn (mund. invis).
Needham Micr. p. 99, pl. 5, fig. 7.
Baker Micr. Expl. p. 80, pl. 5, fig. 9.
Anguille vulgaire, Rozier Journal Phyfique, 1775.
Mars, Nov. 1776.
Ibid, anguille du bled Rachitique.
Ibid, anguille du faux ergot.
Spallanz. Opufc. Phyf. part 2, page 354, pl. 5, fig. 10.

The

The body of this is exceedingly tranſparent; no viſible entrails, though a few tranſverſe lines may be diſcovered on the body. It is ſometimes, though rarely, furniſhed with a long row of little globules, and often with two ſmall oval ones; the tail terminates in a point.

Muller ſays he found theſe eels in the ſediment which is formed by vegetables on the ſides of veſſels in which water has been kept for ſome time.

The eels of paſte have been more diſtinguiſhed than moſt other animalcula, as well on account of the various ſpeculations and theories to which it has given riſe, as their many curious properties. Four different ſpecies of eels may be found in paſte; of the firſt, which has been deſcribed very briefly in page 511, we ſhall now give a more particular deſcription. To be certain of procuring theſe eels, boil ſome flower in water, to which you have added a few drops of vinegar, provide an earthen pot which has a hole at the bottom, fill it with earth, and then put the paſte in a piece of coarſe cloth, and bury it in this earth; the pot is to be expoſed to the ſun in the ſummer, or kept in a warm place in the winter; by this means you will very ſeldom fail of finding in ten or twelve days a large quantity of eels in the paſte.

This eel, when at it's full growth, is about one-tenth of an inch long, and rather leſs than one-hundredth of an inch in diameter. Fig. 6, Plate XI. repreſents one of theſe eels magnified about one hundred and twenty times, only compreſſed ſo much between two plates, by means of an adjuſting ſcrew, as not only to prevent it from moving, but to lengthen and flatten it in a ſmall

4 degree.

degree. At the upper part there are two little moveable pieces, or nipples, *a* a, between which an empty ſpace *b* is formed, that terminates in the mouth; the hinder-part is round, but there projects from it a ſhort ſetaceous tail *w*; in the young eels the termination of the tail is not ſo abrupt as in the preſent ſpecimen, but it finiſhes by a gradual diminution. There is probably a vent near z, for the paſſage of the excrements; becauſe when that part has been gently preſſed, two or three jets, of a very ſubtle ſubſtance, have been obſerved to iſſue from it. If the preſſure is increaſed, a ſmall bladder will be forced out, a further compreſſion burſts the bladder, and the bowels are forced through the opening.

A greater degree of magnifying power is neceſſary to obtain an exact idea of the viſcera of theſe eels. Fig. 10 repreſents the alimentary duct (further magnified) from it's origin to the belly. It is ſhewn here as ſeparated from the animal, which is eaſily effected; for nature, aſſiſted by very little art, performs the operation. The oeſophagus, b c, Fig. 6 and 10, at it's origin a a, is very ſmall, but ſoon grows larger, as at c, and forms a kind of oblong bag, c d; the diameter of this increaſes till it comes to d, where it ſwells out as at d e f; it then grows ſmaller till it comes to g, when it again ſwells out as g k l. There is a narrow neck at i, which in it's natural ſtate is ſeen in the bag k l. The part k l is the ſtomach. M. Becli has ſhewn, that the alimentary duct of many ſpecies of worms is formed of two bags, one of which is incloſed within the other. It is the ſame with this animalculum; the little veſſel b c, that we have called the oeſophagus, which is the origin of the bag c d, enters into the ſame bag, and preſerves it's form within it, till it comes to m,

3 R from

from whence it is prolonged in the form of a black line m n n, which paſſes by the axis of the duct e e h, and apparently terminates itſelf at the beginning of the abdomen k. To this tube, near the center of the ſwelling g h i, are fixed two ſmall tranſparent bodies; that end of theſe which is connected with the tube is round, the other end is pointed; theſe ſmall pieces cannot be diſcerned in every poſition of the eel.

We muſt now ſhew how this duct is to be forced out of the eel. The body, when compreſſed, generally burſts either at the head or tail, and always at that part which is leaſt preſſed; hence when the maſs of fluids contained in the body is forced towards the anterior part, they meet with a reſiſtance in paſſing from the abdomen to the duct already deſcribed; the abdomen being forced by the fluids which are made to act againſt it, burſts at the upper part, and the fluids ſtriking againſt the neck g h i, force it, with all it's contents, out of the body, through an opening at the anterior part; on leſſening the preſſure, the bowel, thus diſcharged, will float in the water between the two plates of glaſs.

Not to enter into a detail of thoſe parts which have been ſuppoſed by ſome writers to conſtitute the heart, &c. of theſe minute animalcula, it will be ſufficient here to deſcribe thoſe in which motion may be diſcovered, and to leave the reſt to future obſervations on the ſubject. The parts which may be ſeen in motion within theſe minute creatures are, 1. the ſmall tube, or duct, from it's origin at m, to the two appendages; 2. theſe appendages themſelves; 3. the remainder of the tube, from the appendages to the inſertion at the ventricule k; 4. in the ſwelling g k l. The reſt of this duct, from the beginning by the

4 oeſopha-

oesophagus b c, to the second swelling, has no motion. There is a variety in the motions of the first part of this duct, sometimes it dilates and contracts, at other times it has an oscillatory motion. It is difficult to gain a good view of the appendages, but when the position of the little creature is favorable, they seem to have a two-fold motion, by which the pointed ends approach to, and then separate from each other, and another by which they move up and down. The part g k l moves backwards and forwards alternately, the motion of each of these parts is independent of the rest. These are the principal parts, whose motion is connected with the life of the animal.

The other viscera that are contained in the body of the eel, and which may be observed by the aid of the microscope, are the vessels which contain the food, those which are filled with a transparent substance, and the womb, or ovary. The first form the abdomen and intestines; these are filled with a black substance, which prevents their being properly and clearly distinguished; these vessels, in their passage through the posterior part of the body, form an empty space, in which we may perceive that one side of the animalculum is occupied by the ovary q q q, which runs from j to u x; it is at these two extremities of the ovaries that the eggs begin to be formed, for the largest eggs are always to be found in the middle, and the smallest at the ends, as may be seen at j f and u x.

All the eels which bear eggs have two protuberances, y y, formed on the exterior part, near the center of the ovary; it appears like a transparent semicircular membrane, but is really a kind of hernia, or bag, in which one or two eggs may be sometimes ſeen; all the larger eels have this appendage, which alſo bears the marks of having been burſt. Now as the younger eels have not this appendage, nor any marks of a rupture, we may reaſonably conclude that it is from hence that the little eels iſſue from the parent.

In the latter part of the year, and during the winter, theſe eels are oviparous, and the young eels may be ſeen to proceed from the egg; at other times they are viviparous, ſix live eels have been ſeen at one time in the belly of the parent, twenty-two eggs have been counted in the ovary. M. Muller ſuſpected that there was a difference of ſex in ſome of theſe animalcula, but it was left to M. Roffredi to afford the proof, and it was only from a variety of repeated obſervations that he could allow himſelf to be convinced of this truth. He continued his reſearches upon the ſame ſubject on other microſcopic eels, and has ſince been able to diſtinguiſh the ſexual parts of the vinegar eels.

The next eel we ſhall deſcribe is the eel of vinegar, Fig. 7, and that becauſe it is oviparous and viviparous; like the preceding it is filiform, but in other reſpects they differ conſiderably. It is longer, not near ſo large, the tail is ſmaller, and more tapering than that of the paſte eel; it moves with much greater eaſe, and is more lively. We may obſerve in ſmall, at the tail of this eel, what may be ſeen at large at the beginning of the viper's tail, a little kind of tongue a b, which ſometimes adheres to the ſkin, at other times is ſeparated from it. An alimentary duct may be eaſily diſcovered, but no other inteſtines can be diſcerned, without deranging altogether the organization of the animalculum.

The

The ſecond ſpecies of paſte eel is oviparous. It is eaſily diſtinguiſhed from the firſt kind, by being much ſmaller; it is repreſented at Fig. 8. Tne conformation of the alimentary duct and the inteſtines are in general nearly the ſame, though an intelligent obſerver will find out ſome ſpecific differences. By the flexion of the inteſtines c c c, a void ſpace is left a little beyond the middle of the body, where the eggs are collected. There is no exterior protuberance near the ovary, as in the preceding one, but a ſmall hole, l, may be diſcovered, near which are placed two little tubercles f f, though they are very ſeldom to be obſerved without compreſſing the animalcula.

We meet with another eel in paſte, which may with reaſon be called the common eel. It is often to be found in grains placed in the earth, in which the germ is deſtroyed, in the roots and ſtems of farinaceous plants, in the tremella of Adanſon, and in ſeveral ſpecies of conferva, as well as in ſeveral infuſions. This eel, when at it's full growth, is rather longer than the common eel of blighted wheat; one of them is repreſented at Fig. 11. They are eaſily diſtinguiſhed from the eels of blighted wheat, becauſe they have no ranges of globules like it, by the two little protuberances which are near the middle of the body, and by the regular diminution of the tail. It is oviparous.

A very ſmall ſpecies, repreſented at Fig. 9, may alſo be found in paſte; they may be diſtinguiſhed from the young eels of the larger ſort by their vivacity and ſlenderneſs.

OF

M. L. F. Dellebarre publifhed an account of his microfcope in the year 1777. It does not appear from this, that it was fuperior in any refpect to thofe that were then made in England, but was inferior in others; for thofe publifhed by my father in 1771, poffeffed all the advantages of Dellebarre's in a higher degree, except that of changing the eye glaffes.

In 1784, M. Æpinus publifhed a defcription of what he termed new-invented microfcopes, in a letter to the Academie des Sciences de St. Peterfburg;* they are nothing more than an application of the acromatic perfpective to microfcopic purpofes. Now it has been long known to every one who is the leaft verfed in optics, that any telefcope is eafily converted into a microfcope, by removing the object glafs to a greater diftance from the eye glaffes; and that the diftance of the image varies with the diftance of the object from the focus, and is magnified more, as it's diftance from the object is greater: the fame telefcope may, therefore, be fucceffively turned into a microfcope, with different magnifying powers. Mr. Martin had alfo fhewn, in his defcription and ufe of a polydynamic microfcope, how eafily the fmall acromatic perfpective may be applied to this purpofe. Botanifts might find fome advantage in attending to this inftrument; it would affift them in difcovering fmall plants at a diftance, and thus often fave them from the thorns of the hedge, and the dirt of a ditch.

Fig. 1, Plate III. reprefents the improved lucernal microfcope.

Fig.

* Defcription des Nouveaux Microfcopes, inventes par M. Æpinus.

OF THE EELS IN BLIGHTED WHEAT.*

Theſe animalcula were diſcovered by Mr. Needham, and deſcribed by him in a work entitled New Microſcopical Diſcoveries. They are not lodged in thoſe blighted grains which are covered externally with a ſoot-like duſt, (whoſe inſide is often alſo little more than a black powder) but abundance of ears may be obſerved in ſome fields of corn, which have grains that appear blackiſh, as if ſcorched; theſe, when opened, are found to contain a ſoft white ſubſtance, that, when attentively examined, looks like a congeries of threads, or fibres, lying as cloſe as poſſible to each other in a parallel direction, and much reſembling the unripe down of ſome thiſtles. This fibrous matter does not diſcover any ſigns of life or motion, unleſs water be applied to it; the fibres then ſeparate, and prove themſelves to be living creatures.

Theſe eels are in general of a large ſize, and may be ſeen with a common magnifying glaſs, being about one-thirtieth of an inch in length, and one hundred and fortieth broad. Fig. 5 repreſents one of them magnified about one hundred and twenty times; they are in general of a bright cheſnut colour, the extremity a b is whiter and more tranſparent than the reſt of the body. The end a is rather round, the end b is pointed. A diſtinguiſhing mark of theſe little creatures is a row of tranſparent globules, which are placed at intervals through the whole length of the body, beginning at b, where the tranſparency of the fore-part ceaſes, and going on to the extremity c. They are in diameter rather leſs than one-third of the body. Another peculiar mark is

* Bled avorti.

is a ſmall lunular tranſparent ſpace *c* near the middle of the body. This part is tranſparent, and is free from the coloured matter of the inteſtines; there is a neck in the inteſtines near this ſpace, which confines them to one part of the body.

Great care ſhould be taken by the obſerver not to burſt the ſkin of the eels in diſengaging them from the grain, for they never break or burſt of themſelves; but if broke, viſible inteſtines, filled with a black matter, ruſh out of the body, from which little black globules are diſengaged, which ſwim ſlowly about the water, but without any principle of internal motion; when the obſervation is made, immediately after the grains proceed from the eel; but if the eels that are broke are left long in the water, the ſame phænomena will take place, as in other animal and vegetable infuſions. It is owing to not properly attending to theſe circumſtances, that we may attribute many of the fanciful poſitions of M. Needham, which were deduced from ill-conducted experiments, and which, when properly examined, are found to be in a great meaſure falſe.

M. Roffredi ſowed ſome of the grains of this wheat, which ſprang up; but the ear was either wholly or in a great part ſpoiled, being filled with theſe eels. He alſo found them in other parts of the plant; to diſengage them from the plant, it muſt be ſoaked in water, and then compreſſed a little. At firſt ſight theſe eels ſeem to reſemble the foregoing, but a more accurate inſpection ſhews that they have not the ſame curious diſpoſition of the internal globules, nor the ſame tranſparent place in the middle of the body. The inteſtinal bag leaves indeed in theſe an empty ſpace, but it is of an indetermined form. The animalcula from the

the plant are much more lively than thofe which are procured from the dried grains.

The principal phænomena of this kind of blighted wheat is probably owing to thefe animalcula, who prevent the regular circulation of the fap. They increafe in their fize in a certain proportion to the plant, fo that at laft they may be obferved with great eafe by the naked eye, being two-tenths of an inch long, and nearly one-tenth in diameter. Fig. 4 reprefents one of thefe magnified nearly in the fame proportion as Fig. 5; a a the ovary, which may be traced almoft from the lower extremity to the middle of the body, where the body becomes fo opake as to prevent it's being feen any further. The eggs, when arrived at their full growth, are nearly of a cylindric fhape, both ends rounded; towards the extremity b there are two little protuberances d d, through which the eggs are moft probably extruded; thefe protuberances are not always vifible. The eggs are formed of a fine tranfparent membrane; it covers the young eel, which is folded curioufly therein; thefe eggs may often be found in the plant.

A moft fatisfactory view of thefe eels is obtained by examining them with the folar microfcope; it affords one of the moft furprizing and magnificent fpectacles; two generations may be often feen, one which draws near the allotted period of it's exiftence, and another which only begins to enjoy the bleffings of life. Some arrived at their full growth, others quite fmall, &c. In fome we may perceive the young animalcula in motion in the eggs, in others no fuch motion can be obferved; with a variety of of other circumſtances too tedious to enumerate, though they afford great pleaſure to the ſpectator.

One of the moſt remarkable circumſtances in theſe animalcula is the faculty they have of receiving again the powers of life, after having loſt them for a conſiderable time; for inſtance, when ſome of theſe blighted grains, that have been preſerved for many years, have been ſoaked in water for ten or twelve hours, you will find in it living eels of this ſpecies; if the water evaporates, or begins to fail, they ceaſe to move, but on a freſh application will be again revived.

It may be proper to notice here, that according to the obſervations of M. Roffredi, thoſe eels which have done laying of eggs are incapable of being reſuſcitated upon being moiſtened; the ſame ſeems to be alſo the caſe with thoſe that are very young; it is probable they muſt attain a certain age and degree of ſtrength before they are endowed with this wonderful faculty.

In the month of Auguſt, 1743, a ſmall parcel of blighted wheat was ſent by Mr. Needham to Martin Folkes, Eſq. Preſident of the Royal Society, (with an account of his then new diſcovery) which parcel the preſident was pleaſed to give to Mr. Baker, deſiring him to examine it carefully; in order ſo to do, he cut open ſome of the grains that were become dry, took out the fibrous matter, and applied water to it on a ſlip of glaſs, but could diſcern no other motion than a ſeparation of the fibres or threads, which ſeparation he imputed wholly to an elaſticity in the fibres; and perceiving no token of life, after watching them with due care, and repeating the experiment till he was weary, an account thereof was written to Mr. Needham, who having, by trials of his own, found out the cause of this bad success, advised him to steep the grains before he attempted to open them; on doing which, he was very soon convinced of his veracity, and entertained with the pleasing sight of this wonderful phænomenon. At different times after this, Mr. Baker made experiments with grains of the same parcel, without being once disappointed. He soaked a couple of grains in water for the space of thirty-six hours, when believing them sufficiently moistened, he cut one open, and applying some of the fibrous substance to the microscope in a drop of water, it separated immediately, and presented multitudes of the anguillæ, without the least motion or sign of life; but being taught by experience that they might notwithstanding possibly revive, he left them for about four hours, and then examining them again, found much the greatest number moving their extremities pretty briskly, and in an hour or two after they appeared as lively as these creatures usually are. Mr. Folkes, and some other friends, were witnesses of this experiment. We find an instance here that life may be suspended, and seemingly destroyed; that by an exhalation of the fluids necessary to a living animal, the circulations may cease, all the organs and vessels of the body may be shrunk up, dried, and hardened; and yet, after a long while, life may begin anew to actuate the same body, and all the animal motions and faculties may be restored, merely by replenishing the organs and vessels with a fresh supply of fluid. Here is a proof that the animalcula in the grains of blighted wheat can endure having their bodies quite dried up for the space of four years together, without being thereby deprived of their living power.

It

It appears plainly from the foregoing experiments, that when the blighted grains of wheat have been kept a long time, and the bodies of theſe animalcula are conſequently become extremely dry, the rigidity of their minute veſſels requires to be relaxed very gently, and by exceeding ſlow degrees; for we find, that on the application of water immediately to the bodies of theſe animalcula, when taken from the dry grains, they do not ſo certainly revive as they do if the grains themſelves be either buried in earth, or ſteeped in water for ſome time before they are taken out: the reaſon of which moſt probably is, that too ſudden a relaxation burſts their delicate and tender organs, and thereby renders them incapable of being any more employed to perform the actions of life; and indeed, there are always ſome dead ones amongſt the living, whoſe bodies appear burſten, or lacerated, as well as others that lie extended and never come to life.

Some diſcretion is needful to adapt the time of continuing the grains in water or earth, to the age and dryneſs of them; for if they are not opened before they have been too much or too long ſoftened, the animalculum will not only ſeem dead, but will really be ſo. Of the two grains he mentions to have been four years old when put to ſoak, he opened one after it had lain thirty-ſix hours, and the event was as already related: the other was let lie for above a week, and on opening found all the anguillæ near the huſk dead, and ſeemingly in a decayed condition; but great numbers iſſued alive from the middle, and moved themſelves briſkly. Unleſs the huſks are opened to let theſe creatures out after they have been ſteeped, they all inevitably periſh; and when taken out and preſerved in water, if the huſks are left with them

 they

they will die in a few days; but otherwise, they will continue alive in water for several months together, and, should the water dry away, may be revived again by giving them a fresh supply.

As the eels in paste are an object which are so often exhibited in the microscope, it will be proper, before we leave this subject, to inform the reader how he may procure the young eels from the parent animalcula, a discovery which was originally made by Mr. Sherwood, but more particularly pursued and described by Mr. Baker. Take up a very small quantity of paste where these eels abound on the point of a pin, or with a sharpened quill; lay it on a slip of glass, and diluting it well with water, many of them will become visible to the naked eye; then with the nib of a pen, cut to a very fine point, and shaved so thin as to be extremely pliable, single out one of the largest eels, and insinuate the point of the pen underneath it; remove it into a very small drop of water, which you must have ready prepared on another slip of glass. When thus confined, it may easily be cut asunder transversely, by the help of a good eye and steady hand, with a lancet or sharp penknife; or if the eye is deficient, a hand-magnifier will enable almost any-body to perform the operation. As soon as the parts are separated, apply your object to the microscope, and if the division has been made about the middle of the animal, several oval bodies, of different sizes, will be seen to issue forth. These are young anguillæ, of different degrees of maturity, each whereof is coiled up, and included in it's proper membrane, which is of so exquisite a fineness, as to be scarce discernible by the greatest magnifier while it incloses the embryo animal. The largest and most forward break immediately through this delicate integument, unfold themselves, and wriggle about in the water nimbly;

nimbly; others get out, uncoil, and move about more ſlowly; and the leaſt mature continue entirely without motion. The uterus, or veſſel that contains all theſe oval bodies, is compoſed of many annula, or ringlets, not unlike the aſpera arteria of land animals, and it ſeems to be conſiderably elaſtic; for as ſoon as the operation is performed, the oval bodies are thruſt out with ſome degree of violence, by the ſpringing back or action of this bowel. An hundred or upwards of the young ones have been ſeen to iſſue from one ſingle eel, whereby the prodigious increaſe of them may be accounted for, as probably ſeveral ſuch numerous generations are produced in a ſhort time. Hereby we alſo learn that theſe creatures are not only like eels in ſhape, but are likewiſe viviparous, as eels are generally ſuppoſed to be.

There is ſcarce a more entertaining experiment, in which there is but little riſk of being diſappointed; for they ſeem, like earth-worms, to be all prolific, and unleſs by accident you cut one that has brought forth all it's young before, or make your trials when the paſte has been kept a very long time, (in which caſe they have been found ſometimes unfruitful) you may be ſure of ſucceſs.

Anguillula Marina.

This, when preſſed between two plates of glaſs, appears to be little more than a cryſtalline ſkin, with a kind of clay-coloured inteſtines. The fore-part of the body is truncated, the lower part drawn out to a fine point, the reſt of the body is of an equal ſize throughout. The younger ones are filled with pellucid molecular inteſtines.

72. Vibrio

72. Vibrio Linter.

Vibrio ventricoſo-ovatus, collo breviſſimo. Ventricoſe oval vibrio, with a ſhort neck.

This is one of the larger animalcula, of an egg ſhape, pellucid, inflated, ſomewhat depreſſed at top; the apex is prolonged into a moveable cryſtalline neck, the belly is replete with pellucid molecules. It is not very common, but is to be found among the lemnæ.

73. Vibrio Utriculus.

Vibrio teres, antice anguſtatus truncatus, poſtice ventricoſus. Round vibrio, the fore-part narrow and truncated, the lower ventricoſe.

It does not ill reſemble a bottle in ſhape; the belly is replete with molecular inteſtines, the neck bright and clear, the top truncated; in ſome a pellucid point is viſible at the bottom of the belly. It is in an unceaſing, vehement, and vacillatory motion, the neck moving from one ſide to the other as faſt as poſſible.

74. Vibrio Faſciola.

Vibrio antice attenuatus, medio latiuſculus, poſtice acutus. Vibrio with a ſmall fore-part, the middle a little bigger, the hind-part acute.

This

This is a pellucid animalculum, in the middle are the inteſtines in the form of points; an alimentary pipe, which leſſens gradually in ſize, is alſo perceptible.

The motion of it is quick, darting itſelf up and down the water with great velocity. It is found in water juſt looſened from the froſt, and ſeldom elſewhere.

75. Vibrio Colymbus.

Vibrio craſſus, poſtice acuminatus, collo ſubfalcato. Thick vibrio, ſharpened at the end, the neck a little bent.

It is larger than moſt of the vibrios, and not unlike a bird in ſhape. The neck is round, ſhorter than the trunk, of an equal ſize throughout, and of a bright appearance, the apex obtuſe. The trunk is thick, ſomewhat triangular, full of yellow molecules; the fore-part broad, the hinder-part acute, the motion ſlow.

76. Vibrio Strictus.

Vibrio elongatus linearis, anticem verſus attenuatus, apice obtuſo. Vibrio lengthened out almoſt to a line, ſmall towards the fore-part, the apex obtuſe.

The body linear, being a membranaceous bright thread, without any flexure; the hind-part thicker, round, and filled with molecules, excepting juſt the end, where there is a ſmall pellucid

6 empty

Fig. 1, Plate V. repreſents a ſolar opake microſcope.

Fig. 4, Plate VI. is a picture of the common ſolar microſcope.

Fig. 3, Plate IV. is what is uſually called Culpeper's, or the three pillared microſcope.

Fig. 1, Plate IV. the improved double and ſingle microſcope.

Fig. 2, Plate IV. the beſt double conſtructed microſcope.

Fig. 1, Plate VII. A. the common double conſtructed microſcope.

Fig. 3, Plate VIII. a microſcopic teleſcope, or convenient portable apparatus for a traveller.

We cannot conclude this chapter better than with the following obſervations on the microſcope. We are indebted to it for many diſcoveries in natural hiſtory; but let us not ſuppoſe, that the Creator intended to hide theſe objects from our obſervation. It is true, this inſtrument diſcovers to us as it were a new creation, new ſeries of animals, new foreſts of vegetables; but he who gave being to theſe, gave us an underſtanding capable of inventing means to aſſiſt our organs in the diſcovery of their hidden beauties. He gave us eyes adapted to enlarge our ideas, and capable of comprehending a univerſe at one view, and conſequently incapable of diſcerning thoſe minute beings, with which he has peopled every atom of the univerſe. But then he gave properties and qualities to matter of a particular kind, by which it would procure us this advantage, and at the ſame time elevated the under-empty ſpace. The apex is obtuſe, and rather globoſe; it has a power of contracting and drawing in the filiform part.

77. Vibrio Anas.

Vibrio oblongus, utroque fine attenuatus, collo cauda longiore. Oblong vibrio, both ends attenuated, the neck longer than the tail.

The trunk round, oblong, opake, and crammed with molecules. Both the fore and the hind-part is prolonged into a pellucid talcy membrane, which the animalculum has a power of retracting at pleaſure. The neck is longer than the tail, and the tail is more acute than the neck. It is moſt generally found in ſalt water; a ſpecies of them have been found in river water, with a longer neck.

78. Vibrio Cygnus.

Vibrio ventricoſus, collo adunco. Corpulent vibrio, with a crooked neck.

This animalculum is little more than a moſt pellucid line, crooked at top, prominent in the middle, and ſharp at the end; the fore-part, or neck, is equal in length to the reſt of the body, and three times longer than the hind-part, or tail, the intermediate part ſwelling out, and is full of darkiſh molecules and pellucid inteſtines. It is very ſmall, and the moſt ſlothful of all thoſe which move and advance their necks.

79. Vibrio

79. Vibrio Anser. Fig. 27 and 29, Plate XXV.

Vibrio ellipticus, collo longo, tuberculo dorfali. Elliptical vibrio, with a long neck, and a little lump on the back.

It is between the vibrio proteus and vibrio falx, and is diftinguifhed by the lump b, Fig. 29, on the back, placed behind the neck; from this an even long neck (a) proceeds.

The trunk (d) is elliptic, round, and without any lateral inequality, full of molecules, the hind-part fharp and bright, the fore-part produced into a bending neck, that is longer than the body; the apex even and whole, blue canals paffing between the marginal edges, occupying the whole length of the neck; in one of them a vehement defcent of water to the beginning of the trunk is perceivable.

The motion of the body is flow, that of the neck is more lively and flexuous, fometimes fpiral. It is found in water where there is duck-weed.

80. Vibrio Olor. Fig. 28, Plate XXV.

Vibrio ellipticus, collo longiffimo, apice nodofo. Elliptical, with a very long neck, and a knob on the apex.

An animalculum which is continually moving it's lively neck. The form of the body is elliptical and ventricofe, the hind-part fomewhat fharp. It is membranaceous, dilatable, winding varioufly; the hind-part is fometimes replete with darkifh mole-

3 T cules.

cules. The neck (d) is three or four times longer than the body, of an equal ſize throughout, except a ſmall degree of thickneſs at the apex (f) very pellucid. The neck is very lively in it's motions, the body ſlow.

Is found in water that is kept for a long time, and which is full of a vegetable greenneſs.

81. Vibrio Falx.

Vibrio gibboſus, poſtice obtuſus, collo falcato. A gibbous vibrio, the hind-part obtuſe, the neck crooked.

The body is pellucid, elliptical, the fore-part leſſening into a little round bright neck, nearly of the ſame length as the trunk, the hind-part obtuſe. The trunk itſelf is rather rounding or tending to the gibbous, and filled with very ſmall molecules; there are alſo two bright globules, one within the hind extremity, the other in the middle of the body. The immobility of the neck gives it motions much the reſemblance of a ſcythe.

82. Vibrio Intermedius.

Vibrio membranaceus, antice attenuatus, poſtice ſubacutus. Membranaceous vibrio, the fore-part ſmall, the hinder-part ſomewhat acute.

It ſeems to be an intermediate ſpecies between the vibrio falx and the faſciola; it is a thin membrane, conſtantly folded. The whole of it is of a cryſtalline talcy appearance, the middle replete with

with grey particles, of different ſizes; it has all round a diſtinct bright margin, the apex of the neck is truncated, the tail obtuſe.

VI. CYCLIDIUM.

Vermis inconſpicuus, ſimpliciſſimus, pellucidus, complanatus, orbicularis vel ovatus. A ſimple, inviſible, pellucid, flat, orbicular, or oval worm.

83. Cyclidium Bulla.

Cyclidium orbiculare hyalinum. Orbicular bright cyclidium.

A very pellucid white animalculum, or orbicular ſkin, the edges a little darker than the reſt. By the aſſiſtance of the compound microſcope, ſome globular cryſtalline-like inteſtines are juſt perceptible. It moves ſlowly and ſemicircularly. Is found occaſionally in an infuſion of hay.

84. Cyclidium Millium.

Cyclidium ellipticum cryſtallinum. Elliptic and cryſtalline cyclidium.

It is very pellucid, and more ſplendid than chryſtal, membranaceous, elliptical; a line is perceived through the whole length of it, a point in the fore-part, the hinder-part getting darker. It's motion ſwift, fluttering, and interrupted; it is probable that both extremities are ciliated.

85. Cyclidium Fluitans.

Cyclidium ovale cryſtallinum. Oval cryſtalline cyclidium.

This is one of the ſmalleſt animalcula. The body of an oval, or rather a ſuborbicular ſhape, depreſſed, cryſtalline; two ſmall blue ſpaces may be diſcovered, by the aſſiſtance of the microſcope, at the ſides of this little creature.

86. Cyclidium Glaucoma.

Cyclidium ovatum, interaneis ægre conſpicuis. Oval cyclidium, the inteſtines perceived with difficulty.

A pellucid oval body, both ends plain, or an oval membrane, with a diſtinct well-defined edge; the inteſtines, when it is empty, are ſo tranſparent, that they are with difficulty diſcerned; being full, they are manifeſted by their green colour; dark globules are diſcoverable in the middle.

In plenty of water it moves ſwiftly in a circular and diagonal direction; whenever it moves ſlowly it ſeems to be taking in water, the inteſtines are then alſo in a violent commotion. Two of the ſmaller ones may often be perceived cohering to each other, and drawing one another by turns; nor are they ſeparated by death, for they remain united even when the water is evaporated. The unſkilful in obſervation muſt be careful leſt they miſtake the ſhade in a ſingle one for a junction of two, or the junction of two for a copulation, for they generate by diviſion.

87. Cyclidium Nigricans.

Cyclidium oblongiufculum, margine nigricans. Oblong cyclidium, with a black margin.

It is very fmall, pellucid, flat, and with a black margin. With a fmall magnifier it may be miftaken for an enchelis.

88. Cyclidium Roftratium.

Cyclidium ovale, antice mucronatum. An oval cyclidium, the fore-part pointed.

This is an oval, fmooth, and very pellucid animalculum, the fore-part produced into an obtufe point; with this it feels and examines bodies. It is probably ciliated, though the hairs have not been difcovered.

The inteftines are filled with a blue liquor, forming in a tube, which, from the aperture to the middle of the body, is divided into two legs, or branches; beyond the middle there are two little tranfverfe blue lines. The colour fometimes vanifhes, and then only veficular inteftines are difcerned.

89. Cyclidium Nucleus.

Cyclidium ovale, poftice acuminatum. An oval cyclidium, the hind-part pointed.

The

The body is pellucid, depreffed, the fore-part obtufely convex, the hind-part acute, the inteftines veficular, the fore and hind-part on each fide dark. It refembles a grape-feed.

90. Cyclidium Hyalinum.

Cyclidium ovatum, poftice acutum. Oval cyclidium, the hind-part acute.

This cyclidium is oval, flat, and bright, without any vifible inteftines, the hinder-part fomewhat fmaller than the fore-part; it has a tremulous kind of motion.

91. Cyclidium Pediculus.

Cyclidium ovale convexum, fubtus planun. An oval convex cyclidium, the bottom even.

Trembley Polyp. 1. p. 282.

This is a gelatinous white animalculum, the bottom over the back gibbous, the extremities depreffed and truncated, fometimes one end feems cloven into two points, perhaps this is the aperture of the mouth.

It runs upon the hydra pallida as if it had feet, going back again every moment. It is fcarce ever feen but on the arms and the body of the hydra.

92. Cycli-

92. Cyclidium Dubium.

Cyclidium ovale, fupra convexum, fubtus cavum. Oval cyclidium, the upper part convex, the under part concave.

This is one of the larger fpecies, the body is of an oval fhape, one fide is convex, the other is concave, the margin is pellucid, the inner part contains a great number of black molecules.

VII. Paramæcium.

Vermis inconfpicuus, fimplex, pellucidus, membranaceus, oblongus. An invifible, fimple, pellucid, membranaceous, flat worm.

93. Paramæcium Aurelia.

Paramæcium compreffum, verfus anticam plicatum, poftice acutum. Paramæcium compreffed, oblong, folded towards the fore-part, the hinder-part acute.

Volvox Terebella. Ellis.

This is rather a large animalculum, membranaceous, pellucid, four times longer than it is broad, the fore-part obtufe, tranfparent, without inteftines, the hind-part replete with molecules of various fizes; the fold which goes from the middle to the apex is a ftriking characteriftic of the fpecies, forming a kind of triangular

gular aperture, and giving it somewhat the appearance of a gimlet. It's motion is rectilinear, vacillatory, and generally vehement.

They may often be seen cohering lengthways; the lateral edges of both bodies appear bright. They may also sometimes be seen lying on one another by turns, and sometimes cohering by the middle. They live many months in the same water, if it is not renewed. They are to be found in June, in ditches where there is plenty of duck-weed.

94. Paramæcium Chrysalis. Fig. 26, Plate XXV.

Paramæcium cylindraceum, versus anticam plicatum, postice obtusum. Cylindrical paramæcium, folded towards the fore-part, the hinder-part obtuse.

It differs but very little from the preceding, only the ends (a b) are more obtuse; the margin is filled with black globules, and it is an inhabitant of salt water.

95. Paramæcium Versutum.

Paramæcium cylindraceum, postice incrassatum, utraque extremitate obtusum. Cylindrical paramæcium, the lower part thick, and both ends very obtuse.

An oblong body, green, gelatinous, filled with molecules, the lower part thick, the fore-part smaller, both ends obtuse, and may be seen to propagate by division. Is found in ditches.

96. Para-

96. Paramæcium Oviferum. Fig. 25, Plate XXV.

Paramæcium depreſſum, intus bullis ovalibus. Paramæcium depreſſed, with large oval molecules within ſide.

A membranaceous, oval, oblong animalculum, grey, pellucid, having many oval very pellucid corpuſcles (a) diſperſed about the body, and many black grains towards b.

97. Paramæcium Marginatum. Fig. 24, Plate XXV.

Paramæcium depreſſum, griſeum, margine duplici. Paramæcium depreſſed, grey, with a double margin.

This is one of the largeſt of this claſs, flat, elliptical, every part filled with molecules, except the lower end (b), where there is a pellucid veſicle; this animalculum is ſurrounded by a broad double margin; when expiring, a bright ſpiral inteſtine may be ſeen. (a), Fig. 24, the apex, (b) the veſicle, (c) the ſpiral inteſtine.

VIII. KOLPODA.

Vermis inconſpicuus, ſimpliciſſimus, pellucidus, complanatus, ſinuatus. An inviſible, very ſimple, pellucid, flat, crooked worm.

understanding from one degree of knowledge to another, till it was able to discover these assistances for our sight.

It is thus we should consider the discoveries made by those instruments, which have received their birth from an exertion of our faculties. It is to the same power, who created the objects of our admiration, that we are ultimately to refer the means of discovering them. Let no one, therefore, accuse us of prying deeper into the wonders of nature, than was intended for us. There is nothing we discover by their assistance, which is not a fresh source of praise; and it does not appear, that our faculties can be better employed, than in finding means to investigate the works of God.

From a partial consideration of these things, we are very apt to criticise what we ought to admire; to look upon as useless what perhaps we should own to be of infinite advantage to us, did we see a little farther; to be peevish where we ought to give thanks; and at the same time, to ridicule those who employ their time and thoughts in examining what we were, i. e. some of us most assuredly were, created and appointed to study. In short, we are too apt to treat the Almighty worse than a rational man would treat a good mechanic, whose works he would either thoroughly examine, or be ashamed to find any fault with them. This is the effect of a partial consideration of nature; but he who has candor of mind, and leisure to look farther, will be inclined to cry out:

How wond'rous is this scene! where all is form'd
With number, weight, and measure! all design'd

For

98. Kolpoda Lamella.

Kolpoda elongata membranacea, antice curvata.

This animalculum is a pellucid membrane, long and narrow, the hind-part obtufe, narrower, and curved towards the top; no inteftines difcoverable, only a ridge, or fold, going through the middle. It's motion is vacillatory and fingular, moving to and fro on it's edge, not on the flat fide, as is ufual with moft microfcopic animals. It is found in water, but is very feldom to be met with.

99. Kolpoda Gallinula.

Kolpoda oblonga, dorfo antico membranaceo hyalino. Oblong kolpoda, the back towards the fore-part bright and membranaceous.

The apex rather bent, the belly oval, convex and ftriated. It is found in fœtid falt water.

100. Kolpoda Roftrum.

Kolpoda oblonga, antice uncinata. Oblong, the fore-part hooded.

The fore-part is bent into a kind of hook, the hind-part is obtufe, and every-where filled with black molecules. One of the edges, from the fore-part to the middle, is often fo blunted and dilated

dilated that the reſt of the body appears quite ſmooth, and that part thick and triangular. It's motion is ſlow and horizontal. It is to be found in water where there is lemna, but not often.

101. Kolpoda Ochrea.

Kolpoda elongata, membranacea, apice attenuato, baſi in angulum rectum producta. Kolpoda long, membranaceous, the apex attenuated, the baſe bent in a right angle to the body.

A large animalculum, long, and of a ſingular figure, depreſſed, membranaceous, flexible; one edge nearly ſtrait, the other ſomewhat bent, filled with obſcure molecules, and a few little bladders diſperſed here and there; the apex bright and ſmall, the baſe projecting like the human foot from the leg.

102. Kolpoda Mucronata.

Kolpoda membranacea dilatata, antice anguſtata, altero margine inciſa. Membranaceous dilated kolpoda, the fore-part ſmaller than the hind-part, with a ſmall inciſion at one ſide.

This animalculum is a dilated bright membrane, the apex an obtuſe point, a broad marked border running entirely round it; within the margin it is filled with grey molecules, a fleſhy diſc on one ſide, which terminates in a ſplendid little point on the other ſide the diſc. It has a truncated appearance.

103. Kolpoda Triquetra.

Kolpoda obovata depreſſa, altero margine retuſo. Kolpoda nearly of an egg-ſhape, one edge turned back.

This animalculum ſeems to conſiſt of two membranes, the upper ſide flattened, the lower convex; the apex is bent ſo as to form a kind of ſhoulder. It was found in ſalt water.

104. Kolpoda Striata.

Kolpoda oblonga, ſubarcuata depreſſa, candida antice acuminata, poſtice rotundata. Oblong, ſomewhat of a pear-ſhape, white, the fore-part pointed, the hind-part round.

It is very pellucid and white, the upper part rather bent, and terminating in a point, the lower part obtuſely round; at the apex, or mouth, there is a little black pellucid veſicle; when a very great power is uſed, the body appears covered with long ſtreaks; the lower extremity is furniſhed, like many other animalcula, with very ſmall globules. Is to be found in ſalt water.

105. Kolpoda Nucleus.

Kolpoda ovata, vertice acuto. Egg-ſhaped kolpoda, with an acute vertex.

It is of an oval ſhape, the vertex pointed, of a brilliant tranſparency, which renders the viſcera viſible; they conſiſt of a heap of round diaphanous veſicules.

106. Kol-

106. Kolpoda Meleagris.

Kolpoda mutabilis antice uncinata, poſtice complicata. Changeable, with the fore-part like a hook, the hind-part folded up. Fig. 22, Plate XXV.

A moſt ſingular animalculum, of the larger ſpecies; it has a dilated membrane, with the fineſt folds, which it varies and bends in a moment; the fore-part of the body to the middle is clear and bright, the hind-part variouſly folded in tranſverſe elevated plaits, and full of molecules; the apex turned into a hook, the margin ſinuous, and beneath the apex denticulated with three or four teeth; or in ſome which are more beautifully wrought, the edge is obtuſely notched, and ſet with ſtill ſmaller notches; in the hind-part there are twelve or more equal pellucid globules. It moves ſometimes in a ſtrait, ſometimes in a crooked line. Fig. 22, Plate XXV. a the hooked apex, b the denticulated margin, c the ſeries of globules, d the folded part at bottom.

107. Kolpoda Aſſimilis.

Kolpoda depreſſa, non plicatilis apice uncinato, margine antico ad medium, uſque crenulato poſtice, dilatato acutiuſculo. Kolpoda depreſſed, the apex turned in the form of a ſmall hook, the margin of the fore-part notched from the top to the middle, the lower part ſwells out, then diminiſhes again into a ſhort point. It is never folded like the foregoing; it has an elliptic maſs in the middle. It was found on the ſea-coaſt.

108. Kolpoda Cucullus. Fig. 23, Plate XXV.

Kolpoda ovata ventricosa, infra apicem incisa. Egg-shaped ventricose, with an incision in the fore-part.

It is very pellucid, with a well-defined margin, filled with little bright vesicles, differing in number and size. The figure of the most part is oval, the top bent into a kind of an obtuse beak, seldom an acute one, but sometimes oblong. It's intestines are formed of from eight to twenty-four bright little vesicles, these are not conspicuous in the young ones; some have supposed that these were animalcula that had been swallowed by the kolpoda, but Mr. Muller thinks they are the offspring of the kolpoda. In some only one crystalline vesicle occupies the middle of the body. When the water is almost exhaled, and death nigh, it moves more slowly than usual, and protrudes it's offspring with violence.

It moves in general with great vivacity, and in all directions. a the cap or hood, b the incision. It is found in infusions of vegetables, and in fœtid hay. In some few a transparent membranaceous substance may be perceived projecting beyond the beak, and resembling an exuvia; the same may be observed in the enchelis vibrio, and it is probable that a decortation or casting of the skin has place in these animalcula, as well as in insects.

109. Kol-

109. Kolpoda Cucullulus.

Kolpoda oblonga, infra apicem oblique incifa. Kolpoda oblong, with an oblique incifion a little below the apex.

A very pellucid cryftalline animalculum; it is furnifhed with feveral pellucid globules; there is a bending a little beneath the top, which in fome pofitions is very diftinctly feen, in others not. It was obferved in an infufion of the fonchi arvenfis.

110. Kolpoda Cucullio.

Kolpoda ovalis depreffa, infra apicem tantillum finuata. Flat oval kolpoda, with a fmall degree of bending beneath the apex.

This is an oval, or rather an elliptical kolpoda, flat on the upper fide, convex on the under fide, membranaceous and bright, the fore-part clear; from the middle to the hinder-part it is filled with filver-like globules. It often ftretches out the fore-part, and folds it in different pofitions.

111. Kolpoda Ren.

Kolpoda craffa medio finuata. This kolpoda is thick, and curved in the middle.

The body is yellow, thick, and rather opake, even where round, curved a little in the middle, fo as to have the appearance of a kidney; the whole body is filled with molecules. It's motion

tion is quick, vacillatory, and interrupted. If the water in which it ſwims fail, it aſſumes an oval form, is compreſſed, and at laſt burſts. It is found in an infuſion of hay, generally about thirteen hours after the infuſion is made.

112. Kolpoda Pirum. Fig. 20 and 21, Plate XXV.

Kolpoda convexa, ovalis, apice in roſtrum producta. Convex kolpoda, oval, the apex formed into a kind of beak.

The body is uniform and tranſparent, without any ſenſible inequality, the neck rather long, and a little bent; it is of a pale colour, and furniſhed with obſcure little globules. Fig. 20 repreſents this animalculum, 21 the ſame dividing to form another, a the fore-part, b the hind-part, c where it is dividing.

113. Kolpoda Cuneus.

Kolpoda clavata, teres, apice dentata. Clavated kolpoda, round, the apex dentated.

This is a large animalculum, the body white, gelatinous, without any diſtinct viſcera. On the fore-part at one ſide there is a pellucid, bright, ſtriated puſtule; the apex is diſtinguiſhed by three or four teeth, the hinder-part is ſmaller than the fore-part, with an obtuſe termination, which it can bend in a ſpiral form.

IX. Go-

IX. GONIUM.

Vermis inconſpicuus, ſimpliciſſimus, complanatus, angulatus. An inviſible, ſimple, ſmooth, angular worm.

114. Gonium Pectorale. Fig. 17, Plate XXV.

Gonium quadrangulare, pellucidum moleculis ſedecim ſphæricis. This gonium is quadrangular, pellucid, with ſixteen ſpherical molecules.

Theſe ſixteen little oval bodies are nearly equal in ſize, of a greeniſh colour, pellucid, and ſet in a quadrangular membrane, like the jewels in the breaſt-plate of the high-prieſt, reflecting light on both ſides. It's animality is evinced by it's ſpontaneous motion, advancing alternately towards the right and left; theſe little bodies ſeem oval when in motion, round when at reſt; the four interior ones are a little larger than the reſt. Found in pure water.

115. Gonium Pulvinatum.

Gonium quadrangulare, opacum, pulvillis quatuor. Quadrangular, opake, with four little pillows.

This appears under the microſcope as a little quadrangular membrane, plain on both ſides; with a deeper lens it looks like a bolſter, formed of three or four cylindric pillows, flattened or ſunk here and there. Thus it appeared to M. Muller on the firſt examination; ſome days after, all the ſides were plain, without any convexity, and divided into little ſquare ſpaces by lines croſſing each other. Found upon dunghills.

116. Gonium Corrugatum.

Gonium quadrangulare, albidum, medio correptum. Quadrangular gonium, white, ſunk a little in the middle.

It is ſomewhat of a ſquare ſhape, very minute, without any viſible viſcera, a little depreſſed in the middle. It is found in various infuſions; in ſome poſitions it appears ſtreaked.

117. Gonium Rectangulum.

Gonium rectangulum, dorſo arcuato. This gonium is rectangular, the hind-part arched.

It differs from the preceding one but little, the angle at the baſe a right one, the larger veſicle is tranſparent, the reſt green.

118. Gonium Truncatum.

Gonium obtuſangulum, poſtice arcuatum. Gonium with obtuſe corners, the hind-part arched.

Much larger than the foregoing, the fore-part is a ſtrait line, the ſides forming therewith obtuſe angles, the ends of theſe ſides are united by a curved line; the internal molecules are of a dark green,

green, there are two little bright veſicles in the middle, it's motion is languid. It is but rarely met with, and then moſtly in pure water.

X. BURSARIA.

Vermis ſimpliciſſimus, membranaceus, cavus. A very ſimple, hollow, membranaceus worm.

119. Burſaria Truncatella.

Burſaria ventricoſa, apice truncata. Ventricoſe burſaria, the top truncated.

An animalculum that is viſible to the naked eye, white and oval, truncated at the top, where there is a large aperture, the opening that forms the aperture deſcending towards the baſe; at the bottom of moſt of them there are three or five yellow eggs.

It moves itſelf at pleaſure from right to left, and from left to right, aſcending to the ſuperficies of the water in a right line; ſometimes it rolls about while deſcending.

120. Burſaria Bullina.

Burſaria cymbæformis, antice labrata. Boat-ſhaped burſaria, the fore-part formed into a lip.

For ſome great end! where not alone the plant
Of ſtately growth; the herb of glorious hue,
Or food-full ſubſtance! not the laboring ſteed,
The herd, and flock that feed us; not the mine
That yields us ſtores for elegance and uſe;
The ſea that loads our table, and conveys
The wanderer man from clime to clime, with all
Thoſe rolling ſpheres, that from on high ſhed down
Their kindly influence; not theſe alone,
Which ſtrike ev'n eyes incurious, but each moſs,
Each ſhell, each crawling inſect, holds a rank
Important in the plan of Him, who fram'd
This ſcale of beings; holds a rank, which loſt
Would break the chain, and leave behind a gap
Which nature's ſelf would rue. Almighty Being,
Cauſe and ſupport of all things, can I view
Theſe objects of my wonder; can I feel
Theſe fine ſenſations, and not think of thee?
Thou who doſt thro 'th' eternal round of time,
Doſt thro' th' immenſity of ſpace exiſt
Alone, ſhalt thou alone excluded be
From this thy univerſe? Shall feeble man
Think it beneath his proud philoſophy
To call for thy aſſiſtance, and pretend
To frame a world, who cannot frame a clod?—
Not to know thee, is not to know ourſelves—
Is to know nothing—nothing worth the care
Of man's exalted ſpirit:—all becomes,
Without thy ray divine, one dreary gloom,
Where lurk the monſters of phantaſtic brains,

Order

A pellucid cryſtalline animalculum, furniſhed with ſmaller and larger ſplendid globules ſwimming about within it, the under-ſide convex, the upper-ſide hollow, the fore-part forming a kind of lip.

121. Burſaria Hirundinella. Fig. 19, Plate XXV.

Burſaria utrinque laciniata, extremitatibus productis.

Burſaria with two little projecting wings, one on each ſide, the fore and hind-part produced ſo as to give them ſome reſemblance to the head and tail of a bird. It is inviſible to the naked eye, but appears to be a pellucid hollow membrane under the microſcope. They have no viſible inteſtines; it moves ſomewhat like a ſwallow; a the head, b the tail, c one of the wings.

122. Burſaria Duplella. Fig. 18, Plate XXV.

Burſaria elliptica, marginibus inflexis. Elliptic burſaria, with the edge bent in and out.

A cryſtalline membrane folded up, no viſible inteſtines, if we except a little congeries of points under one of the folds. Was found among duck-weed.

123. Burſaria Globina.

Burſaria ſphærica, medio pellucentiſſima. Spherical burſaria, very pellucid in the middle.

A ſub-

A ſubſpheric hollow animalculum, the lower end furniſhed with black molecules of various ſizes, the fore-part with obſcure points, the reſt entirely empty, and the middle very pellucid; it moves ſlowly from right to left.

XI. CERCARIA.

Vermis inconſpicuus, pellucidus, caudatus. An inviſible pellucid worm with a tail.

124. Cercaria Gyrinus.

Cercaria rotundata, cauda acuminata. This cercaria is round, and has a ſharp tail.

The body is white, gelatinous, without any traces of inteſtines; the fore-part ſomewhat globular, the hind-part round, long, and pointed; ſometimes it appears a little compreſſed on each ſide. The tail is in a continual vibration while it is ſwimming, like that of the tadpoles. It ſeems very ſimilar to the ſpermatic animalcula.

125. Cercaria Gibba.

Cercaria ſubovata convexa, antice ſubacuta, cauda tereti. Somewhat of an oval ſhape, convex, the fore-part rather acute, the tail round.

It

It is a ſmall animalculum, gelatinous, white, opake, without any viſible inteſtines, the upper part convex or gibbous; many of them were found in an infuſion of hay, alſo in other infuſions.

126. Cercaria Inquieta. Fig. 31 and 32, Plate XXV.

Cercaria mutabilis convexa, cauda lævi. Changeable convex cercaria, with a ſmooth tail.

This animalculum ſo often changes the form of it's body, that it is not eaſy to deſcribe it; it is ſometimes ſpherical, ſometimes like a long cylinder, at others of an oval figure, white, gelatinous, the tail is filiform and flexible, the upper part vibrating vehemently, no viſible viſcera, a pellucid globule may be obſerved at the baſe, and two very ſmall black points placed near the top at d, Fig. 32; whether they are eyes to the animalculum is not known. Was found in ſalt water. a, Fig. 31, the body, b the tail.

127. Cercaria Lemna, Fig. 33, 34, and 35.

Cercaria mutabilis, ſubdepreſſa, cauda annulata. Mutable cercaria, ſomewhat flattened, with an annulated tail.

This animalculum puts on ſuch various forms, that at firſt ſight it appears like the proteus of Baker, though it is altogether different.

The body is capable of being contracted or extended, of the ſhape of an oblong pear, or triangular, kidney-ſhaped. The tail ſhort,

ſhort, thick, and annulated, ſometimes long, bending, cylindric, and without rings. It vibrates, when it is ſtretched out, with ſo much velocity, that it appears as it were double. The inteſtines not very diſtinct, near the apex a ſmall pellucid globule is perceivable, that Muller takes to be it's mouth; two black points which are near it, but with difficulty diſcovered, he ſuppoſes to be the eyes. It draws the tail ſometimes into the body. Fig. 33, a, the body rather ſpherical, b the tail; Fig. 34, c, the triangular body; Fig. 35, the body extended, e e the eyes, f f the bowels, g a large veſicle, h a ſmaller one.

It walks ſlowly after taking three or four ſteps; it extends the tail, erecting it perpendicularly, ſhaking and bending it; in this ſtate it reſembles much the leaf of the lemna.

128. Cercaria Turbo. Fig. 30, Plate XXV.

Cercaria globuloſa, medio coarctata, cauda uniſeta. Globular cercaria, the middle contracted, with a tail like a briſtle.

Partly of an oval, and partly of a ſpherical ſhape, pellucid, and of a talcy appearance. It ſeems to be compoſed of two globular bodies, the lower one being the ſmalleſt; this figure is occaſioned by the contraction at the middle. There are two black points, like eyes, at the upper part of the animalculum, even with a tranſverſe line which croſſes the top of this little creature; ſeveral large globules may be diſcerned, the tail is ſometimes quite ſtrait, ſometimes turned back on the body. It is to be met with among the duck-weed.

129. Cer-

129. Cercaria Poduria. Fig. 37 and 38, Plate XXV.

Cercaria cylindracea, poſtice acuminata ſubfiſſa. Cylindric cercaria, the hind-part ſharp, and ſomewhat cloven.

It reſembles the young ones of the podura which live among the lemna, is pellucid, and ſeems to conſiſt of a head, a trunk, and a tail; the fore-part reſembles the head of a herring, the trunk is cylindric, and replete with black ſpiral inteſtines; appears more or leſs ventricoſe, at the will of the animal. Nothing to be diſcovered in the hinder-part. The tail, in moſt ſituations, appears divided into two briſtles. When the animal moves, there is a continual motion among the inteſtines, which, from the various ſhades they occaſion, make the body appear very rough; ſome lateral hairs (cilia) are ſometimes perceived. It moves from one place to another, turning round at the ſame time as upon an axis. It is to be found in November and December, in marſhy places that are covered with lemna. Fig. 36, a the head, b the trunk, c the tail, d with one point, it is ſeen at e, Fig. 37, with two points; f the hairs on the ſide.

130. Cercaria Viridis.

Cercaria cylindracea mutabilis, poſtice acuminata fiſſa. Cylindrical cercaria, mutable, the lower end ſharp, and divided into two parts.

This animalculum, when in it's longeſt ſtate, is not unlike the preceding; but from the changes to which the body is ſubject, as well

well as the colour, it differs confiderably from it. It fometimes contracts the head and tail, fo as to form a fpherical figure; at others the fides project outwards. Is found in the fpring, in ditches of ftanding water.

131. Cercaria Setifera.

Cercaria cylindracea, antice anguftior, poftice acuminata. Cylindric cercaria, the fore-part fmalleft, the hind-part pointed.

This is a fmall cercaria, the body rather opake, round, the upper part bright, and fmaller than the reft; the trunk is more opake, the tail fharp, near it is a little row of fhort hairs. It has a flow rotatory motion, and is feldom to be met with, and when found it is in falt water.

132. Cercaria Hirta.

Cercaria cylindrica, antice fubtruncata, poftice obtufa, bimucronata. Cylindrical cercaria, the fore-part fomewhat truncated, the lower part obtufe, finifhing with two fmall points.

A cylindrical opake animalculum, with two fmall points at the lower end, moveable, yet rigid, and placed at fome diftance from each other; when in motion, the body feems as if it was furrounded with rows of fmall hairs, feparated a little from each other. It was obferved in falt water.

133. Cercaria Crumena.

Cercaria cylindraceo-ventricofa, antice oblique truncata, cauda lineari bicufpidata. Cylindrical ventricofe cercaria, the fore-part obliquely truncated, the tail linear, terminating with two diverging points.

The body is ventricofe and cylindrical, mufcular and thick, the lower part fmall; the upper part terminates in a fmall, ftrait neck, like the neck of a pitcher; the body appears wrinkled, the tail terminated as in the definition.

134. Cercaria Catellus.

Cercaria tripartita, cauda bifecta. Three-parted cercaria, the tail divided into two parts.

This animalculum is more complex in it's form than many others; it has a moveable head, which is affixed to the body only by a point; an abdomen, which is not fo wide, but twice as long as the head, replete with inteftines, and a tail which is fhorter than the head, narrower than the belly, and terminating in two briftles; thefe it can unite and feparate at pleafure. It moves with vivacity, though without going far from it's firft place.

135. Cercaria Catelina.

Cercaria tripartita, cauda bicufpidata. Cercaria diftinguifhed into three parts, with a fhort forked tail.

It

It differs from the preceding in ſeveral reſpects, being larger, the body thicker, more cylindrical, and the lower part truncated, with two ſhort diverging points projecting from the middle. Was found in a ditch where there was plenty of duck-weed.

136. Cercaria Lupus. Fig. 39, Plate XXV.

Cercaria cylindrica, elongata, toroſa cauda ſpinis duabus. Cylindric cercaria, long, the tail furniſhed with two ſpines.

This animalculum is larger than moſt of the cercarias, and has ſome particulars in which it reſembles the vorticella. It is full of muſcles, capable of being contracted or extended; cylindric, compoſed of a head, a trunk, and a tail; the head is larger than the body, the apex turned downwards into a little hook; the tail is like the body, but narrower, terminating in two very bright ſpines, that it extends differently. It ſometimes contracts itſelf into one half it's ſize; then again it extends itſelf to it's uſual form. Was found in water among duck-weed. a the head, b the trunk, c the tail, d d the ſpine thereof.

137. Cercaria Vermicularis. Fig. 40.

Cercaria cylindrica annulata, proboſcide exſertili, cauda ſpina duplici. Cylindrical, annulated, with a projecting proboſcis, two ſmall ſpines for the tail.

It is a long, cylindrical, fleſhy, mutable animalculum, divided into eight or nine rings, or folding plaits, the apex either obtuſe or notched into two points, the hind-part rather acute, and terminating

minating in two pellucid thorns; ſometimes a ſwelling is perceived between theſe. It often projects from the inciſion at the apex, a kind of cloven proboſcis. Is found in water where there is duck-weed. d d the points of the fore-part, e the proboſcis.

138. Cercaria Forcipata.

Cercaria cylindrica, rugoſa, proboſcide forcipata exſertili, cauda bicuſpidata.

Cercaria cylindrical, wrinkled, with a forked proboſcis, that it can thruſt out, or pull in. It is found in marſhy ſituations.

139. Cercaria Pleuronectes. Fig. 38, Plate XXV.

Cercaria orbicularis, cauda uniſeta. Orbicular the tail, conſiſting of one briſtle.

It is membranaceous, rather round, and white. In the fore-part are two blackiſh points. The hind-part is furniſhed with a ſlender ſharp tail. In the middle are orbicular inteſtines of different ſizes; the larger of them are bright. It's motion is vacillatory; in ſwimming, one edge of the lateral membrane is upwards; the other, folded down. Found in water that has been kept ſeveral months.

140. Cer-

140. Cercaria Tripos. Fig. 38, Plate XXV.

Cercaria fubtriangularis, brachiis deflexis, cauda recta. Cercaria fomewhat of a triangular form, two bent arms, and a ftrait tail.

The body flat, pellucid, triangular, each angle of the bafe of the triangle, or fore-part thereof, being bent down into two linear ears, or arms; the apex of the triangle is prolonged into a tail. It was found in falt water; b the tail, a the bent arms.

141. Cercaria Cyclidium.

Cercaria ovalis, poftice fubemarginata, cauda exterfili. This is oval, the hind-part fomewhat notched, with a tail, that it thrufts out at pleafure.

It's body is oval, fmooth, membranaceous, pellucid, with a black margin. The tail is not fixed to the edge, but concealed under it, and coming out from it at every motion, and yet fo as to project but little from the edge. There is a kind of border to the hinder-part. It's inteftines are very pellucid veficles. Is frequently found in pure water.

142. Cercaria Tenax.

Cercaria membranacea, antice craffiufcula, truncata, cauda triplo breviore. Membranaceous, the fore-part rather thick, truncated, the tail three times fhorter.

Order bereft of thought, uncaus'd effects,
Fate freely acting, and unerring chance.
Where meanless matter to a chaos sinks,
Or something lower still, for without thee
It crumbles into atoms void of force,
Void of resistance—it eludes our thought.
Where laws eternal to the varying code
Of self-love dwindle. Interest, passion, whim,
Take place of right, and wrong, the golden chain
Of beings melts away, and the mind's eye
Sees nothing but the present. All beyond
Is visionary guess—is dream—is death.*

* Stillingfleet's Miscellaneous Tracts.

R. HINDMARSH, Printer.

It is an oval, pellucid membrane, ſomething larger than the mona lens. The fore-edge thick and truncated, the hinder-part acute, or terminating in a ſhort tail. It whirls about in various directions with great velocity.

143. Cercaria Diſcus.

Cercaria orbicularis, cauda curvata. A ſmall orbicular cercaria, with a bent tail.

144. Cercaria Orbis.

Cercaria orbicularis, ſeta caudali duplici longiſſima. Orbicular cercaria, with a tail, conſiſting of two very long briſtles.

145. Cercaria Luna.

Cercaria orbicularis, cauda lineari duplici brevi. Orbicular cercaria, with two ſhort ſpines for a tail; the fore-part hollowed, ſo as to form a kind of creſcent.

XII. LEUCOPHRA.

Vermis inconſpicuus, pellucidus, undique ciliatus. An inviſible worm, pellucid and every where ciliated.

146. Leu-

145. Leucophra Conflictor.

Leucophra sphærica, subopaca, interaneis mobilibus. Spherical opake leucophra, with moveable intestines.

This animalculum, or rather a heap of animalcula, is perfectly spherical, and larger than most species of the vorticella; it is semitransparent, of a yellow colour, the edges of a dark colour. It is filled with a number of the most minute molecules, it rolls at intervals from right to left, but seldom removes from the spot where it is first found.

The innumerable molecules circumscribed within this sphere are in continual motion, and, as it were, in vehement conflict, without any order. From the great concourse of combatants on one side, or the other, the sphere is turned either to the right or left, the molecules going in the same direction; it is then tranquil for a short time, but soon the conflict becomes more violent, and the sphere is moved towards the other side, and continues to move in a spiral line. When the water begins to fail, they assume an oblong, oval, or a cylindric figure; the hind-part of some is compressed into a triangular shape, and the transparent part escaping as it were from the intestines, which continue to move with the same violence till the water fails, when the molecules are spread into an uninformed mass. But this also soon vanishes, when they shoot into the form of the crystals of sal ammoniac, as described by Baker, p. 3, No. 3.

147. Leu-

147. Leucophra Mamilla.

Leucophra ſphærica, opaca, papilla exſertili. Sphærical opake leucophra, with a ſmall papillary projection.

It is of a dark colour, and filled with globular molecules, the ſhort hairs are curved inwards; it projects, and draws in occaſionally a little white protuberance, not uncommon in marſhy water.

148. Leucophra Viriſcens.

Leucophra cylindracea, opaca, poſtice craſſiore. Cylindrical, opake leucophra, the lower part much thicker than the upper part.

This is a large, pear ſhaped, greeniſh coloured animalculum, filled with opake molecules, and covered with ſhort hairs, generally moving in a ſtrait line. Found in ſalt water.

149. Leucophra Viridis.

Leucophra ovalis opaca. Oval, opake leucophra.

Though at firſt ſight it may be taken for a variety of the leucophra viriſcens, yet on a further examination, it differs in many particulars; it cannot lengthen and ſhorten itſelf in the ſame manner that does. It is alſo much ſmaller. Sometimes it is ſeen to be contracted in the middle, as if it was going to be divided in two.

150. Leu-

150. Leucophra Burſata.

Leucophra viridis, ovalis, antice truncata. Green oval leucophra, the fore-part truncated.

This is ſimilar in many reſpects to the foregoing leucophra, it is a long oval, bulging in the middle, filled with green molecules, every where ciliated, except at the apex, which is truncated, and ſomewhat of the ſhape of a purſe; the hairs larger, and ſometimes collected in little faſcicles. It is to be found in ſalt water.

151. Leucophra Poſthuma.

Leucophra globularis, opaca, reticulo pellucenti. Globular opake leucophra, covered as it were with a pellucid net.

Was found in fœtid ſalt water.

152. Leucophra Aurea.

Leucophra ovalis, fulva, utraque extremitate æquali obtuſus. Oval yellow leucophra, both ends of it equally obtuſe.

The little hairs are with difficulty diſcovered; it has, in general, a vehement rotatory motion.

153. Leucophra Pertufa.

Leucophra ovalis, gelatinofa, apice truncato obtufa, altera latera fuffoffa. Oval gelatinous leucophra, the apex obtufely truncated, one fide funk down.

Gelatinous, yellow, without any fmall or large molecules; the fore-part truncated, the hind-part brought nearly to a point, a kind of oval hole on one fide. It was found in falt water.

154. Leucophra Fracta.

Leucophra elongata, finuato angulata fubdepreffa. Leucophra long, with finuated angles, rather flat.

The body is white, gelatinous, granulated, flat, changing it's form confiderably.

155. Leucophra Dilatata.

Leucophra complanata, mutabilis, marginibus finuatis. Smooth changeable leucophra, with a finuated edge.

A gelatinous membrane, with a few grey molecules in the fore-part, and a great number in the hinder-part; it is fometimes dilated into a triangular form, with finuated fides; at other times the fhape is more irregular and oblong.

156. Leu-

156. Leucophra Scintillans.

Leucophra ovalis, teres, opaca viridis. Oval, round, opake, green leucophra.

This animalculum is ſuppoſed to be ciliated, from it's bright twinkling appearance, which probably ariſes from the motion it gives the water; it is nearly of an egg-ſhape. Was found in December among the leſſer lemnæ.

157. Leucophra Veſiculifera. Fig. 41, Plate XXV.

Leucophra ovata, interaneis veſicularibus. Oval leucophra, with veſicular inteſtines.

An animalculum that is a kind of mean between the orbicular and oval, very pellucid, with a defined dark edge and inſide, containing ſome very bright veſicles, or little bladders. The middle often appears blue, ſo that the little bright veſicles ſeem ſet in a cerulean ſubſtance. Muller could never perceive any of thoſe rays which are mentioned by Spalanzani; he confeſſes, however, that he once ſaw an individual like this environed with very ſmall unequal ſhining rays.

158. Leucophra Globulifera.

Leucophra cryſtallina, ovato-oblonga. Cryſtalline leucophra, of an oblong oval ſhape.

The body is round, very pellucid, without molecular inteſtines, though at one edge it has three little pellucid globules; it is every-where beſet with ſhort hairs. It was found in a ditch where the lemna minor grows.

159. Leucophra Puſtulata.

Leucophra ovato-oblonga, poſtice oblique truncata. An oblong oval leucophra, the lower end obliquely truncated.

The body is white, gelatinous, ſomewhat granulated; the lower part is truncated, as if an oblique ſection was made in an egg near the bottom. It is covered with little ſhining erect hairs, at the lower end a few bright puſtules may be diſcovered. It is found in marſhy waters.

160. Leucophra Turbinata.

Leucophra inverſe conica, ſubopaca. Leucophra in ſhape like an inverted cone, and rather opake.

It is a round pellucid body, ſomewhat of an acorn ſhape, with a pellucid globule at the lower end. Was found in ſtinking ſalt water.

161. Leucophra Acuta.

Leucophra ovata, teres, apice acuto, mutabilis, flavicans. Oval leucophra, round, with the apex acute, mutable, yellow.

Gela-

Gelatinous, mutable, and thick, the apex bright, the reſt of the body crammed with an innumerable quantity of little ſpherules. It is ſometimes drawn up into an orbicular ſhape, at other times one edge is ſinuated. It was found in ſalt water.

162. Leucophra Notata.

Leucophra ovata, teres, punĉto marginali atro. Oval leucophra, round, with a black point at the edge.

163. Leucophra Candida.

Leucophra hyalina, oblonga, altera extremitate attenuata, curvata. Leucophra of a talcy appearance, oblong, one end ſmaller than the other, and bent back.

The body membranaceous, flat, very white, with no viſible inteſtines, if we except two oval bodies which are with difficulty perceived; the whole edge is ciliated. Found in an infuſion of ſalt water.

164. Leucophra Nodulata.

Leucophra ovato-oblonga, depreſſa, ſerie nodulorum duplici. An oblong oval ſpecies of leucophra, with a double row of little nodules.

165. Leu-

165. Leucophra Signata.

Leucophra oblonga, ſubdepreſſa. Oblong ſubdepreſſed leucophra, with a black margin, filled with little molecular globules, but more particularly diſtinguiſhed by a curved line in the middle, ſomething in the ſhape of a long S; one end of this is at times bent into a ſmall ſpiral. Common in ſalt water, in the months of November and December.

166. Leucophra Trigona.

Leucophra craſſa, obtuſa, angulata, flava. Thick, obtuſe, angular, and yellow leucophra.

A triangular yellow maſs, filled with unequal pellucid veſicles, one of which is much larger than the reſt, the edge ſurrounded with little fluctuating hairs. It is not common. Was found in a marſhy ſituation.

167. Leucophra Fluida.

Leucophra ſubreniformis, ventricoſa. Leucophra ſomewhat of a kidney ſhape, but ventricoſe.

168. Leucophra Fluxa.

Leucophra ſinuata reniformis. Reniform ſinuated leucophra.

169. Leu-

169. Leucophra Armilla.

Leucophra teres annularis. Round annular leucophra.

170. Leucophra Cornuta. Fig. 42 and 43, Plate XXV.

Leucophra inverſe conica, viridis opaca. An inverted cone, green, opake.

It bears ſome reſemblance to the vorticella polymorpha and the vorticella viridis, and requires to be obſerved for ſome time before it's peculiar characters can be aſcertained; the body compoſed of molecular veſicles, of a dark green colour; for the moſt part it is like an inverted cone, the fore-part wide and truncated; with a little prominent horn, or hook, on both ſides, the hind-part being conical, every-where ciliated, the hairs exceeding minute; thoſe in the fore-part are three times longer than theſe, and moving in a circular direction. The hinder-part is pellucid, and ſometimes terminates in two or three obtuſe pellucid projections. The animalculum will at one moment appear oval, at another reniform, and ciliated on the fore-part; at another time the hairs are concealed. When the water evaporates, it breaks or diſſolves into molecular veſicles. It is found late in the year in marſhy grounds. Fig. 42, a the hinder-part pointed, it is obtuſe at b, Fig. 43, e the fore-part, g the cilia, f the horns, h the ſides.

171. Leu-

CHAP. II.

OF VISION, OF THE OPTICAL EFFECT OF MICROSCOPES, AND OF THE MANNER OF ESTIMATING THEIR MAGNIFYING POWERS.

THE progreſs that has been made in the ſcience of optics, in the laſt and preſent century, particularly by Sir Iſaac Newton, may with propriety be ranked among the greateſt acquiſitions of human knowledge. And Meſſ. Delaval and Herſchel have ſhewn by their diſcoveries, that the boundaries of this ſcience may be conſiderably enlarged.

The rays of light, which miniſter to the ſenſe of ſight, are the moſt wonderful and aſtoniſhing part of the inanimate creation; of which we ſhall ſoon be convinced, if we conſider their extreme minuteneſs, their inconceivable velocity, the regular variety of colours they exhibit, the invariable laws according to which they are acted upon by other ſubſtances, in their reflections, inflections, and refractions, without the leaſt change of their original properties; and the facility with which they pervade bodies of the greateſt denſity and cloſeſt texture, without reſiſtance, without crouding or diſturbing each other. Theſe, I believe, will be deemed ſufficient proofs of the wonderful nature of theſe rays; without adding, that it is by a peculiar modification of them, that we are indebted for the advantages we obtain by the microſcope.

The

171. Leucophra Heteroclita. Fig. 44 and 45.

Leucophra cylindrica, antice obtufa, poftice organo criftato duplici exfertili. Cylindrical leucophra, the fore-part obtufe, the hind-part furnifhed with a double-tufted organ, which it can thruft in or out at pleafure. To the naked eye it appears as a white point, in the microfcope as a cylindrical body, the fore-part obtufely round, the middle rather drawn in, the lower part round, but much fmaller than the upper part. With a large magnifying power the whole body is found to be ciliated. The inteftines are very vifible. It is reprefented in Fig. 44 as it generally appears, in Fig. 45 with the plumed organs. a the fore-part, b the hind-part, d the hooked inteftines, ii the plumes, g g the fheaths from which they are projected.

XIII. TRICHODA.

Vermis inconfpicuus, pellucidus, crinitus. An invifible, pellucid, hairy worm.

172. Trichoda Grandinella.

Trichoda fphærica, pellucida, fuperne crinata. Spherical, pellucid, the upper part hairy.

A moft minute pellucid globule, the inteftines fcarce vifible, the top of it's furface furnifhed with two, three, or more fhort briftles, which are with difficulty feen, the animalculum extending, and

and then withdrawing them in an inſtant. It is found in pure water, and in infuſions of vegetables.

173. Trichoda Cometa. Fig. 46 and 47, Plate XXV.

Trichoda ſphærica, antice crinita, globulo appendente. Spherical, the fore-part hairy, with an appendant globule.

It is a pellucid globule, replete with bright inteſtines, the fore-part furniſhed with hairs, the hind-part with a pellucid appendant globule.

174. Trichoda Granata. Fig. 48, Plate XXV.

Trichoda ſphærica, centro opaco, peripheria crinata. Spherical, with an opake center, the periphery hairy.

It reſembles the trichoda grandinella and trichoda cometa. It has a darkiſh nucleus in the center; it's inteſtines are imperceptible; ſhort hairs on the edge.

175. Trichoda Trochus.

Trichoda ſubpiriformis, pellucida, antice utrinque crinita. Trichoda ſomewhat of a pear-ſhape, pellucid, each ſide of the fore-part diſtinguiſhed by a little bunch of hairs.

176. Trichoda Gyrinus.

Trichoda ovalis teres cryſtallina, antice crinita. Oval, round, cryſtalline trichoda, the front hairy.

It is one of the ſmalleſt among the trichoda, the body ſmooth and free from hairs, except at the fore-part, where there are a few. Found in ſalt water.

177. Trichoda Sol. Fig. 65 and 66, Plate XXV.

Trichoda globularis, undique radiata. Globular trichoda, every-where radiated.

This ſplendid creature conſtitutes a new genus, but as we know of no more of the ſame kind, it is introduced here. It is a little cryſtalline round corpuſcle, the upper part convex; it is beſet with innumerable diverging rays, which are longer than the body, proceeding from every part of it's ſurface: in the inſide are ſimilar molecules. The body contracts and dilates itſelf, the animalculum remaining confined to the ſame ſpot. It was found in water in which there were other infuſoria, and which had been kept for three weeks. It propagates by diviſion, and is repreſented as dividing in Fig. 66.

178. Trichoda Solaris.

Trichoda ſphæroidea, peripheria crinita. Spheroidal trichoda, with a few hairs round the circumference.

The

The body is bright, orbicular, with globular viſcera in the middle of it; in many a moveable ſubſtance, ſomething like the letter S, may be diſcovered; it has ſeldom more than ſeventeen hairs, which are diſpoſed round the circumference; each of them is in length nearly equal to the diameter of the animalculum.

179. Trichoda Bomba. Fig. 67 and 68.

Trichoda mutabilis, antice pilis ſparſis. Changeable, with a few hairs diſperſed on the fore-part.

It is larger than the trichoda granata, and of a yellow colour; it is a thick animalculum, pellucid, and replete with a kind of clay molecules; it is very lively, moving about with ſo much velocity as to elude the ſharpeſt ſight and moſt pertinacious obſerver, ſometimes appearing ſpherical, ſometimes reniform, (kidney-ſhaped) ſometimes as at Fig. 67.

180. Trichoda Orbis.

Trichoda orbicularis, antice emarginata crinita. Orbicular, the fore-part notched and hairy.

It in ſome reſpects reſembles the former, but is larger; is orbicular, ſmooth, and pellucid, a little notched in the fore-part; the hairs, which are longer than uſual, occupy this inciſion, the reſt of the margin has no hairs; the whole is compoſed of veſicular molecules.

 181. Tri-

181. Trichoda Urnula. Fig. 64.

Trichoda urceolaris, antice crinita. This trichoda is in the form of a water pitcher, the fore-part hairy.

A membranaceous pellucid animalculum, the hind-part obtufe, the middle fomething broader, the fore-part truncated, filled with veficular black molecules; the hairs in the fore-part are even and fhort. It's motion is flow.

182. Trichoda Diota.

Trichoda urceolaris, antice anguftata, ora apicis utrinque crinita. Pitcher-fhaped trichoda, the fore-part fmalleft, each edge of the upper-part of the mouth hairy.

The body is of a clay colour, and filled with molecules; the lower part fpherical, the upper part cylindrical and truncated.

183. Trichoda Horrida.

Trichoda fubconica antice latiufcula, truncata poftice obtufa, fetis radiantibus cincta. Trichoda fomewhat of a conical form, the fore-part rather broad and truncated, the lower part obtufe, the body covered with radiating briftles.

184. Tri-

184. Trichoda Urinarium.

Trichoda ovata, roſtro breviſſimo crinito. Egg-ſhaped, with a ſhort hairy beak.

185. Trichoda Semiluna.

Trichoda ſemiorbicularis, antice ſubtus crinita. Semiorbicular, the fore-part hairy underneath.

A pellucid ſmooth animalculum, reſembling the figure of the moon in the firſt quarter.

186. Trichoda Trigona. Fig. 63.

Trichoda convexa, antice ciliata, poſtice eroſa. Convex, the fore-part ciliated, the hind-part as it were gnawed off.

This is a triangular animalculum, a little convex on both ſides, the fore-part acute, the hind-part a little broader. A notch is ſeen at a in the hind-part, b the ciliated fore-part, c a tube.

187. Trichoda Tinea.

Trichoda clavata, antice crinita, poſtice groſſa. This is clubbed, the fore-part hairy, the hind-part large.

This animalculum is round, not very pellucid, reſembling an inverted club, narrow before; it is alſo like ſome of the tinea.

188. Tri-

188. Trichoda Nigra.

Trichoda ovalis compreſſa, antice latior crinita. Oval compreſſed trichoda, the fore-part broader and hairy.

The body is opake, when in violent motion it is black, when at reſt one ſide is pellucid; the middle of the fore-part is furniſhed with little moveable hairs. It was found in ſalt water.

189. Trichoda Pubes. Fig. 61 and 62.

Trichoda ovato-oblonga gibba, antice depreſſa. An egg-ſhaped oblong bunch, fore-part depreſſed.

An animalculum with a bunch above the hind-part, marked with black ſpots, depreſſed towards the top, a little folded, and ſomewhat convex underneath; at leaſt this is it's appearance when in motion. Very minute hairs occupy the apex, but which are with difficulty ſeen, except when it is in the agonies of death, it then ſtretches them out with all it's might from an arched chink at the top, moving them vehemently, and endeavouring as it were to draw in the laſt drop of water. Is found in water where the duck-weed grows, moſtly in December. b the hairs, c the black globules, a the projecting bunch.

190. Trichoda Floccus.

Trichoda membranacea, antice ſubconica, papillis tribus crinitis. Membranaceous trichoda, the fore-part rather conical, three ſmall papillæ project from the baſe, which are ſet with hairs.

6 Tri-

191. Trichoda Sinuata.

Trichoda oblonga depreſſa, altero margine ſinuato crinita, poſtice obtuſa. An oblong depreſſed trichoda, one margin hollow and hairy, the lower end obtuſe.

The inteſtines ſeem to be more lymphatic than molecular; it is of a yellow colour, the hollow edge is that which is ciliated. It was found in river water.

192. Trichoda Præceps.

Trichoda membranacea, ſublunata, medio protuberante, extrorſum crinita. Membranaceous trichoda, ſomewhat lunated, protuberant in the middle, a row of hairs on the outſide.

A pellucid membrane, the fore-part formed into a kind of neck, one edge riſes into a protuberance like a hump back, the other edge is convex.

193. Trichoda Proteus. Fig. 56, 57, 58, 59, 60, Plate XXV.

Trichoda ovalis, poſtice obtuſa, collo elongata retractile, apice crinito. Oval trichoda, the lower part obtuſe, with a long neck, which it has a power of contracting or extending.

Baker's Empl. for Micr. p. 340, 348.

This

This is the ſame animalculum which was dignified by Mr. Baker with the name of proteus, on account of it's aſſuming a great number of different ſhapes, ſo as ſcarce to be known for the ſame animal in it's various transformations; and indeed, unleſs it be carefully watched while paſſing from one ſhape to another, it will often become ſuddenly inviſible.

When water, wherein any ſorts of vegetables have been infuſed, or animals preſerved, has ſtood quietly for ſome days, or weeks, in any glaſs or other veſſel, a ſlimy ſubſtance will be collected about the ſides, ſome whereof being taken up with the point of a penknife, placed on a ſlip of glaſs, in a drop of water, and looked at through the microſcope, will be found to harbour ſeveral kinds of little animals that are ſeldom ſeen ſwimming about at large. The inſect we are treating of is one of theſe, and was diſcovered in ſuch ſlime-like matter, taken from the ſide of a glaſs jar, in which ſmall fiſhes, water-ſnails, and other creatures had been kept. It's body in ſubſtance and colour reſembled a ſnail's; the ſhape thereof was ſomewhat elliptical, but pointed at one end, whilſt from the other a long, ſlender, and finely-proportioned neck ſtretched itſelf out, and was terminated with a head, of a ſize perfectly ſuitable to the other parts of the animal.

194. Tri-

194. Trichoda Verfatilis.

Trichoda oblonga, poftice acuminata, collo retractili, infra apicem crinito. Oblong trichoda, the hind-part acute, with a neck that it can extend or contract at pleafure, the under part of the extremity of the neck hairy.

It refembles in fome meafure the trichoda proteus, but the neck is fhorter, and the apex lefs fpherical, the hinder-part of the trunk acute. It lives in the fea.

195. Trichoda Gibba. Fig. 55.

Trichoda oblonga, dorfo gibbera, ventre excavata, antice ciliata, extremitatibus obtufis. Oblong trichoda, with a bunch on the back, the belly hollowed out, the fore-part ciliated, both ends obtufe.

The body is pellucid, the upper-part fwelled out, within it are numerous obfcure molecules, and three large globules, the ends rather incline downwards; when the water begins to fail, a few minute hairs may be difcovered about the head, and at the abdomen; the body then becomes ftriated longitudinally.

196. Trichoda Foeta.

Trichoda oblonga, dorfo protuberante, antice ciliata, extremitatibus obtufis. Oblong trichoda, with the back protuberant, the fore-part ciliated, both ends obtufe.

The ſcience of optics, which explains and treats of many of the properties of theſe rays of light, is deduced from experiments, on which all philoſophers are agreed. It is impoſſible to give an adequate idea of the nature of viſion, without a knowledge of theſe experiments, and the mathematical reaſoning grounded upon them; but as to do this would alone fill a large volume, I ſhall only endeavour to render ſome of the more general principles clear, that the reader, who is unacquainted with the ſcience of optics, may neverthleſs be enabled to comprehend the nature of viſion by the microſcope. Some of the moſt important of theſe principles may be deduced from the following very intereſting experiment.

Darken a room, and let the light be admitted therein only by a ſmall hole; then, if the weather is fine, you will ſee on the wall, which is facing the hole, a picture of all thoſe exterior objects which are oppoſite thereto, with all their colours, though theſe will be but faintly ſeen. The image of the objects that are ſtationary, as trees, houſes, &c. will appear fixed; while the images of thoſe that are in motion, will be ſeen to move. The image of every object will appear inverted, becauſe the rays croſs each other in paſſing through the ſmall hole. If the ſun ſhines on the hole, we ſhall ſee a luminous ray proceed in a ſtrait line, and terminate on the wall. If the eye is placed in this ray, it will be in a right line with the hole and the ſun: it is the ſame with every other object which is painted on the wall. The images of the objects exhibited on the ſame plane, are ſmaller in proportion as the objects are further from the hole.

Many

The body is round and long, and when extended resembles a rolling-pin in shape, with the ends obtuse, and one shorter than the other; it can draw in the ends, and swell out the sides, so as to appear almost spherical.

197. Trichoda Patens. Fig. 54.

Trichoda elongata, teres, antice foveata, fovæ marginibus ciliata. This trichoda is long, round, in the fore-part it has a long hole, the edges of which are ciliated.

It is a long cylindrical animalculum, filled with molecules, the fore-part bright and clear, a long opening (a) near the top, which tapers to a point, and is beset with hairs. It is found of different lengths in salt water.

198. Trichoda Patula.

Trichoda ventricosa, subovata, antice canaliculata, apice & canaliculo crinito. Ventricose, rather inclining towards an oval figure, with a small tube at the fore-part, the upper end of the tube beset with hairs.

199. Trichoda Foveata.

Trichoda oblonga, latiuscula, antice corniculis micantibus, postice mutica. Oblong trichoda, rather broad, three little horns on the fore-part, the hinder-part beardless.

200. Tri-

200. Trichoda Striata.

Trichoda oblonga, altero margine curfum, finuata et ciliata, utraque extremitate obtufa. Oblong trichoda, one edge rather curved, and alfo furnifhed with a row of hairs, both extremities obtufe.

It is a fplendid animalculum, of a fox colour, and at firft fight might be taken for a kolpoda. The body is oblong, the lower end is the largeft, the body becoming fmaller at that part where the hairs commence; it has a fet of ftreaks which run from one end to the other, and at the abdomen a double row of little eggs, lying in a tranfverfe direction. It was found in river water in December.

201. Trichoda Uvula. Fig. 53.

Trichoda planiufcula elongata, æqualis, antice crinita. Rather flat and long, of an equal fize throughout, the fore-part hairy.

This animalculum is fix times longer than it is broad, round, flexuous, of an equal fize, the greater part filled with obfcure molecules, the fore-part (a) rather empty, diftinguifhed by an alimentary canal, and lucid globules near the middle c; fhort hairs occupy the margin of the fore-part, fome are difperfed into a chink near the canal. Found in an infufion of hay, &c.

202. Trichoda Aurantia.

Trichoda fubfinuata, ovata, antice patula, apice ad medium crinita. Trichoda fomewhat finuated, oval, the fore-part broad, the apex hairy to the middle.

It is of a gold colour, pellucid, and filled with a variety of veficles.

203. Trichoda Ignita.

Trichoda ovata, apice acuminata, fubtus fulcata, fulco crinito. Oval trichoda, the apex rather acute, the under part furrowed, the furrows hairy.

It is of a fine purple gold colour, fomewhat of a reddifh caft, pellucid, fplendid, with a number of different-fized globules; the fore-part fmall, the hind-part obtufe, and having a very large opening, which runs as it were through the body.

204. Trichoda Prifma.

Trichoda ovata, fubtus convexa, fupra in carinam compreffa, antice anguftior. Oval trichoda, the under part convex, the upper part compreffed into a kind of keel, the fore-part fmall.

It is very fmall, and fo tranfparent, as not eafily to be delineated; no hairs could be obferved, and it's form is fingular.

205. Tri-

205. Trichoda Forceps.

Trichoda ovalis, antice forcipata, cruribus inæqualibus crinitis. Oval trichoda, with a pair of forceps at the fore-part, with unequal hairy legs.

A large animalculum, ſomewhat depreſſed, of a pellucid yellow colour, filled with molecules; in the lower part there is a black opake globule, the fore-part is divided into long lobes, one of theſe in the ſhape of a bill, (falciformis) and acute, the other is dilated, and obliquely truncated; both the apex and the edge of theſe are furniſhed with hairs of different lengths; it can open and ſhut theſe forceps, and croſs them at pleaſure; by this motion it ſucks in the water. It was found in water that was covered with lemna, about the winter ſolſtice.

206. Trichoda Forfex.

Trichoda ventroſa, antice forcipata, poſtice papilla duplici inſtructa. Ventroſe trichoda, the fore-part formed into a kind of forceps, and two ſmall protuberances.

One of the forceps of this animalculum is twice as long as the other, hooked, and ciliated. It was found in river water.

207. Trichoda Index.

Trichoda obovata, margine antico ſubtus crinito, alteroque apicis in degitum producto. Obovated trichoda, the under part of of the front margin hairy, the apex is formed by the fore-part, projecting like the finger on a direction-post. It was found in salt water.

208. Trichoda S.

Trichoda striata, antice ciliata, extremitatibus in oppositum flexis. Striated trichoda, the fore-part ciliated, the extremities bent in opposite directions.

A yellow animalculum, formed of two pellucid membranes, striated longitudinally; the lower end is obliquely truncated.

209. Trichoda Navicula.

Trichoda triquetra, antice truncata ciliata, postice acuta prominula. Three-cornered trichoda, the fore-part truncated and ciliated, the hind-part acute, and bent a little upwards.

It is crystalline, rather broad, the under-side towards the hinder-part convex, the fore-part broad, the apex nearly a strait line, the bent end pointed and turned upwards; it has a kind of longitudinal keel running down the middle.

210. Trichoda Succisa.

Trichoda ovalis depressa, margine crinito, postice in crura inæqualia erosa. Flattened oval trichoda, the edge hairy, the hinder-part hollowed out so as to form two unequal legs.

211. Tri-

211. Trichoda Sulcata.

Trichoda ovato-ventricoſa, apice acuminata, ſulco ventrali, utrinque crinito. Ovated ventricoſe trichoda, the apex acute, a furrow at the abdomen, both ſides of it ciliated.

212. Trichoda Anas. Fig. 49.

Trichoda elongata, apice colli ſubtus crinito. Long, the apex of the neck underneath hairy.

A ſmooth animalculum, five times broader than it is long, filled with darkiſh molecules; a bright neck b c, under the top of the neck at d there ſhine a few unequal hairs. It's motions are languid. It is found in pure water.

213. Trichoda Barbata.

Trichoda elongata, teres, ſubtus ab apice ad medium crinita, Trichoda long, round, the under-part, from the apex to the middle, hairy.

This animalculum is round, ſomewhat linear, both ends obtuſe, the fore-part narrower, forming as it were a kind of neck; under this is a row of fluctuating hairs. The trunk is full of grey molecules.

214. Tri-

214. Trichoda Farcimen. Fig. 50 and 52, Plate XXV.

Trichoda elongata, torulofa, fetulis cincta. Long and thick trichoda, furrounded with fmall briftles.

The body is long, round, pellucid, and covered with very minute hairs; it has alfo about the body a great number of mucid veficles.

215. Trichoda Crinita.

Trichoda elongata, teres, undique ciliata, fubtus ad medium ufque crinita. Long trichoda, round, every-where ciliated, the under-part alfo hairy as far as the middle.

216. Trichoda Angulus.

Trichoda angulata, apice crinita. Angular, the apex hairy.

This animalculum is long, more convex than moft of it's kind, divided, by a kind of articulation, into two parts, of equal breadth, but differing in length, the fore-part fhorter than the hind-part, the apex furnifhed with fhort waving hair, indiftinct molecules within-fide, no hair on the hind-part.

217. Trichoda Linter. Fig. 51, Plate XXV.

Trichoda ovato oblonga, utraque extremitate prominula. The fhape of an oblong egg, with prominencies at both extremities.

Both extremities of the body are raiſed, ſo as to be convex at bottom, the upper part depreſſed like a boat; ſometimes the whole body whirls about. It differs from itſelf at different ages. Is found in an infuſion of old graſs.

218. Trichoda Paxillus.

Trichoda linearis depreſſa, antice truncata crinitaque, poſtice obtuſa. Linear flat trichoda, the fore-part truncated and hairy, the hinder-part obtuſe.

A long animalculum, full of grey molecules, the fore-part rather ſmaller than the hind-part, and furniſhed with minute hairs. Was found in ſalt water.

219. Trichoda Vermicularis. Fig. 1, Plate XXVI.

Trichoda elongata, cylindracea, collo brevi, apice crinito. Long cylindrical trichoda, with a ſhort neck, the apex hairy.

Gelatinous, the fore-part pellucid, the hind-part full of molecules. It was found in river water. It is repreſented in different appearances in the figure, a the neck, b the hairs, c a little veſicle in the hinder-part.

220. Trichoda Melitea. Fig. 2, Plate XXVI.

Trichoda oblonga, ciliata, colli dilatabilis, apice globoſo, pilifero. Oblong ciliated trichoda, with a dilatable neck, the apex globular, and ſurrounded with hairs, the edge is ciliated, and a kind of periſtaltic motion may be perceived. It is very rarely found, and even then in ſalt water. a the neck, b the globular apex, c the body ciliated.

222. Trichoda Fimbriata. Fig. 2. Plate XXVI.

Trichoda obovata, apice crinita, poſtice oblique truncata ſerrata. Obovated trichoda, the apex hairy, the hinder-part obliquely truncated and ſerrated.

223. Trichoda Camelus.

Trichoda antice crinita, craſſiuſcula medio utrinque emarginata. Thick, and the fore-part hairy, with notches on the middle and each ſide.

The fore-part of the body is ventricoſe; the back is divided, by an inciſion in the middle, into two tubercles, the lower part of the belly ſinuated. Languid in it's motion. Is found, though not often, in infuſions of vegetables.

224. Trichoda Augur.

Trichoda oblonga, vertice truncata, antico corporis margine, ſuperne pedata, inferne ſetoſa. The body oblong, depreſſed, pellucid, and filled with molecules; the vertex truncated, the fore-part forming a ſmall beak, underneath are three feet; beyond theſe, towards the hinder-part, it is furniſhed with briſtles.

225. Tri-

225. Trichoda Pupa.

Trichoda cucullata, fronte crinita, cauda inflexa. This trichoda is hooded, the front hairy, the tail inflected.

At firft fight it refembles the pupa of the gnat. The body is rather round, pellucid, and may be defcribed as confifting of three parts; the head, which is broad, and as it were hooded, the top furnifhed with very fmall hairs, a tranfparent veficle occupies the lower region of the head, and a certain production hangs over the breaft from the bafe of the head, refembling the fheath of the feet in the pupa of the gnat.

226. Trichoda Lunaris.

Trichoda arcuata, teres, apice crinita, cirro caudali inflexo. Arched trichoda, round, the apex hairy, the tail bent.

This animalculum bends itfelf in the form of an arch, is round and cryftalline, the hind-part fomewhat fmaller than the fore-part; the inteftines are with difficulty diftinguifhed. The edge of the back, and the part near the tail, are bright and clear.

227. Trichoda Bilunis.

Trichoda arcuata, depreffa, apice crinita, cauda bifeta. Arched flattened trichoda, the apex hairy, two little briftles proceeding from the tail.

Many and important are the inferences which may be deduced from the foregoing experiment, among which are the following:

1. That light flows in a right line.

2. That a luminous point may be feen from all thofe places to which a ftrait line can be drawn from the point, without meeting with any obftacle; and confequently

3. That a luminous point, by fome unknown power, fends forth rays of light in all directions, and is the center of a fphere of light, which extends indefinitely on all fides; and if we conceive fome of thefe rays to be intercepted by a plane, then is the luminous point the fummit of a pyramid, whofe body is formed by the rays, and it's bafe by the intercepting plane.—The image of the furface of an object, which is painted on the wall, is alfo the bafe of a pyramid of light, the apex of which is the hole; the rays which form this pyramid, by croffing at the hole, form another, fimilar and oppofite to this, of which the hole is alfo the fummit, and the furface of the object the bafe.

4. That an object is vifible, becaufe all it's points are radiant points.

5. That the particles of light are indefinitely fmall; for the rays, which proceed from the points of all the objects oppofite to the hole, pafs through it, though extremely fmall, without embarraffing or confounding each other.

6. That

228. Trichoda Rattus. Fig. 4, Plate XXVI.

Trichoda oblonga, carinata, antice crinita, postice seta longissima. Oblong trichoda, with a kind of keel, the fore-part hairy, a very long bristle proceeding from the hinder-part. a the mouth, b a small knob at the bending of the tail, c the tail.

229. Trichoda Tigris.

Trichoda subcylindrica, elongata, apice crinita, cauda setis duabus longis. This trichoda is long, and somewhat cylindrical, the apex hairy, the tail divided into two long bristles.

It differs from the preceding in two particulars; first, that of the tail; second, in a kind of incision in the body, at some little distance from the apex.

230. Trichoda Pocillum. Fig. 5 and 6, Plate XXVI.

Trichoda oblonga, antice truncata, crinita, cauda articulata, bifeta. Oblong trichoda, the fore-part truncated and hairy, the tail articulated, and divided into two bristles.

The body is cylindrical, pellucid, muscular, capable of being folded up, seems as if it were formed of two; the interior one, which is filled with molecules, has also an orbicular muscular appendage, which it can shut and open, and that forms the mouth. The exterior one is membranaceous, dilated, pellucid, and marked with transverse streaks; the animalculum can protrude or or draw in the orbicular membrane at pleafure. In fome there are four articulations to the tail, in others five; it has two pair of briftles, or projecting parts, one placed at the fecond joint, the other at the laft. It has been found very often in marfhy waters. In Fig. 6 it is feen with the mouth open, in Fig. 5 with it fhut, a the jaws, b the firft briftles, c the fecond pair, d the fpine at the tail.

231. Trichoda Clavus.

Trichoda antice rotundata, crinita poftice acuminato-caudata. The fore-part round and hairy, the hind-part furniffied with a fharp-tail. This animalculum is not much unlike in fhape to a common nail.

232. Trichoda Cornuta.

Trichoda fupra convexa, fubtus plana, apice crinita, cauda lineari fimplici. Trichoda with the upper part convex, the under fide plain, the apex hairy, the tail linear and fimple.

To thefe characters we may add, that the body is membranaceous, elliptical, crammed with molecules, the fore-part lunated, the hinder-part round, and terminated with a tail as long as the body.

233. Tri-

233. Trichoda Gallina.

Trichoda elongata, antice ſinuata, fronte crinita, cauda piloſa. Long trichoda, the fore-part ſinuated, the front hairy, the tail formed of ſmall hairs.

The body flat, of a grey colour, with ſeven large molecules and globules within it, the front obtuſe, and ſet with hairs, the hinder-part terminating in a tail, which is formed of very fine hairs. It was found in river water.

234. Trichoda Muſculus. Fig. 7, Plate XXVI.

Trichoda ovalis antice crinita, poſtice ſubtus caudata. Egg-ſhaped, the fore-part hairy, the tail projecting from the under-part.

A ſmooth egg-ſhaped animalculum, with a double margin, or line, drawn underneath it, the fore-part narrow, and furniſhed with ſhort hairs that are continually playing about; underneath the hind-part is a ſmall tail. It is furniſhed with molecular entrails, and moves ſlowly. Is found in infuſions of hay, which have been kept for ſome months. a the head, b the tail.

235. Trichoda Delphis.

Trichoda clavata, fronte crinita, cauda acuminata, ſubreflexa. Clubbed trichoda, the front hairy, the tail ſmall, and rather bent upwards.

It is ſmooth and pellucid, the fore-part dilated into a ſemi-circle, decreaſing in breadth towards the tail; the hairs ſtand as rays from the ſemicircular edge at the front, one edge is ſometimes contracted. It is to be found in river water.

236. Trichoda Delphinus. Fig. 8, Plate XXVI.

Trichoda oblonga, antice crinita, poſtice cauda reflexa truncata. Oblong, the fore-part hairy, in the hind-part is the tail, which is turned back, the end of it truncated.

A pellucid, ſmooth, egg-ſhaped animalculum; the hind-part is produced into a tail about half the length of the body, dilated at the upper end, and truncated; it is always bent upwards.

In the inſide are veſicles of an unequal ſize; it ſometimes moves on it's belly, ſometimes on one ſide; the tail ſeldom varies in it's poſition. Was found in hay that had been infuſed for ſome months. a the hairs on the fore-part, b the tail.

237. Trichoda Clava.

Trichoda clavata, fronte crinita, cauda reflexili. The club trichoda, the fore-part hairy, the tail turned back.

The fore-part is thick, the hind-part narrow, both extremities obtuſe, pellucid and replete with molecules, the hind-part bent downwards towards the middle.

238. Tri-

238. Trichoda Cuniculus.

Trichoda oblonga, antice crinita, poſtice ſubacuminata. Oblong, the fore-part hairy, the hind-part rather acute, filled with molecules and black veſicles.

239. Trichoda Felis. Fig. 9, Plate XXVI.

Trichoda curvata, groſſa, antice anguſtior, poſtice in caudam attenuata, ſubtus longitudinaliter crinita. Curved trichoda, large, the fore-part ſmall, the hinder-part gradually diminiſhed ſo as to form a tail, the under-ſide beſet longitudinally with hairs. a the head, b the tail, c the hairs.

240. Trichoda Piſcis. Fig. 13 and 14, Plate XXVI.

Trichoda oblongata, antice crinita, poſtice in caudam exquiſitam attenuata. Oblong, the fore-part hairy, the hind-part terminating in a very ſlender tail. Smooth and pellucid, much longer than it is broad, but of nearly an equal breadth throughout, filled with yellow molecules, the fore-part obtuſe, the hind-part exquiſitely ſlender and tranſparent, the upper ſide is convex. a the fore-part, b the tail.

241. Trichoda Larus.

Trichoda elongata, teres, crinita, cuſpidi caudali duplici. Long round trichoda, beſet with hairs, the tail divided into two points. See Zoologia Danica.

242. Tri-

242. Trichoda Longicauda. Fig. 10, Plate XXVI.

Trichoda cylindracea, antice truncata et crinita, cauda elongata, biarticulata & bifeta. Cylindrical trichoda, the fore-part truncated and fet with hairs, the tail long, with two joints, and terminated by two briftles. a the hairs at the mouth, d the oefophagus, c the articulation of the tail, f the briftles.

243. Trichoda Fixa.

Trichoda fphærica, peripheria crinita, pedicello folitario. Spherical trichoda, the circumference fet with hairs, and a little folitary pedicle projecting from the body.

244. Trichoda Inquilinus.

Trichoda vaginata, folliculo cylindrico hyalino, pedicello intra folliculum retortili. Sheathed trichoda, in a cylindrical tranfparent bag, and a little pedicle bent back within the bag. See Zool. Dan. prodr. addend. p. 281.

245. Trichoda Ingenita.

Trichoda vaginata, folliculo depreffa, bafi latiore feffilis. Sheathed trichoda, the bag depreffed, the bafe broadeft.

The animalculum that is contained in this fheath is funnel-fhaped; a hair, or hairs, may be perceived on each fide of the mouth of the funnel. It can extend or contract itfelf freely in the bag, without even touching the ſides, the tail reſting on the baſe thereof. It was found in ſalt water.

246. Trichoda Innata. Fig. 11, Plate XXVI.

Trichoda vaginata, folliculo cylindrico, pedicello extra folliculum. Sheathed trichoda, with a cylindrical bag, the pedicle paſſing through and projecting beyond the bag. Theſe characters diſtinguiſh it ſufficiently from the preceding one. b the animalculum in the ſheath, d the tail.

247. Trichoda Transfuga.

Trichoda latiuſcula, antice crinita, poſtice ſetoſa, altero latere ſinuata, altero mucronata. Broad trichoda, the fore-part hairy, the hinder-part full of briſtles, one ſide ſinuated, the other pointed. See Zool. Dan. prod. addend. p. 281.

248. Trichoda Ciliata.

Trichoda ventricoſa, poſtice crinibus pectinata. See Zool. Dan. Icon. tab. 73, Fig. 13, 15.

249. Trichoda Bulla.

Trichoda membranacea, lateribus inflexis, antice & poſtice crinita. Membranaceous trichoda, the ſides bent inwards, the fore and hind-part are both furniſhed with hairs; it differs only by the laſt circumſtance from the burſaria bulla.

250. Tri-

250. Trichoda Pellionella.

Trichoda cylindracea, antice crinita, poſtice ſetofa. Cylindrical, the fore-part hairy, the hinder-part furniſhed with briſtles.

This trichoda is rather thick in the middle, pellucid, with a few molecules here and there, the ſides obtuſe, the fore-part ciliated, the hairs very fine, the hind-part terminating in a kind of briſtles.

251. Trichoda Cyllidium. Fig. 15, Plate XXVI.

Trichoda ovata, apice hiante, baſique crinita. Egg-ſhaped, the apex gaping, the baſe hairy.

Pellucid, replete with globules of different ſizes, in the hind-extremity; the fore-part narrower, without any footſteps of an external organ. It vacillates upon the edge, commonly advancing on it's flat ſide, continually drawing up water; it then gapes, opens into a very acute angle, almoſt to the middle of the body. It is difficult to be perceived, as it effects this in an inſtant. a the mouth, b the hairs or briſtles, which it extends when in agonies.

252. Trichoda Curſor.

Trichoda ovata, antice crinita, poſtice duplici pilorum ſtrictorum & curvorum faſciculo. Oval trichoda, the fore-part hairy, the hinder-part furnifhed with two fafcicles of ftrait and curved hairs.

The body flat, and filled with molecules; in the fore-part there is an oblong empty fpace, into which, under certain circumftances, we may fee the water as it were fucked in.

253. Trichoda Pulex. Fig. 12, Plate XXVI.

Trichoda ovata, antice incifa, fronte & bafi crinita. Egg-fhaped, with an incifion in the fore-part, the front and the bafe hairy. a the anterior, b the pofterior part, c the incifion.

254. Trichoda Lynceus. Fig. 16, Plate XXVI.

Trichoda fubquadrata, roftro adunco, ore crinito. Nearly fquare, with a crooked beak, the mouth hairy.

At firft fight it does not appear very diffimilar to fome of the monoculi. The body is membranaceous, and as it were compreffed, being broad without thicknefs, ftretched out into a beak above, the lower part truncated; under the beak is a little bundle of hairs, the lower edge bends in and out, and is girt round with a few briftles. The inteftines are beautifully vifible, a fmall bent tube goes from the mouth to the inteftines in the middle of the body; thefe, as well as the tube, are in frequent agitation; another tube is alfo perceivable between the fore and hind edge. It is filled with a blue liquor. a the beak, b the mouth, c the bafe.

252. Tri-

255. Trichoda Erofa.

Trichoda orbicularis, antice emarginata, altero latere crinita, poftice fetofa. Orbicular trichoda, the fore-part notched, one fide fet with hairs, the hinder-part with briftles.

256. Trichoda Roftrata.

Trichoda depreffa, mutabilis, flavefcens, ciliis longis fetifque pediformibus. Depreffed trichoda, mutable, yellow, with long ciliated hairs, and feet tapering to a point.

The body depreffed, both the feet and hairs are within the margin, the feet are four in number, one of them is longer than the reft. The figure of the body is for the moft part fomewhat triangular, the apex formed into a kind of obtufe beak; the beak is fometimes drawn in fo that the animalculum then appears altogether orbicular. Found in water where duck-weed has been kept.

257. Trichoda Lagena.

Trichoda teres, ventricofa, roftro producta, poftice fetofa. Round ventricofe trichoda, with a long neck, the lower end fet with briftles.

258. Tri-

6. That every ray of light carries with it the image of the object from which it was emitted.

The nature of viſion in the eye, may be imperfectly illuſtrated by the experiment of the darkened room; the pupil of the eye being conſidered as the hole through which the rays of light paſs, and croſs each other, to paint on the retina, at the bottom of the eye, the inverted images of all thoſe objects which are expoſed to the ſight, ſo that the diameter of the images of the ſame object are greater, in proportion to the angles formed at the pupil, by the croſſing rays which proceed from the extremities of the object; that is, the diameter of the image is greater, in proportion as the diſtance is leſs; or, in other words, the apparent magnitude of an object is in ſome degree meaſured by the angle under which it is ſeen, and this angle increaſes or diminiſhes, according as the object is nearer to, or further from the eye; and conſequently, the leſs the diſtance is between the eye and the object, the larger the latter will appear.

From hence it follows, that the apparent diameter of an object ſeen by the naked eye, may be magnified in any proportion we pleaſe; for as the apparent diameter is increaſed, in proportion as the diſtance from the eye is leſſened, we have only to leſſen the diſtance of the object from the eye, in order to increaſe the apparent diameter thereof.* Thus, ſuppoſe there is an object, AB, Plate I. Fig. 1, which to an eye at E ſubtends or appears under the angle AEB, we may magnify the apparent diameter in what proportion we pleaſe, by bringing our eye nearer to it. If, for inſtance, we would magnify it in the proportion of FG to

* Rutherforth's Syſtem of Natural Philoſophy, p. 330.

258. Trichoda Charon. Fig. 17 and 18, Plate XXVI.

Trichoda cymbiformis fulcata, antice et poftice crinita. Boat-ſhaped trichoda with furrows, the fore and hind-parts both hairy.

The body is oval; it refembles a boat both in ſhape and motion, the upper part hollowed, the under part furrowed and convex, the ſtern round, with feveral hairs projecting from it. Several hairs may alfo be feen on one fide. Was found in falt water. a the head, b the tail; d, Fig. 18, a pellucid bubble that is fometimes to be perceived.

259. Trichoda Cimex. Fig. 19, Plate XXXI.

Trichoda ovalis, marginibus lucidis, antice et poftice crinita. Oval trichoda, with a lucid margin, both the fore and hind-part hairy.

It is about the fize of the trichoda lynceus, an oval body, the back convex, the belly flat, an incifion in the edge of the fore-part; the edges of this incifion are feen to move. It's inteftines are pellucid and ill-defined.

It both fwims and walks. When it meets with any obftacles, four fmall briftles, which are fixed underneath, come into view; thefe it ufes as feet. a the hairs in the fore-part, b the briftles at the hind-part, d the back, e two fmall projecting hairs.

260. Tri-

260. Trichoda Cicada.

Trichoda ovalis, marginibus obfcuris, antice & fubtus crinita, poftice mutica. Oval trichoda, with an obfcure margin, the fore-part underneath fet with hairs, the hinder-parts beardlefs.

It does not differ confiderably from the preceding, though M. Muller has pointed out fome fhades by which they may be dif-criminated.

XIV. KERONA.

Vermis inconfpicuus corniculatus. An invifible worm with horns.

261. Kerona Raftellum.

Kerona orbicularis membranacea, nafuta, corniculis in tota pagina. Membranaceous orbicular kerona, with one projecting point, the upper furface covered with fmall horns. There are three rows of horns on the back, which nearly occupy the whole of it. It was found in river water.

262. Ke-

262. Kerona Lyncafter.

Kerona fubquadrata. roftro obtufo, difco corniculis micantibus. This fpecies of kerona is rather fquare, the difc furnifhed with fhining horns. See Zool. Dan. prod. add. p. 281.

263. Kerona Hiftrio. Fig. 20, Plate XXVI.

Kerona oblonga, antice punctis mucronatis nigris, poftice pinnulis longitudinalibus, inftructa.

It is an oblong membrane, pellucid, with four or five black points in the fore-part, which are continually changing their fituation, thick fet with fmall globules in the middle, among which four larger ones are fometimes perceived, thefe are probably eggs; in the middle fpace of the hind-part are fome longitudinal ftrokes refembling briftles; they do not feem to project beyond the body. b the horns, c fome hairs, d a folitary horn, e a large globule, f fome briftles.

264. Kerona Cypris. Fig. 21, Plate XXVI.

Trichoda obovata, verfus poftica fuperne finuata, antice crinita. Egg-fhaped, towards the hind-part finuated, the fore-part hairy.

This animalculum is compreffed, and fomething in a pear-fhape, the fore-part broad and blunt, the front is furnifhed with fhort hairs a, or little vibrating points inferted under the edge, fhorter in in the hind-part, partly extended ftrait, partly bent down; the motion is retrograde. It is found in water which is covered with lemna.

265. Kerona Hauftrum.

Kerona orbiculata, corniculis mediis, antice membranacea ciliata, poftice fetofa. Orbicular kerona, the horns in the middle, the fore-part membranaceous and ciliated, at the hinder-part there are feveral briftles.

266. Kerona Hauftellum.

Differs from the preceding only in having the hinder-part without any briftles.

267. Kerona Patella. Fig. 22 and 23, Plate XXVI.

Kerona univalvis, antice emarginata corniculata, poftice fetis flexilibus pendulis. With one valve, orbicular, cryftalline, the fore-part fomewhat notched, the flefhy body lies in the middle of the fhell; above and below are hairs, or horns, of different lengths, jutting out beyond the fhell, and acting inftead of feet and oars, fome of which are bent; the fuperior ones conftitute a double tranfverfe row. a the fore-part, b the horns, d a lunated figure in the fhell, c a pulpous body, f briftles at the hinder-part.

268. Kerona Vannus.

Kerona ovalis, fubdepreffa, margine altero flexo, oppofito ciliato, corniculis anticis, fetifque pofticis. Oval and rather flat kerona, one edge bent, the oppofite edge ciliated, the front furnifhed with horns, the hinder-part with briftles.

269. Kerona Pullafter. Fig. 24 and 25, Plate XXVI.

Kerona ovata, antice finuata, fronte creftata, bafi crinita. Oval, the fore-part finuated, a creft on the front, the bafe hairy.

It agrees with the trichoda pulex in many particulars, but the upper part is pellucid, without any black molecules, the front truncated, the whole fuperficies of the head covered with hair, and the fore-part finuous. a the horns, b the hairs at the hinder-part, c the cilia of the front.

270. Kerona Mytillus. Fig. 29, Plate XXVI.

Kerona fubclavata, utraque extremitate latiori, hyalina ciliata. Rather clubbed, broad at both extremities, clear and ciliated.

A large animalculum, the fore and hind-part rounded, very pellucid and white, dark in the middle, with black inteftines, intermixed with a few pellucid veficles. Both extremities feem as it were compofed of two thin plates. The fore-part is ciliated, the hairs fhort, lying within the margin; it is alfo ornamented with

with two little horns, erected from an obſcure maſs; with theſe it agitates the water, forming a little whirlpool. The hind-part is ciliated, and furniſhed with two briſtles, that ſtretch out beyond the margin. a the horns, b the fore-part ciliated, c the hind-part, d projecting briſtles.

271. Kerona Lepus.

Kerona ovata, apice crinito, baſi ſetoſa. Egg-ſhaped, the fore-part hairy, the baſe furniſhed with briſtles.

The body is egg-ſhaped, compreſſed, pellucid, crowned with ſhort waving hairs, the baſe terminating with briſtles.

272. Kerona Silurus.

Kerona oblonga, antice & poſtice crinita, dorſo ciliato. Oblong, the fore and hind-part hairy, the back ciliated.

An oval ſmooth animalculum, ſomething crooked and opake, a faſcicle of vibrating hair on the fore-part; the hind-part, or ſharp tail, furniſhed with unequal moveable rows of hairs, the back is alſo ciliated; theſe hairs produce a rotatory motion, in the inſide are ſome unequal, lucid, opake points. The figure varies from oval to oblong, the filaments of the conferva are often entangled in the tail.

4 D 2 273. Ke-

273. Kerona Calvitium.

Kerona latiufcula, oblonga, antice corniculis micantibus. Rather broad, oblong, with glittering horns on the fore-part.

The body is rather broad and flat, both fides obtufe, filled with black molecules, and more particularly a dark fpot near the hinder-part; the interjacent veficles are pellucid, no hairs on the fore-part, but inftead thereof two little moveable horns, and from three to five moveable black points, a few fhort briftles at the hind-part. Found in the infufions of vegetables.

274. Kerona Puftulluata.

Kerona ovalis convexa, poftice altero margine finuata, utraque extremitate crinita, corniculifque anticis. Oval convex kerona, one edge of the hinder-part finuated, both ends fet with hairs, and fome horns placed on the fore-part.

This animalculum was found in falt water.

XV. HIMANTOPUS.

Vermis inconfpicuus, pellucidus, cirratus. A pellucid, invifible, cirrated * worm.

275. Hi-

* That is, furnifhed with a tuft or lock of hair.

275. Himantopus Acarus. Fig. 27, Plate XXVI.

Himantopus ventrofus, poftice cirratus, antice acuminatus. Ventrofe himantopus, the hinder-part cirrated, the fore-part fharp.

It is a lively, conical, ventricofe animalculum, full of black molecules, the fore-part bright and tranfparent. The apex is more or lefs attenuated, at the will of the little creature, with rows of long hairs, like fo many rays underneath; four locks of hair, or feet, long and crooked, proceed from the belly; it is continually moving thefe and the other hairs in various directions, it has the fame circular motion in the fame place. It is found, though feldom, where there is lemna. a the apex, b the ciliated part, c the feet.

276. Himantopus Ludio. Fig. 26, Plate XXVI.

Himantopus cirrata, fupra crinita, cauda furfum extenfa. Curled himantopus, the upper part hairy, the tail extended upwards.

This is a lively and diverting animalculum, fmooth, pellucid, full of little points, the fore-part clubbed, and a little bent, the hind-part narrow, the bafe obliquely truncated, terminating in a tail ftretched out tranfverfely. The top of the head, and the middle of the back b, furnifhed with long vibrating hairs; from the fide ſide of the head hang three moveable and flexible curls a, diſtant from each other. When the animalculum is in motion, the tail is drawn tight, and extended upwards, and often appears as if it was cleft. It is curled up when the little creature is at reſt.

277. Himantopus Sannio.

Himantopus incurvata, ſupra ciliata, infra crinita. Crooked himantopus, the upper part ciliated, the under part hairy.

It is very much like the himantopus ludio, the cilia are longer than the hairs, and are continually vibrating; it has alſo two moveable curls hanging on both ſides the head. Is found but ſeldom, and then generally in water where the lemna vegetates.

279. Himantopus Volutator.

Himantopus lunatus, antice cirratus. Lunated himantopus, the fore-part hairy.

A very lively animalculum, of the ſhape of a creſcent, with ſome viſible cryſtalline points, the convex part furniſhed with a row of hairs, which are longeſt towards the tail; underneath are four feet. It often turns round ſwiftly in a circular direction.

280. Himantopus Larva.

Himantopus elongatus, medio cirratus. Long himantopus, cirrated in the middle.

By it's motion it refembles the himantopus ludio, but differs from it in figure and fituation of the parts. The body is rather depreffed and long, the hinder parts acute, and generally curved, pellucid, filled with granular molecules.

281. Himantopus Charon.

Himantopus cymbæformis fulcata, in fovea ventrali cirrata. Boat-fhaped furrowed himantopus, the hollow part of the belly cirrated.

An oval pellucid membrane, the fore-part hairy, furrowed longitudinally, each fide bent up fo as to form an intermediate hollow place, or belly, crammed with grey molecules; beneath the middle it has feveral bent diverging rows of hairs; no hairs on the hinder-part. Rarely to be found, and then in fea-water.

282. Himantopus Corona.

Himantopus femiorbiculata, depreffa, in utraque pagina cirrata. Semiorbicular himantopus, flattened, both fides cirrated.

A membranaceous lamina, very thin, very pellucid, cryftalline, femilunar; the edge of the bafe thick fet with molecular inteftines, the other angle, or fore-part, furnifhed with fhort hairs, or a kind of mane; towards the hind part three equal curved hairs, or fpines.

to AB; that is, if we would fee the object under an angle as large as FEG, or would make it appear the fame length that an object as long as FG would appear, it may be done by coming nearer to the object. For the apparent diameter is as the diftance inverfely; therefore, if CD is as much lefs than CE, as FG is greater than AB, by bringing the eye nearer to the object in the proportion of CD to ED, the apparent diameter will be magnified in the proportion of FG to AB; fo that the object AB, to the eye at D, will appear as long as an object FG would appear to the eye at E. In the fame manner, we might fhew, that the apparent diameter of an object, when feen by the naked eye, may be infinite. For fince the apparent diameter is reciprocally as the diftance of the eye, when the diftance of the eye is nothing, or when the eye is clofe to the object at C, the apparent diameter will be the reciprocal of nothing, or infinite.

There is, however, one great inconvenience in thus magnifying an object, without the help of glaffes, by placing the eye nearer to it. The inconvenience is, that we cannot fee an object diftinctly, unlefs the eye is about five or fix inches from it; therefore, if we bring it nearer to our eye than five or fix inches, however it may be magnified, it will be feen confufedly. Upon this account, the greateft apparent magnitude of an object that we are ufed to, is the apparent magnitude, when the eye is about five or fix inches from it: and we never place an object much within that diftance; becaufe, though it might be magnified by this means, yet the confufion would prevent our deriving any advantage from feeing it fo large. The fize of an object feems extraordinary, when viewed through a convex lens; not becaufe it is impoffible to make it appear of the fame fize to the naked eye,

4 but

XVI. VORTICELLA.

Vermis contractilis, nudus, ciliis rotatoriis. A worm capable of contracting or extending itſelf, naked, with rotatory cilia.

283. Vorticella Viridis. Fig. 31, Plate XXVI.

Vorticella cylindracea, uniformis, viridis opaca. Cylindrical, uniform, green, and opake.

To the naked eye it appears as a ſmall green point, through the microſcope as an opake corpuſcle, of a dark-green colour, cylindrical, obtuſe at both extremities, yet rather thicker in the fore-part a; very ſimple, deſtitute of limbs, not changing it's figure. Notwithſtanding it's ſimplicity, the continual motion into which it puts the water gives room to ſuſpect that it is furniſhed with an inviſible rotatory inſtrument, it moves ſometimes circularly, ſometimes in a ſtrait line. a the fore-part, b the hind-part, c ſhort hairs.

284. Vorticella Sphæroida.

Vorticella cylindrico-globoſa, uniformis, opaca. A globous cylinder, uniform and opake.

To the naked eye it appears little more than a point ſwimming about in the water; but with the microſcope as a globular maſs, of a dark-green colour; they occaſion a vehement motion in the adjacent

adjacent water, very ſhort hairs, which are probably the cauſe thereof, may be perceived.

285. Vorticella Cincta. Fig. 30, Plate XXVI.

Vorticella trapeziformis, nigro-viridis, opaca. This vorticella is in the form of a trapezium, of a blackiſh green colour, and opake.

It is of an irregular figure, inviſible to the naked eye, ciliated on every ſide, the hairs all moveable, and longer on one ſide than on the other. It ſometimes aſſumes an oval ſhape, and appears girt round with a tranſverſal keel.

286. Vorticella Lunifera.

Vorticella viridis, poſtice lunata, medio margine mucronato. Green vorticella, the hinder-part lunated, with a point in the middle, projecting from the edge.

The fore-part obtuſe, the baſe broad, and hollowed away like a creſcent, with a protuberance in the middle of the concave part, ſhorter than the horns or points of the creſcent; the fore-part is ciliated. It is found in ſalt water.

287. Vorticella Burfata. Fig. 32, Plate XXVI.

Vorticella viridis, apertura truncata, papillaque centrali. Green vorticella, the aperture truncated, with a central papillary projection.

Ventricofe, crammed with molecules, the fore-part truncated, and both fides of it, c c, pellucid; in the center of the aperture there is a prominent papilla or nipple b, which, when the animalculum is at reft, appears notched; the edge a a of the aperture is furrounded with cilia; thefe are fometimes all erected, fhining, and in motion, or part bent back and quiefcent, and part in motion; fometimes a few of them are collected together, and turned back like little hooks, one on each fide. Found in falt water. a the cilia, b the projecting papilla, c the pellucid fpace at the fore-part.

288. Vorticella Varia.

Vorticella cylindrica, truncata, opaca, nigricans. Cylindrical, truncated, opake, blackifh-coloured vorticella, the fore-part ciliated.

289. Vorticella Sputarium.

Vorticella ventrofa, apertura orbiculari, ciliis longis raris excentricis. Ventrofe vorticella, with an orbicular aperture, and long hairs radiating as from a center.

This

This is a ſingular animalculum, even among thoſe where all are ſingular; viewed ſideways it is ſometimes cylindrical, though ſomewhat tapering towards the hinder-part, with a broad pellucid edge; viewed from the top it has ſometimes a broad face, or diſc, furniſhed with radiating hairs, the under part contracted into a globular ſhape, of a dark-green colour, and filled with ſmall grains. It was found in October with the leſſer lemna.

290. Vorticella Polymorpha. Fig. 33, 34, 35, Plate XXVI.

Vorticella multiformis, viridis, opaca. Many-ſhaped vorticella, green, opake.

To the naked eye it appears as a moſt agile green point; when viewed by the microſcope, it puts on every moment ſo many and ſuch various forms, that they can neither be exhibited to the eye by drawings, nor deſcribed by words; it is truly one of the wonders of nature, aſtoniſhing the mind, fatiguing the eye, and continually exciting the ſpectator to aſk,

"Quo teneam vultus mutantem protea nodo?"

Fig. 33, 34, 35, repreſent it in three different forms; a the fore-part, g the hind-part, c the fore-part ſimple, d the fore-part turned in or doubled, the body is granulous, a ſeries of pellucid points is ſometimes to be obſerved.

291. Vorticella Multiformis.

Vorticella viridis, opaca, varia, veficulis fparfis. Green, opake, variable vorticella, with veficles fcattered about the body.

This is fo like the preceding one, that it needs no further defcription. Is found in falt water, and the vefieles are larger.

292. Vorticella Nigra. Fig. 36 and 37, Plate XXVI.

Vorticella trochiformis nigra. Top-fhaped black vorticella.

To the naked eye they prefent themfelves as fmall black points fwimming on the water; through the microfcope it appears as a little conical corpufcle, opake, obtufe, and ventricofe at one extremity, the other acute; when it extends the extremities, two little white hooks come into fight, by their affiftance it moves in the water, and it is probable, from fome circumftances, that they inclofe a rotatory organ. It is in continual motion, vacillating on the top of the water. Is found in Auguft, in meadows that are covered with water. a the rotatory organ, b the two fmall hooks, c the acute end.

293. Vorticella Cucullus.

Vorticella elongata, teres, apertura oblique truncata. This vorticella is long, round, the aperture or mouth obliquely truncated.

5 This

This vorticella may be ranked among the larger ones, as it is viſible to the naked eye. The body is ſomewhat conical, of a dirty red colour; it's ſhape has been compared to that of a grenadier's cap.

294. Vorticella Utriculata.

Vorticella viridis, ventricoſa, productilis, antice truncata. Green vorticella, ventricoſe, the belly capable of being lengthened or ſhortened, the fore-part truncated, much in the ſhape of a common water-bottle, the neck ſometimes very long, at others with ſcarce any at all, and is filled with green molecules.

295. Vorticella Ocreata.

Vorticella ſubcubica, infra in angulum obtuſum producta. This vorticella is ſomewhat of a cubical figure, the under part bent in an obtuſe angle.

It is a very ſingular animalculum, being in ſhape like the lower part of a boot; the apex of the upper part, or leg, is truncated and ciliated, the heel pointed, the foot round. It is an inhabitant of rivers, though very rarely to be met with.

296. Vorticella Valga.

Vorticella cubica, infra divaricata. Cubical vorticella, the lower part divaricated.

This

This is filled with grey molecules, and is as broad as it is long, the apex truncated and ciliated, both angles of the bafe projecting outwards, one fomewhat like a wart, the other like a finger. Found in marfhy waters.

297. Vorticella Papillaris.

Vorticella ventricofa, antice truncata, papilla caudali & laterali hyalina. Ventricofe vorticella, the fore-part truncated, a papillary tail, and a fplendid papillary excrefcence on the fide. Is an inhabitant of marfhes, where the conferva nitida is met with.

298. Vorticella Sacculus.

Vorticella cylindracea, apertura repanda, margine reflexo. Cylindrical vorticella, the aperture broad and flat, the edge turned down.

A thick animalculum, every-where of an equal diameter, and filled with molecules; the edge of the mouth bent back, the hinder-part obtufe, fometimes notched and contracted, cilia to be feen on both fides the mouth.

299. Vorticella Cirrata.

Vorticella ventrofa, apertura finuata, cirro utrinque ventrali. Ventrofe vorticella, the aperture finuated, two tufts of hair on each fide of the belly. It is an inhabitant of the water in ditches.

300. Vor-

300. Vorticella Nafuta. Fig. 38, 39, Plate XXVI.

Vorticella cylindracea, crateris medio mucrone prominente. Cylindrical, with a prominent point in the middle of the cup.

An animalculum that is invifible to the naked eye; but when it is armed with microfcopic lenfes, it appears curioufly furnifhed with a rotatory organ, which encompaffes the middle of the body.

It is pellucid, cylindrical, of an unequal fize, the fore-part (a) truncated and ciliated, and a triangular prominency (e) in the middle of the aperture; the hind-part obtufe, a point on each fide of the middle of the body. This is the appearance of this little creature when in motion; but when the water is nearly exhaled, fome further parts of it's ftructure are rendered vifible; befides the rotatory organ in the anterior part, another is now difcovered encompaffing the middle of the body; the hairs of this are in vehement motion. There are other fafcicles of moving hairs to be difcovered at the fame time. The variegated and quick motion of this apparatus (more particularly if the animalculum is big with young, and moving at the fame time within the mother,) fill the mind with amazement.

301. Vor-

301. Vorticella Stellina.

Vorticella orbicularis, difco moleculari, peripheria ciliata. Orbicular vorticella, with a molecular difc, and ciliated periphery.

302. Vorticella Difcina. Fig. 8, 9, 10, Plate XXVI. A.

Vorticella orbicularis, margine ciliato, fubtus convexo-anfata. Orbicular vorticella, the edge ciliated, with a kind of convex handle on the under fide.

303. Vorticella Scyphina.

Vorticella crateriformis, cryftallina, medio fphærula opaca. Bowl-fhaped vorticella, cryftalline, an opake fpherule in the middle.

304. Vorticella Albina.

Vorticella cylindrica, poftice acuminata. Cylindrical vorticella, the hinder-part tapering, and almoft brought to a point.

305. Vorticella Fritillina.

Vorticella cylindrica vacua, apice truncata, ciliis prælongis. Empty cylindrical vorticella, the apex truncated.

306. Vor-

306. Vorticella Truncatella.

Vorticella cylindrica, differta, apice truncata, ciliis breviuſculis. Cylindrical vorticella, ſtuffed or filled, the apex truncated, with very ſhort cilia.

It is of the number of the larger animalcula, the body is cryſtalline, and replete with black molecules, it's ſkin is perfectly ſmooth and colourleſs, it's hinder extremity is rounded, the anterior is truncated; there is a large opening viſible at this extremity, which ſerves as a mouth; this is thickly ciliated.

307. Vorticella Limacina. Fig. 60, Plate XXVI.

Vorticella cylindrica, truncata, ciliis bigeminis. Cylindrical truncated vorticella, with two pair of cilia.

308. Vorticella Fraxinina.

Vorticella gregaria, cylindracea, oblique truncata, ciliis bigeminis, apice margine fiſſa. Gregarious cylindrical vorticella, obliquely truncated, with two pair of cilia, and a fiſſure or notch at the upper edge.

The greater part of the body is cylindrical, the hinder-part is rather tapering, and filled with opake molecules; towards the upper end it is tranſparent; within the edge, at top, are two ſmall tubercles, from each ſide of which a pair of ſmall hairs proceed.

4 F 309. Vor-

but becauſe at the diſtance from the eye which would be neceſſary for this purpoſe, it would appear exceedingly confuſed; for which reaſon, we never bring our eye ſo near to it, and conſequently, as we have not been accuſtomed to ſee the object of this ſize, it appears an extraordinary one.

On account of the extreme minuteneſs of the atoms of light, it is clear, a ſingle ray, or even a ſmall number of rays, cannot make a ſenſible impreſſion on the organ of ſight, whoſe fibres are very groſs, when compared to theſe atoms; it is neceſſary, therefore, that a great number ſhould proceed from the ſurface of an object, to render it viſible. But as the rays of light, which proceed from an object, are continually diverging, different methods have been contrived, either of uniting them in a given point, or of ſeparating them at pleaſure: the manner of doing this, is the ſubject of dioptrics and catoptrics.

By the help of glaſſes, we unite in the ſame ſenſible point a great number of rays, proceeding from one point of an object; and as each ray carries with it the image of the point from whence it proceeded, all the rays united muſt form an image of the object from whence they were emitted. This image is brighter, in proportion as there are more rays united; and more diſtinct, in proportion as the order, in which they proceeded, is better preſerved in their union. This may be rendered evident; for, if a white and poliſhed plane is placed where the union is formed, we ſhall ſee the image of the object painted in all it's colours on this plane; which image will be brighter, if all adventitious light is excluded from the plane on which it is received.

E The

309. Vorticella Cratægaria.

See page 437 of this work.

310. Vorticella Hamata. Fig. 40, Plate XXVI.

Vorticella burſæformis, margine aperturæ aculeis rigidis. Purſe-formed vorticella, the edge of it's aperture or mouth ſet with rigid points.

It is not ciliated, nor have any hairs as yet been diſcovered about it; the body is granulated, the fore-part broad and truncated, the hinder-part obtuſe, and capable of being contracted or extended. a the rigid points.

311. Vorticella Crateriformis. Fig. 41, Plate XXVI.

Vorticella ſubquadrata, ciliorum faſciculis etiam poſtice. This vorticella is rather of a ſquare figure, and has faſcicles of cilia even at the hinder-part.

Lively, pellucid, round, longer than it is broad, approaching ſomewhat to a ſquare, with convex ſides; the head is ſituated at the large end, the ſkin is ſmooth, ſome traces of inteſtines are with difficulty diſcovered; at the larger end there is a conſiderable opening, ſurrounded by hair; the filaments compoſing this are in continual motion.

5

Two

Two of thefe are fometimes feen conjoined together, as at Fig. 41, and full of fmall fpherules; at this time they may without care be taken for frefh animalcula; they draw each other alternately different ways; in this ftate the furface is fmooth and the hairs invifible. e moveable cilia.

312. Vorticella Canaliculata.

Vorticella dilatata, pellucida, latere incifo. Dilated, pellucid, with an incifion on the fide.

To the naked eye it appears as fo many white points adhering to the fides of the glafs; when magnified, the anterior part is narrower than the hind-one; in the fide a kind of incifion may be perceived, and the hind-part is a little notched towards the middle; it is furnifhed with a rotatory organ, by which it excites a continual whirling in the water.

313. Vorticella Verfatilis.

Vorticella elongata fpiculiformis, mox urceolaris. Long fpear-formed vorticella, but which often changes it's fhape into a pitcher-like form.

A pellucid gelatinous animalculum, of a greenifh colour, furnifhed with fmall radii, particularly about the circumference, whence it may be confidered as a minute water hedge-hog.

314. Vorticella Ampulla. Fig. 4 and 5, Plate XXVI. A.

Vorticella folliculo ampulaceo, pellucido, capite bilobo. This vorticella is contained in a pellucid bottle-ſhaped bag, the head of it is divided into two lobes.

Little more need be ſaid to enable the reader to know this animalculum, if he ſhould meet with it, than to obſerve that the bag is much in the ſhape of the common water-bottle; that the animalculum is ſometimes to be obſerved at the bottom of it, ſometimes nearly filling it.

315. Vorticella Folliculata.

Vorticella oblonga, folliculo cylindraceo hyalino. Oblong vorticella, in a bright cylindrical bag.

This animalculum is gelatinous and cylindrical; when at it's greateſt extenſion, the baſe appears attenuated, and the apex truncated.

316. Vorticella Larva.

Vorticella cylindrica, apertura lunata, ſpinis caudalibus binis. Cylindrical vorticella, the aperture ſomewhat in the ſhape of a creſcent, two ſmall thorny points projecting from the hinder-part.

The head, the trunk, and the tail may be eaſily diſtinguiſhed from each other. It is of a clay-colour, the aperture ciliated; a gloa globular projection may at times be feen to proceed from the aperture.

317. Vorticella Succolata. Fig. 42 and 43, Plate XXVI.

Vorticella inverfe conica, apertura lunata, trunco poftice bidentato, cauda elongata biphylla. This vorticella is in figure an inverted cone, the aperture of a crefcent fhape, the lower part of the trunk is notched, forming, as it were two teeth, the tail biphyllous.

Each of thefe parts is furrounded with a loofe bright fkin, the head is divided from the trunk by a deep incifion. a a a fmall points projecting from the head, b the cilia, c and d the interior parts; l, Fig. 42, the little horn at the bottom of the trunk.

318. Vorticella Aurita.

Vorticella cylindrico-ventrofa, apertura mutica, ciliis utrinque rotantibus cauda, articulata biphylla. Cylindrical ventrofe vorticella, the aperture deftitute of hairs, both fides of it furnifhed with rotatory cilia, the tail biphyllous.

319. Vorticella Tremula.

Vorticella inverfe conica, apertura lobata fpinulofa, cauda brevi unicufpi. This vorticella is fomewhat of a conical fhape, the mouth divided into parts which are fet with fmall fpines or thorns, a point projects from the tail.

It

It is a pellucid, cryſtalline, ventricoſe animalculum; within it, on one ſide of the body, there is a large clay-coloured oval maſs, adjacent to which there is a pellucid oval ſubſtance; the tail is articulated and very ſhort.

320. Vorticella Senta.

Vorticella inverſe conica, apertura ſpinoſa integra, cauda brevi bicuſpi. Somewhat of the ſhape of a cone, the aperture ſet with ſpines, the tail ſhort, and divided into two points.

It has ſome reſemblance to the larger vorticella rotatoria, but is eaſily diſtinguiſhed from them by it's horned ſpiny aperture, and ſimple rotatory organ.

The body is muſcular, pellucid, folding variouſly, the fore-part truncated; round the margin of the aperture are rows of hairs, but ſtiffer hairs or ſpines are alſo continually vibrating, with which it draws in all animate and inanimate ſubſtances.

321. Vorticella Lacinulata. Fig. 45, Plate XXVI.

Vorticella inverſe conica, apertura lobata, ſetis binis caudalibus. In ſhape ſomewhat of an inverted cone, the aperture lobated, the tail ſmall, and furniſhed with two briſtles (d).

The body is muſcular, pellucid, cylindrical, the apex about a third part down, drawn into a little neck, the aperture or apex is ſpread on both ſides into a kind of flap or lappet, in the middle is a lita little lamina, or triangular point; another of these is discovered when the aperture faces the observer, which makes it appear like a small flower. The hind-part, when in motion, is a little bent; it terminates in two minute bristles, which are seen sometimes united, at other times diverging. When the animalculum is swimming, it's rotatory organ (a) may be seen; molecular intestines are visible; it moves with velocity in an oblique direction. Is found in pure water.

322. Vorticella Constricta.

Vorticella elliptico ventricosa, apertura integra, cauda annulata biphylla. Elliptical ventricose vorticella, the aperture or mouth undivided, the tail annulated and forked.

In this kind, the head, the tail, and the trunk, are fully distinguished. A substance in motion has been perceived, which has been supposed to be the heart; there are two kinds of them, one a pale yellow, the other of a white colour; they move by fixing their tail to the glass upon the stage, and then extending their body as much as possible; they fix the fore-part to the place where they intend to move, and then draw the hinder-part to it, and so on. They sometimes turn round about upon one of the points of their tail, others spring forwards with a jerk. When at rest, they open their mouths very wide, the lips are ciliated, two black globules are discovered in some of them.

323. Vor-

323. Vorticella Togata.

Vorticella ſubquadrata, apertura integra, ſpinis caudalibus binis, plerumque unitis. Square vorticella, the aperture not divided, the tail conſiſting of two long ſpines, which are ſometimes ſo united as to appear as one.

The body is convex, of a dark colour, filled with molecules, the middle part pellucid, the hinder-part rather broader than the fore-part, the ſore-part ciliated, the tail formed of two very thin pellucid ſpines, which are ſomewhat curved, and much longer than the body.

324. Vorticella Longiſeta.

Vorticella elongata, compreſſa, ſetis caudalibus binis longiſſimis. Long vorticella, flat, the tail formed of two very long briſtles.

The fore-part ſinuated, and ſet with minute cilia; the two briſtles which conſtitute the tail are long, but one is longer than the other.

325. Vorticella Rotatoria. Fig. 46, 47, 48, 49, Pl. XXVI. A.

Vorticella cylindrica, pedicello collari, cauda longa quadracuſpi. Cylindrical vorticella, with a little foot projecting from the neck, a long tail furniſhed with four points.

Brachi-

Brachionus corpore conico ſubæquali. Hill Hiſt. Anim.

Brachionus corpore conico toruloſo. Ditto.

Brachionus. Pallas Zooph. 50.

Joblot Microſ. part 2, p. 77, plate 10, fig. 18; and p. 96, plate 5, A B C D E K.

Adams's Micrographia Illuſtrata, p. 148, plate 40, fig. 255.

Leeuwenhoeck Contin. Arc. Nat. p. 386, f. 1, 2.

Baker's Microſ. Exp. p. 95, pl. 6, f. 6, 7, 8.

Baker's Empl. for the Micr. p. 348, 379, pl. 11, f. 1 to 13; and fig. 1, 2, 3, 6, 7, 11, 12, 14, 15, 16, 17, 18, 19, 20, 21, 22, 23, of plate XXVI. A, belonging to the work.

Spallanz. Opuſc. 2 p. 301, 345, pl. 4, f. 3 to 5.

Rozier Journal Phyſique, 1775, p. 220.

No perſon ſeems to have ſucceeded ſo well in the deſcription of the wheel animalculum as Mr. Baker, and all ſucceeding writers refer us to him for a full account of this little creature. What I ſhall ſay upon this animalculum will therefore be taken chiefly from him, though with ſuch additions and alterations as appear to me neceſſary to render his account complete.

It may be proper to obferve, firft, that Mr. Muller's wheel animal differs in fome refpects from that of Mr. Baker's; firft, by the rotatory organs on the back, which ftretch out like ears; fecondly, the two little fplendid fubftances within the body; and thirdly, the two black points near the top of the head, which are probably the creature's eyes.

This little animal is found in rain water that has ftood for fome days in leaden gutters, or in the hollows of lead on the tops of houfes, or in the flime and fediment left in rain water; they are fometimes to be found alfo in ditches and amongft duck-weed.

It has been called the wheel animal becaufe it is furnifhed with a pair of inftruments, which in figure and motion refemble wheels. It appears only as a living creature when in water, and yet it may be kept for many months out of water, and in a ftate as dry as duft, without lofing the principle of life. When dry, it is of a globular form, about the fize of a grain of fand, and without any apparent figns of life. If it be put into the water, in the fpace of half an hour a languid motion begins, the globule turns itfelf about, lengthens itfelf by flow degrees, becomes very lively, and in a little time protrudes it's wheels, and fwims about in fearch of food; or elfe, fixing itfelf by it's tail, brings the food to it by the motion induced on the water by it's rotatory organs.

If the water that is found ftanding in gutters of lead, or the fediment it has left behind, has any thing of a red colour, you may be almoft fure of finding thefe animalcula therein. In fummer, when all the water is dried away, if the duft appears red, or of a dark brown, and is put into water, you will feldom fail to difcover,

difcover, by means of the microfcope, a great number of minute reddifh globules, which are the animalcula themfelves. It is moft proper to obferve them firft with the third or fourth magnifiers, and then to ufe thofe which are deeper.

This little creature has fome likenefs to a caterpillar; it's motion from place to place is performed like many of thofe infects, by firft fixing the tail to fome fubftance, then extending the whole body, and fixing the head, then drawing the tail to it; by thefe alternate actions it moves with fome degree of fwiftnefs.

It very often changes it's appearance, and affumes a different form; for the fnout being drawn inwards, the fore-part becomes clubbed, and immediately dividing, exhibits to our view two circular inftruments, fet with minute hairs, that move very brifkly, fometimes in a rotatory manner, fometimes in a kind of trembling, or vibratory mode. An aperture, or mouth, is alfo perceived between the two femicircles; the animal may often be feen fwimming about in purfuit of food while in this ftate.

The moft diftinguifhing parts of this animalculum are the head, the thorax, and the abdomen. The form and ftructure of the head is wonderful, differing from any other creature hitherto defcribed; the fudden change of the head from one form to another is equally furprizing and fingular; for from being of a very taper form, it becomes on a fudden as broad as any part of the infect, and protrudes an amazing piece of machinery, formed to procure it's food.

 The

The point of union of the rays of light, formed by means of a glaſs lens, &c. is called the FOCUS.

Now, as each ray carries with it the image of the object from whence it proceeded, it follows, that if thoſe rays, after interſecting each other, and having formed an image at their interſection, are again united by a refraction or reflection, they will form a new image, and that repeatedly, as long as their order is not confounded or diſturbed.

It follows alſo, that when the progreſs of the luminous ray is under conſideration, we may look on the image as the object, and the object as the image; and conſider the ſecond image, as if it had been produced by the firſt as an object, and ſo on.

In order to gain a clear idea of the wonderful effects produced by glaſſes, we muſt proceed to ſay ſomething of the principles of refraction.

Any body, which is ſo conſtituted as to yield a paſſage to the rays of light, is called a MEDIUM. Air, water, glaſs, &c. are mediums of light. If any medium affords an eaſy paſſage to the rays of light, it is called a RARE MEDIUM; but if it does not afford an eaſy paſſage to theſe rays, it is called a DENSE MEDIUM.

Let Z, Fig. 2, Plate I. be a rare medium, and Y a denſe one; and let them be ſeparated by the plane ſurface G H. Let I K be a perpendicular to it, and cutting it in C.

With

The circular bodies which project from them have much the reſemblance of wheels, and ſeem to turn round with conſiderable velocity, by which means a very rapid current of water is brought from a great diſtance to the mouth of the little creature; as theſe wheels are very tranſparent, except the edge, which is ſet with fibrillæ, (as cogs to a wheel) it is difficult to determine how they are turned about, or what is their real figure, whether they are flat, concave, or conical; be this as it may, they are protruded from a couple of tubular caſes, in which they can be again retracted, at the will and pleaſure of the animal. They do not always turn the ſame way, nor with the ſame velocity; they will ſometimes move in contrary directions, ſometimes both one way. The figure varies, from the degree of their protruſion, and from other circumſtances. They appear ſometimes like minute oblong ſquares, riſing from the periphery of a circle; at other times they terminate in ſharp points, ſometimes they are curved, bending the ſame way like ſo many hooks; now and then the ends appear clubbed, or in appearance like a number of little mallets.

When the fore-part of this creature is firſt ſeen to open or divide, the parts, which when fully protruded reſemble wheels, ſeem only like a couple of ſemicircles, the edges whereof are ſet with little ſpiculæ, having all a nimble and continual vibrating motion upwards and downwards, whereby the water becomes agitated, each wheel being in this caſe doubled, or like a round piece of paper folded in the middle.

When the wheels are in motion, the head appears very large in proportion to the ſize of the animal; and though it is then every-where tranſparent, yet a ring or circle, more particularly remark-

remarkable for it's brightneſs, may be perceived about the middle of the forehead; many veſſels may be ſeen to take their origin from this.

The thorax, or breaſt, is joined to the head by a ſhort annular circle, or neck; the thorax in ſize is nearly one-ſixth part of the whole animalculum. In it we diſtinctly perceive the heart of the little creature; the heart is placed almoſt in the middle, the diaſtole and ſyſtole cannot fail to catch the eye of every attentive obſerver. It is ſeen very plainly through the back, ſhutting and opening alternately with great regularity and exactneſs. It appears to be compoſed of two ſemilunar parts, wich in the time of contraction approach each other laterally, and form between them a figure ſomewhat like a horſe-ſhoe, whoſe upper ſide is flat, the under one convex. In the diaſtole theſe two parts ſeparate; the ſeparation begins exactly in the middle of the lower part next the tail. The alternate motions of the heart are performed with great ſtrength and vigour. In each of the ſemilunar parts there is a cavity, which cloſes when they come together, and opens when they ſeparate.

The motion of the heart is communicated to all the other parts of the thorax, and indeed through the whole animal we may perceive contractions and dilatations going on, that are apparently correſpondent thereto. It is neceſſary, however, to remark, that the motion of the heart is ſometimes ſuſpended, or at leaſt quite imperceptible for two or three minutes, after which it recommences, and goes on with the ſame vigour and regularity as before. From the under part of the thorax a ſmall tranſparent horn proceeds, which cannot be ſeen unleſs the inſect turns on it's back or ſide.

Below the thorax there is an annular circle that joins the thorax to the abdomen. The abdomen is much the largeſt part of this animal, it contains the ſtomach and viſcera. When this creature is full of food, the bowels are opake, and of a crimſon colour, extending from the thorax quite through the belly and a great part of the tail, and exhibits a fine view of the periſtaltic motion, or thoſe gradual contractions and dilatations of the inteſtines, which propel their contents downwards. There are many ramifications of veſſels, both longitudinal and tranſverſe, round the bowels. It can extend the abdomen in length very much, or contract and widen it conſiderably, ſo as to become a caſe for all the reſt of the body. The tail goes from a joint at the lower part of the belly to the poſterior extremity; it is of a tapering form, and conſiſts generally of three joints; when it is inclined to fix itſelf to any thing by the tail, it thruſts out four, ſometimes ſix, little hooks from the end thereof; theſe are placed in pairs, one pair at the very extremity itſelf, the other two a little way up the ſides; the three are ſeldom ſeen at the ſame time. The wheels ſeem to be the organ that the animal uſes to aſſiſt it in ſwimming.

All the actions of this creature ſeem to imply ſagacity and quickneſs of ſenſation; at the leaſt touch or motion in the water they inſtantly draw in their wheels. Mr. Baker conjectures that they have eyes lodged near the wheels, becauſe while they are in the globular or maggot ſtate, their motions are ſlow and blundering;

ing; but after the wheels are protruded, they are performed with great regularity, ſwiftneſs, and ſteadineſs.

Fig. 17, Plate XXVI. A, repreſents this little animal in what Mr. Baker calls the maggot ſtate; while in this form ſmall ſpiculæ are ſeen to dart out near the anterior part; the ſnout is ſometimes more and ſometimes leſs acute than in this delineation. (a) a ſmall horn near the thorax.

Fig. 15 repreſents it's manner of moving from place to place, while in the maggot ſtate.

Fig. 12 exhibits it, with the two ſemicircular parts, put out, and in the poſture it places itſelf in when it is preparing to ſwim about, or going to put it's wheels in motion.

Fig. 1 ſhews the head at it's full extent, with a couple of ſmall bodies on the top of it, armed with ſmall teeth like thoſe of the ballance-wheel of a watch.

At Fig. 18 the interior parts are more particularly exhibited. (a) the circle from which many veſſels originate; (b) the thorax, or breaſt, joined to the head by the neck (c.) The part which is ſuppoſed to be the heart is plainly ſeen at (d.) The abdomen (f) is ſeparated from the breaſt by a ring (e). (g) the tail.

Fig. 19 is the wheel animal, not full extended, but yet working it's wheels about.

Fig.

Fig. 20 ſhews it with it's ſide towards the eye; one of the wheels in this poſition appears to lie conſiderably below the other.

Fig. 6 and 16 repreſent two of theſe creatures in the poſtures they are often ſeen in when the wheels are not out, but the fiibrillæ are vibrating quickly.

Fig. 2, it is ſeen with the body nearly drawn into the abdomen; at Fig. 21 it is ſtill further drawn in; at Fig. 22 as it appears juſt as the tail is drawn in; at Fig. 23 in a globular form, but ſtill adhering by the tail.

Sometimes, when in the maggot form, it rolls it's head and tail together, without drawing them into it's body; it is repreſented in this ſtate at Fig. 14.

Mr. Baker has alſo deſcribed three other ſpecies, one of which, that differs only from the preceding in having a very long tail, is repreſented at Fig. 7, Plate XXVI. A.

Fig. 11 is another kind, with cruſtaceous ſpiculæ at the forepart; within this, at c, an opake oval body may be ſeen, which has been taken for an egg.

Fig. 3 is another kind; it has two projecting points from the tail, and the head furniſhed with a number of fibrillæ.

Fig.

Fig. 13 reprefents another fpecies, defcribed by Spallanzani.

Fig. 46, 47, 48, 49, Plate XXVI. reprefent the wheel animals, feen and delineated by Mr. Müller. a the head, b the eyes, c a fmall horn, d the rotatory organ, e the tail, f the points of the tail.

326. Vorticella Furcata.

Vorticella cylindrica, apertura integra, cauda longiufcula bifida. Cylindrical vorticella, the aperture undivided, the tail rather long, and divided into two parts.

A cylindric body, with a rotatory organ, or row of hairs, at the apex; the tail divided into two parts, a little turning inwards. When at reft, it joins the fegments of the tail; but when in motion, it feparates them. Generally found in common water.

327. Vorticella Catullus. Fig. 50, Plate XXVI.

Vorticella cylindracea, apertura mutica, cauda per brevi, reflexa, bicufpi. Cylindrical vorticella, the aperture plain, the tail fhort, bent back, and divided into two points.

It is a little thick animalculum, mufcular, folding itfelf up, of an equal breadth throughout, the body disfigured by longitudinal folds, winding varioufly; the anterior part, or head, connected to the body by a little neck, it occafionally manifefts a very minute rotatory organ. The tail (e) is fhort, terminating in two

4 H very

very ſmall briſtles (d), which it moves and hides at pleaſure; the inteſtines ill-defined. It's motion is rotatory, but in various directions. Is found commonly in marſhy waters.

328. Vorticella Canicula.

Vorticella cylindracea, apertura mutica, cauda brevi, articulata, bicuſpi. Cylindrical vorticella, the aperture plain, the tail ſhort, articulated, and dividing into two pointed parts.

329. Vorticella Felis.

Vorticella caudata, cylindracea, mutica, cauda ſpinis duabus longis terminata. With a tail, cylindrical, beardleſs, the tail terminating in two long ſpines.

The body is large, the apex of an equal thickneſs, obtuſe, with rotatory filaments; the tail acute, with two pellucid ſpines, about one-third of the body in length, ſeparating from and then approaching each other alternately.

330. Vorticella Stentorea.

See page 429 of this work.

331. Vorticella Socialis.

See page 432 of this work.

332. Vor-

332. Vorticella Flofculofa. Fig. 51 and 52, Plate XXVI.

Vorticella caudata aggregata, oblongo-ovata, difco dilatato pellucido. With a tail aggregated, of an oblong oval fhape, with a dilated pellucid difc.

To the naked eye it appears as a yellow globule, adhering to the ceratophyllon (a) like a little flower (b), or like a heap of yellow eggs. By the microfcope they are difcovered to be a congeries of vorticellas, conftituting a fphere from a mouldy center. They either fingly, or many of them together, extend and contract their little bodies, and by means of the difc excite a vortex in the water.

Sometimes they quit the fociety, and act fingly; they may then be obferved more eafily, and will be found to confift of three parts, a head, abdomen, and tail. The head is often fo drawn back into the abdomen (d), that no veftige of it remains; but it exhibits a broad difc ftanding out, of a kidney-fhape. The abdomen (d) is an oblong, oval, pellucid, replete with obfcure inteftines, amongft which are one or two remarkable black oval fpots (e); the tail is fharp, and as long again as the abdomen, rough and annulated, or altogether fmooth.

333. Vorticella Citrina. Fig. 53, Plate XXVI.

Vorticella fimplex, multiformis, orificio contractili, pedunculo æqufali. Simple, many-fhaped, with an orifice that it can contract, and equal-fized foot-ftalk.

 The

The head is full of molecules, round, and every-where of an equal ſize; very pellucid, both ſides of the orifice are ciliated, and each has a rotatory motion, appearing ſometimes without the edge of the mouth, as at a a; ſometimes within it. No diſtinct inteſtines, or internal motion, perceivable. It's motion is different from moſt of this genus, but not eaſily deſcribed. c c ſmall feet. It is found in ſtagnant water.

334. Vorticella Piriformis.

Vorticella ſimplex, obovata, pedicello minimo retractili. Simple, ſomewhat oval, with a very ſmall retractile foot, or one which it can draw within itſelf.

335. Vorticella Tuberoſa.

Vorticella ſimplex, turbinata, apice bituberculata.

Simple vorticella, the upper part broad, the under part ſmall, with two projecting parts at the anterior end, which are furniſhed with a number of vibrating fibrillæ, that produce a current of water by their quick motion, and thus collect food for our vorticella. Mr. Baker has delineated it in Fig. 10, 11, 12, Plate XIII. of his Employment for the Microſcope.

336. Vor-

336. Vorticella Ringens.

Vorticella ſimplex, obovata, pedunculo minimo, orificio contractili. Simple, ſomewhat of an oval ſhape, a ſmall pedicle, an orifice that it contracts or dilates.

The ſmall head, or rather body, of this little creature is pear-ſhaped, pellucid, the middle of the aperture convex, both ſides ciliated, the pedicle four times ſhorter than the body; it can contract the orifice to an obtuſe point.

337. Vorticella Inclinans.

Vorticella ſimplex, deflexa, pedunculo brevi, capitulo retractili. Simple, bent, with a ſhort pedicle, and ſmall retractile head.

A pellucid pendulous little head, the anterior part truncated, and is occaſionally, by contraction, made twice as ſhort as the pedicle; it's ſhape is like that of a tobacco-pipe.

338. Vorticella Vaginata.

Vorticella ſimplex, erecta, ovato-truncata, pedunculo vaginato. Simple vorticella, erect, of the ſhape of a truncated egg, the pedicle contained in a ſheath.

For

With the center C, and any diftance, let a circle be defcribed. Then let AC be a ray of light, falling upon the denfe medium. This ray, if nothing prevented, would go forward to L; but becaufe the medium Y is fuppofed to be denfer than Z, it will be bent downward toward the perpendicular IK, and defcribe the line CB.

The ray AC is called the INCIDENT RAY; and the ray CB, the REFRACTED RAY.

The angle ACI is called the ANGLE OF INCIDENCE, and the angle BCK is called the ANGLE OF REFRACTION.

If from the point A, upon the right line CI, there be let fall the perpendicular AD, that line is called the fine of the angle of incidence.

In the fame manner, if from the point B, upon the right line IK, there be let fall the perpendicular BE, that line will be the fine of the angle of refraction.

The fines of the angles are the meafures of the refractions, and this meafure is conftant; that is, whatever is the fine of the angle of incidence, it will be in a conftant proportion to the fine of the angle of refraction, when the mediums continue the fame. A general idea of refraction may be formed from the following experiments.

Let ABCD, Fig. 3, Plate I. reprefent a veffel fo placed, with refpect to the candle E, that the fhadow of the fide AC may fall

For the 339th, 340th, and 341ſt, the author refers to the Zool. Dan. he terms them vorticella cyathina, vorticella putrina, vorticella patellina.

342. Vorticella Globularia.

Vorticella ſimplex, ſphærica, pedunculo retortili. Simple, ſpherical, with a twiſted pedicle.

The little head is ſpherical, the aperture of the mouth ciliated, the pedicle four times longer than the body, which it contracts in a ſpiral form. It is frequent among the cyclope quadricorni.

343. Vorticella Lunaris. Fig. 54, Plate XXVI.

Vorticella ſimplex, hemiſphærica, pedunculo retortili. Simple, hemiſpherical, with a twiſted pedicle.

The ſmall head of this animalculum is crater-form (goblet-ſhaped), the margin of the orifice protuberant, ciliated on both ſides, the hairs undulating, the pedicle eight or ten times the length of the body. As often as the mouth is opened, the pedicle extends itſelf; when it is ſhut, this is twiſted up ſpirally, and theſe motions are often reiterated in a ſhort ſpace. a the head when expanded, b when ſhut, c the undulated edge, d the cilia erect, e when horizontal, f the pedicle when ſtrait, g when bent.

344. Vor-

344. Vorticella Convallaria.

See page 445 of theſe eſſays.

345. Vorticella Nutans.

Vorticella ſimplex, turbinata, pedunculo retortili. Simple, with a twiſted turbinated pedicle.

The pedicle is ſimple, and twiſts itſelf ſpirally, is exceeding ſlender, and has a kind of cap on the head; the margin white and round, and as it were encompaſſed with a lucid ring; the head diminiſhes towards the baſe. It is tranſparent.

346. Vorticella Nebulifera. Fig. 66, Plate XXVI.

Vorticella ſimplex, ovata, pedunculo reflexili. Simple, egg-ſhaped, the pedicle bent back.

The body is narrow at the baſe, open and truncated at top, the margin as it were ſurrounded with a ring; but when the aperture is ſhut, the animalculum is egg-ſhaped, the inteſtines may be ſeen diſtinctly, the pedicle is ſimple, ſetaceous, conſiderably longer than the body, and generally much bent back. a the head open, b almoſt ſhut, c quite ſhut, d the ſtalk when ſtrait, at e it is bent.

347. Vor-

347. Vorticella Annularis.

Vorticella ſimplex, truncata, pedunculo apice retortili. Simple, truncated, with a pedicle twiſted at the end.

This is viſible to the naked eye; the head an inverted cone, convex when the mouth is ſhut, truncated when it is open, with a protuberant edge, the pedicle is ſimple, very long, thick, and whiter at the top than elſewhere, formed into a little head, the apex is twiſted ſpirally. This animalculum, when contracted, appears to be annulated.

348. Vorticella Acinoſa.

See page 440 of this work.

349. Vorticella Faſciculata.

Vorticella ſimplex, viridis, campanulata, margine reflexo, pedunculo retortili. Simple, green, bell-ſhaped, the margin or edge turned back, the pedicle twiſted.

A congealed green maſs, which is often ſwimming about in ditches, is compoſed of myriads of theſe animalcula, which are not viſible to the eye; when magnified, they appear as a bundle of green flowers. The head is bell-ſhaped, green, opake, narrow at bottom, pellucid. It has a rotatory organ, which may ſometimes be ſeen projecting beyond the aperture; the pedicle is twiſted and very ſlender; a little head at the apex.

350. Vorticella Hians.

Vorticella fimplex, citriformis, pedunculo retortili. This is among the moft minute. The head refembles a citron, the apex truncated, the bafe narrow; a gaping cleft is difcovered defcending from the apex to one-third of the body.

351. Vorticella Bellis.

Vorticella fimplex, hemifpherica, margine contractili. Simple, hemifpherical, with a margin that it can contract at pleafure.

The head (capitulum) fcarcely pellucid, the infide quite filled, yellow, refembling much the flower of the daify; it is ciliated round the margin, and are in great abundance, moving in a rotatory manner.

The foot, or pedicle, is long, flender, and pellucid; it is divided into two parts, with fmall knobs on the top of each; the bafe adheres to a bulb, the under part is covered with fmall fcales.

352. Vorticella Gemella.

Vorticella fimplex, fphærica, capitulo gemino. Simple, fpherical, with a double head.

The pedicle is long, and conftantly furnifhed with two little heads at it's apex; thefe are bright and clear.

4 I 353. Vor-

353. Vorticella Pyraria.

See page 437 of this work.

354. Vorticella Anaftatica.

See page 434 of thefe effays.

355. Vorticella Digitalis.

See page 444 of this work.

356. Vorticella Polypina. Fig. 61, Plate XXVI.

Vorticella compofita, ovato-truncata, pedunculo reflexili ramofiffimo. Compound vorticella, oval, truncated, with a bending branching ftalk.

When viewed with a fmall magnifier, they appear like fo many little trees; the upper part, or heads, are egg-fhaped, the top truncated, the lower part filled with inteftines; the branches are thick fet with little knobs. a the trunk, b the branches, c the head when extended, f the fmall knobs thereon.

357. Vorticella Racemofa.

Vorticella compofita, pedunculo rigido, pedicellis ramofiffimis longis. Compound, pedicle rigid, with fmall branched long feet.

To

To the naked eye it appears like the vorticella focialis, but is diftinguifhed from it by always adhering to the fides of the veffel in which it is placed. On examining it with a magnifier, a long very fine pedicle is perceived fticking to the fides of the veffels, from which proceed an innumerable quantity of cryftalline pellucid pearls, which, together with the ftalk, are varioufly agitated in the water. They fometimes move feparately, fometimes together, are fometimes drawn down to the root, and in a moment again expanded.

XVII. Brachionus.

Vermis contractilis, tefta tectus, ciliis rotatoriis. A worm capable of contracting, covered with a fhell, and furnifhed with rotatory cilia.

358. Brachionus Striatus. Fig. 64 and 65, Plate XXVI.

Brachionus univalvis, tefta ovata ftriata, apice fexdentata, bafi integra, cauda nulla. Univalved brachionus, the fhell oval and ftriated, fix notches or teeth round the upper edge, the bafe whole or even, without a tail.

The fhell is oblong, pellucid, and capable of alterations in it's figure. The apex (a) truncated, with fix fmall teeth on the edge of it, twelve longitudinal ftreaks down the back, the bafe obtufe and fmooth. The teeth are occafionally either protruded or retracted; on the other fide of the fhell, towards the tail, there are two little fpines or horns (c).

 The

The animalculum is pellucid, cryſtalline, and muſcular, often of a yellow colour; from the apex it now and then puts forth three little bundles of playing hairs, the two lateral ones ſhorter than the middle one; a forked deglutatory muſcle (e) may be perceived, and on the under ſide, when the apex is drawn in, we diſcover two rigid points. It is an inhabitant of the ſea.

359. Brachionus Squamula.

Brachionus univalvis, teſta orbicularis, apice truncata quadridentata, baſi integra, cauda nulla. Univalved brachionus, with an orbicular ſhell, the apex truncated, and having four teeth, the baſe ſmooth, no tail.

360. Brachionus Pala.

Brachionus univalvis, teſta oblonga excavata, apice quadridendata, baſi integra, cauda nulla. Univalved brachionus, with an oblong excavated ſhell, four long teeth at the apex, the baſe ſmooth, no tail. It is of a yellow colour.

361. Brachionus Bipalium.

Brachionus univalvis, teſta oblonga inflexa, apice decemdentata, baſi integra, cauda ſpuria. Univalved brachionus, the ſhell oblong and inflected, ten teeth at the apex, the baſe ſmooth, a ſpurious tail.

362. Bra-

362. Brachionus Patina.

Brachionus univalvis, teſta orbiculari integra, cauda mutica. Univalved brachionus, with an orbicular ſhell, the edges regular, and having a long beardleſs tail.

This animalculum is large, the ſhell cryſtalline, nearly circular, without any teeth or inciſion, though towards the apex it rather falls in, ſo as to form a ſmooth notch. This little creature is remarkably bright or ſplendid; it is affixed to the middle of the ſhell; it projects from the apex a double glittering organ, the edges of which are ciliated; both theſe organs are of a conical figure, and ſtand as it were upon a pellucid ſubſtance, which is divided into two lobes; between theſe lobes and the rotatory inſtrument there is a ſilver-coloured crenulated membrane; two ſmall claws may be diſcovered near the mouth and other organized parts.

363. Brachionus Clypeatus.

Brachionus univalvis, teſta oblonga, apice emarginata, baſi integra, cauda mutica. Univalved brachionus, the ſhell oblong, the apex notched, the baſe ſmooth, the tail naked.

364. Brachionus Lamellaris.

Brachionus univalvis, teſta producta, apice integra, baſi tricorni, cauda bipili. Univalved brachionus, the ſhell extending conſider-confiderably beyond the body, the bafe divided into three fmall horns, at the end of the tail there are two hairs.

365. Brachionus Patella.

Brachionus univalvis, tefta ovata, apice bidentata, bafi emarginata, cauda bifeta. Brachionus with a univalve oval fhell, two teeth at the apex, the bafe notched, two briftles at the tail.

The fhell plain, oval, orbicular, cryftalline, the anterior part terminating in two acute points on both fides, though the head of the animal for the moft part fills up the intervening fpace.

The head, the tail, and the trunk are very diftinct; the bottom of the trunk is terminated in a femicircle, the fore-part marked with two tranfverfal lines; it occupies the difc of the fhell. The inteftines are indiftinct, the tail is affixed to the trunk; it is fhort, annulated, flexible, the middle projecting beyond the fhell, the apex diverging into two very fine briftles (g); it faftens itfelf by thefe, and whirls about with the body erect; the rotatory cilia (c) are with great difficulty perceived. Found in marfhy water all the winter.

366. Brachionus Bractea.

Brachionus univalvis, tefta fuborbiculari, apice lunata, bafi integra, cauda fpina duplici. Univalved brachionus, the fhell rather orbicular, the apex lunated, the bafe fmooth, the tail furnifhed with two fpines.

5 367. Bra-

367. Brachionus Plicatilis.

Brachionus univalvis, teſta oblonga, apice crenulata, baſi emarginata. Univalved brachionus, with an oblong ſhell, the apex hairy, the baſe notched.

368. Brachionus Ovalis.

Brachionus bivalvis, teſta depreſſa, apice emarginata, baſi inciſa, cauda cirro duplici. Bivalved brachionus, with a flattened ſhell, the apex notched, a hollow part at the baſe, the tail formed of two tufts of hair.

369. Brachionus Tripos. Fig. 59, Plate XXVI.

Brachionus bivalvis, teſta apice mutica, baſi tricorni, cauda duplici. Bivalved, the apex of the ſhell beardleſs, three horns at the baſe, double tail.

The body is pellucid, nearly triangular, bivalved, open on the back of the animalculum; from the orifice two little laminæ proceed, that are larger than the rotatory cilia; at the bottom are three or four ſtiff points e f a, and a moveable tail (g) between them, divided into two filaments, which the little creature opens and ſhuts at pleaſure; by theſe it fixes itſelf to objects. a the lateral cilia, b two ſmall laminæ, c a deglutatory muſcle, e an opake maſs.

370. Bra-

at D. Suppofe the veffel to be now filled with water, and the fhadow will withdraw to d; the ray of light, inftead of proceeding to D, being refracted or bent to d. And there is no doubt but that an eye, placed at d, would fee the candle at e, in the direction of the refracted ray d A. This is alfo confirmed by the following pleafing experiment.

Lay a fhilling, or any piece of money, at the bottom of a bafon; then withdraw from the bafon, till you lofe fight of the fhilling; fill the bafon nearly with water, and the fhilling will be feen very plainly, though you are at the fame diftance from it.

Experiment 3. Place a ftick over a bafon which is filled with water; then reflect the fun's rays, fo that they may fall perpendicularly on the furface of the water; the fhadow of the ftick will fall on the fame place, whether the veffel be empty or full.

What has been faid of water, may be applied to any tranfparent medium, only the power of refraction is greater in fome than in others. It is from this wonderful property, that we derive all the curious effects of glafs, which make it the fubject of optics. It is to this we owe the powers of the microfcope and the telefcope.

To produce thefe effects, pieces of glafs are formed into given figures, which, when fo formed, are called lenfes. The fix under-mentioned figures, are thofe which are moft in ufe for optical purpofes.

1. A

370. Brachionus Dentatus.

Brachionus bivalvis, testa arcuata, apice et basi utrinque dentata, cauda spina duplici. Bivalved brachionus, with an arched shell, the apex and the base are both toothed, the tail formed of two spines.

371. Brachionus Mucronatus.

Brachionus bivalvis, subquadrata, apice et basi utrinque mucronata, cauda spina duplici. Bivalved, somewhat of a square form, the base and apex pointed, the tail consisting of two spines.

372. Brachionus Uncinatus. Fig. 55, Plate XXVI.

Brachionus bivalvis, testa ovali, apice integra, basi mucronata, cauda rugosa biseta. Bivalved brachionus, with an oval shell, the apex even, the base pointed, two thick bristles for the tail.

This is one of the smallest bivalved animalcula, the apex and anterior part round, the hinder-part strait, terminating in a point, muscular, furnished with a hook on the fore-part, a small rotatory organ, a tail composed of joints, long, and cloven at the end into two bristles. It can open it's shell both at the fore and hind-part. a the shell when close, c the posterior point, d the animalculum, h the tail, i the bristles.

373. Bra-

373. Brachionus Cirratus.

Brachionus capfularis, tefta apice producta, bafi curti, bicorni, cauda bifeta. Larger than the preceding, ventricofe, fomewhat pellucid, the head conical, on both fides of which is a bundle of hairs; it has alfo a rotatory organ.

374. Brachionus Paffus.

Brachionus capfularis, tefta cylindracea, frontis cirris binis pendulis, fetaque caudali unica. Capfular brachionus, in a cylindric fhell, two long pendulous locks of hair proceed from the front, the tail confifts of a fingle briftle.

375. Brachionus Quadratus.

Brachionus capfularis, tefta quadrangula, apice bidentata, bafi bicorni, cauda nulla. Capfular brachionus, in a quadrangular fhell, with two fmall teeth at the apex, two horns proceed from the bafe, it has no tail.

376. Brachionus Impreffus.

Brachionus capfularis, tefta quadrangula, apice integra, bafi obtufi emarginata, cauda flexuofa. Capfular brachionus, the fhell quadrangular, the apex fmooth or undivided, the bafe obtufe, the margin notched, the tail flexuous or bending.

4 K 377. Bra-

377. Brachionus Urceolaris.

Fig. 56 and 57, Plate XXVI. and Fig. 36, 37, 38, Plate XXIII.

For a full defcription of this fee page 448.

378. Brachionus Bakeri. Fig. 58, Plate XXVI.

Brachionus capfularis, tefta ventricofa, apice quadridentata, bafi bicorni, cauda longa, bicufpi. Capfular brachionus, the fhell ventricofe, four teeth at the apex, two horns at the bafe; the tail long, and terminating in two fhort points.

This differs confiderably from the foregoing in the fhape of the fhell, from each fide of which there is a curved projection inclining towards the tail, nearly of the fame length with it, and terminating in a point. The upper part alfo of the fhell is of a different form, having in general four longer fpiculæ, and two fhorter ones. From the head two arms, or branches, are frequently extended; the circular end of each is furnifhed with a border of little hairs, which one while move in a vibratory manner, at another time they have a rotatory motion. The eggs are either affixed to the tail, or the curved part of the fhell; they have from one to five hanging from them. Mr. Muller has further difcovered two fmall feelers, and a kind of tongue to this little creature. a the rotatory organ, b the tongue, c the feelers, d a ciliated part on the fide of the fhell.

379. Brachionus Patulus.

Brachionus capfularis, tefta ventrofa, apice octodentata, bafi lunata quadricorni, cauda brevi bicufpi. Capfular brachionus, the fhell ventrofe, eight teeth at the apex, the bafe lunated or hollowed into the form of a crefcent, and furnifhed with four horns, the tail fhort, with two fmall points at the end.

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CHAP. IX.

ON THE ORGANIZATION OR CONSTRUCTION OF TIMBER, AS VIEWED BY THE MICROSCOPE.

THE fubject of the following chapter opens an extenfive field of obfervation to the naturalift, in which the labour of a life may be well employed: it is a branch where the obferver will find the microfcope of continual ufe, and without which he will fcarce be able to form any juft idea of the organization of trees and plants, of the variations in the difpofition, the number, nature, and offices of the feveral parts thereof.

Malphigi, Grew, Duhamel, Hill, Bonnet, and De Sauffure, are almoft the only writers who have treated on this fubject; and if we confider the imperfection of the inftruments ufed by fome in thofe anatomical refearches, and the little attention paid by the reft to the advantages their favorite purfuits might have derived from the ufe of the microfcope and the diffecting knife, we have rather more to wonder at what has been done, than at what remains to be performed. One reafon that our knowledge of the fubject of this chapter is fo circumfcribed, is the general inatten-

4 tion

tion to the ftructure of plants; to this, among other caufes, we may alfo afcribe the inftability and fluctuation of the different theories on the principles of vegetation. We are, however, fo little acquainted with the fteps which Providence takes to lead intellectual, but free agents, to the knowledge of truth, and the various difficulties, errors, and prejudices that muft be removed before it can fhine in it's native colours, that it is our duty to encourage every humble effort towards the advancement of fcience, that thus we may co-operate with our Creator and Redeemer in promoting that vaft plan to which all things are now converging, the bringing all his creatures to a ftate of truth, goodnefs, and confequent happinefs, an end worthy of the beft and wifeft of beings.*

As Dr. Hill is the firft writer who has treated this part of natural hiftory in an orderly and fcientific manner, I fhall ufe the names he has adopted for characterizing the different parts of trees, &c. which are, 1. the rind; 2. the bark; 3. the blea; 4. the wood; 5. the corona or circle of propagation; 6. the pith. Thefe are placed immediately within or under one another; they are the effential parts upon which the ftrength of the tree depends: in, among, and between thefe, the various veffels are placed, which nourifh the whole, and maintain and carry on the vegetation of the tree, and from which it obtains it's peculiar qualities and virtues. Thefe veffels are of five kinds.

JUICE

* See the Bifhop of Exeter's Sermon before the Society for the Propagation of the Gofpel.

JUICE VESSELS.

1. The exterior veſſels, placed between the rind and the bark.
2. The interior, in the ſubſtance of the bark.
3. The intimate, in the ſubſtance of the blea.
4. The ſap veſſels, in the ſubſtance of the wood.
5. The coronal, in the corona.

More accurate inſtruments, or a more minute inveſtigation of the parts, may probably diſcover new veſſels, in a ſyſtem which appears to be entirely vaſcular, and bring us more thoroughly acquainted with the nature of vegetation.

OF THE RIND.

The exterior covering of all trees is a thin, dry, parched ſubſtance, which has been compared by many writers to the ſkin of animals, and called by names analogous thereto; thus it is called the epidermis by Duhamel, the ſkin by Grew, the rind by Hill.

When a tree is full of ſap, this membrane may be eaſily detached from the part it covers; it may be ſeparated from green branches which are not in ſap, by boiling them in water; large pieces of it may alſo be obtained from rotten branches; the rind of the leaves of many trees is detached with ſingular dexterity from the other parts, by ſome of the mining caterpillars; artificial methods for effecting this purpoſe have been deſcribed in page 159 of this work. Though the rind may at firſt ſight be thought to be of little uſe, it will be found to be a principal organ in the proceſs procefs of vegetation; the part which covers the root has the moft important offices affigned to it.

Many are of opinion that the rind is formed of dried veficula; and Malphigi fays, that we may fee in the vafcular texture of the Bark of the cherry and plumb trees an arrangement of the parts proper to form the rind, and this arrangement is occafioned by the endeavour of the vafcular part to extend itfelf to the circumference, and the refiftance it meets with from the rind; and that hence the veffels are flattened, and affume a membranaceous form.

The rind is a general covering to the young trunks of trees, to the branches, the roots, the leaves, the fruit, the flowers, &c. Upon the trunks of large trees fome pieces only of the rind are to be found, having probably been broke by the increafed fize of the tree. The rind of fome fpecies of trees will bear being ftretched much further than thofe of others, and remain for a confiderable time uniformly fpread over the bark. Duhamel afferts, that the rind of vigorous healthy trees remains longer whole than on thofe that are more languid, notwithftanding that the growth of the laft is flower, and therefore makes lefs efforts againft the rind. This circumftance is much in favour of the diftinct organization of the rind, and againft the opinion of thofe who only fuppofe it to confift of dried bladders.

Thin as the rind is, it is formed of many coats, adhering clofely to each other, which in fome fpecies may be feparated with eafe, in others with difficulty. Duhamel fays, that he has divided the

rind

rind of the birch into ſix diſtinct coats, and that he had no doubt but what the diviſion might have been carried much further. Dr. Hill ſays, that unleſs ſome of theſe coats are obtained in a ſtate of ſeparation from the reſt, the true conſtruction of the rind cannot be diſcovered, for the connection and form of the parts is loſt by the confuſion in which they appear while they lie one upon another.

The following experiments may throw a little light upon this obſcure ſubject.* All the rind was taken from the trunk of a cherry tree, and the tree thus ſkinned, expoſed to the air, a part of the bark which was next to the rind dried up and exfoliated; the part next to this did the ſame; after two or three exfoliations, a farinaceous ſubſtance covered the ſuperficies of the trunk, ſoon after which a new rind appeared. Some pieces of rind were taken from a few young branches, and the wounds were covered with a cloth that had been ſoaked in wax and turpentine; on theſe the rind appeared in a very little time, without any apparent exfoliation. From ſome other branches, not only the rind, but a part of the bark, was alſo taken away, and the wounds covered as before; a ſlight exfoliation was obſerved here, which was ſoon followed with a new rind. The bark was taken entirely off from a vigorous cherry-tree, while it was in full ſap, ſo that the wood appeared the whole extent of the trunk. This was protected from the rays of the ſun, and from the air. A new bark and rind formed themſelves upon the trunk, but they did not originate from the bark that was left on the branches and the root, but extended from different ſpots, which were firſt formed at conſiderable

* Duhamel Phyſique des Arbres, tom. 1, p. 12.

fiderable diftances from each other. After a lapfe of fifteen years, this new rind did not appear like the natural rind of the cherry-tree. From thefe experiments we learn, that the rind regenerates more readily in fome cafes than in others, and that it preferves and prevents in a degree the bark from becoming dry too foon, and in confequence thereof exfoliating.

Aided by the microfcope, a number of luminous points may be difcovered in the rind;* thefe are fo many minute holes for other purpofes of tranfpiration. In the cane thefe holes are vifible to the naked eye. A few oval holes may alfo be perceived in it; thefe are, however, no more than a feparation of the parts, occafioned by the extenfion of the vafa interiora.

Dr. Grew fuppofed the rind to be formed of fmall veficles, or bladders, cluftered together, and intermixed with lignous fibres or veffels, which run through the length of the rind; thefe are conjoined by other tranfverfe ones, but that as the rind dries, the bladders or blebs fhrink up and difappear. This account does not differ much from that of Dr. Hill, who fays, that the rind is formed of a feries of longitudinal veffels, and a filmy fubftance between them, which, when viewed in a tranfverfe fection, form fmall circles, the fides of which are fupported and made up of thefe longitudinal fibres; that the tranfverfe veffels are only a deception, occafioned by the fpaces between part and part of the film. The mode of obtaining an accurate view of the organization of this part, by conveying coloured liquors into the feveral veffels thereof, has been already defcribed in page 162 of thefe

4 L effays;

* Duhamel Phyfique des Arbres, vol. 1, p. 9.

1. A PLANE GLASS, one that is flat on each fide, and of an equal thicknefs throughout. F, Fig. 13, Plate I.

2. A DOUBLE CONVEX GLASS, one that i more elevated towards the middle than the edge. B, Fig. 13, Plate I.

3. A DOUBLE CONCAVE is hollow on both fides, or thinner in the middle than at the edges. D, Fig. 13, Plate I.

4. A PLANO CONVEX, flat on one fide, and convex on the other. A, Fig. 13, Plate I.

5. A PLANO CONCAVE, flat on one fide, and concave on the other. C, Fig. 13, Plate I.

6. A MENISCUS, convex on one fide, concave on the other. E, Fig. 13, Plate I.

It has been already obferved, that light proceeds invariably from a luminous body, in ftrait lines, without the leaft deviation; but if it happen to pafs from one medium to another, it always leaves the direction it had before, and affumes a new one. After having taken this new direction, it proceeds in a ftrait line, till it meets with a different medium, which again turns it out of it's courfe.

A ray of light, paffing obliquely through a plane glafs, will go out in the fame direction it entered, though not precifely in the fame line. The ray CD, Fig. 4, Plate I. falling obliquely upon the furface of the plane glafs A B, will be refracted towards the effays; by this means, together with the microfcope, we find that the veffels are every-where pierced with fmall dots, or openings; of the ufe of thefe the following conjectures have been formed.*

The root, which is equal in furface to a third part of the tree above ground, is covered with a pierced rind. The cold of winter contracts the whole of this, the parts are drawn clofer together, and the mouths of thefe innumerable veffels are fhut, or nearly fo, by this contraction; a very little of the half congealed moifture of the ground gets into them, but this fuffices for the fervice of the tree, when there is little heat to caufe any perfpiration, and at a time when in the deciduous trees, the very organs of the greateft perfpiration, the leaves, do not exift.

The warmth of fpring arrives, the fluids of the earth grow thinner, every part of the root expands; this opens the mouths of the veffels, and the torrent of nutrition rufhes in. By this means, every coat of the rind, and the interftitial fpaces thereof, are rendered fupple, and may be eafily feparated from the under coverings.

In roots the colour of the rind varies very much, being white in fome, brown in others, &c. Every root, according to Grew, after it has arrived at a certain age, has a double fkin, the one coeval with the other parts, and exifts in the feed: a ring is afterwards fent off from the bark, which forms the fecond fkin; thus in the root of dandelion, towards the end of May, the original or outer fkin appears fhrivelled, and is eafily feparated from the new one,

* Hill's Conftruction of Timber, &c. p. 37.

one, which is fresher, and adheres more firmly to the bark. Perennial plants are supplied in this manner with a new skin every year; the outer one always falls off in the autumn and winter, and a new one is formed from the bark in the succeeding spring.

OF THE VESSELS WHICH ARE CONTAINED BETWEEN THE RIND AND THE BARK.

These are called by Duhamel the cellular coat, (enveloppe cellulaire) by Hill the exterior vessels, and the vasa propria exteriora.

It has been already observed, that in trees the juice vessels, or vasa propria, do not form those constituent parts of the wood of which the timber consists, but that it is from the nature of these recipient vessels that it derives it's virtues, qualities, and specific properties.* A tree may grow, live, and give shade without them; but on those it's peculiar character and decided virtues depend; these are greatest where the vasa propria are largest or most numerous, and where we do not find these, we scarce find any thing that will affect the taste or the smell. There are different ranges of these vessels between the several parts, each of which has it's allotted place, it's peculiar form, it's different structure, and it's separate use. Many trees have them in all their parts, others only in some of them, while others do not exhibit any.

On taking off the rind, we find a substance of a deep green colour, succulent and herbaceous, formed of a prodigious number of

* Hill's Construction of Timber, p. 73.

of filaments, interwoven together in various directions; it is more abundant in some trees than in others, particularly in the elder, and more succulent in summer than in winter; it is then also less adherent to the rind. Dr. Hill thinks the best time of separating the rind, in order to view this part, is in a living branch, at the time of it's swelling for the spring, or for the mid-summer shoot, but much easier by the means of maceration.*

When the rind is perfectly separated, it leaves the vasa propria of this class behind it; they scarce adhere to the inner bark, and but little to the rind; they are disposed in packets, and do not run strait down the branch, but interweaving with each other form a kind of net. These packets may be separated easily from the bark; when a thin transverse section of one of them is examined, it is found to be composed of twelve or fifteen distinct vessels, with hard rinds. Dr. Hill says, that with a great deal of patience, a vast number of objects, and a good microscope, we may see by what means these vessels adhere to the bark; for we shall find upon the sides small oval depressions which fit thereto, and that are probably a kind of glands, that separate from the general store of sap with which the bark is filled, the juices peculiar to these vessels.

OF THE BARK.

The bark lies next within the rind, and differs but little from it in construction, though it holds a more important office in the scale of vegetation, the growth and qualities of the tree being in a great

* Hill's Construction of Timber, p. 75.

a great meafure connected with it. It is, therefore, found to differ confiderably in fubftance, quantity, and quality, in various kinds.

It is originally the outer membrane, covering the lobes of the feed. Even there, as in the branch of a tree, it appears in form of a kind of fpunge, or like a cruft of bread, compofed of flatted bladders.

It's fpunge-like nature may be further inferred from the contraction of it's pores when dry, and the eafe with which they dilate when in water. Grew has called it a moft curious and exquifitely fine-wrought fpunge. In the courfe of it's growth, the outer ranges of thefe bladders drying, it becomes what we call the rind; for the rind was once bark, and has only fuffered a flight change in feparating from it.

By the bark the tree is fed with a continual fupply of moifture, protected from external injuries, and defended from the exceffes of heat and cold; for thefe purpofes it is varioufly difpofed in different trees. In the hardy and flow growing, as the oak, it is thin; in the quick growing, as willow, poplar, and the like, it is thick. And what is more particularly to be attended to is, that in fome it's inner verge is radiated. There are fome trees, and a great many herbaceous plants, in which this part is continued inward, in form of rays, through the blea into the wood, forming as it were fo many wedges, that fplit as it were the fubftance of both thofe parts,* a circumftance which accounts for the vegetation of fome particular trees, which are known to live when deprived

* Hill's Conftruction of Timber, p. 118. Ibid. p. 120.

prived of the bark; becaufe they have rays of the fame fubftance within, which anfwer the purpofe, and this in a degree anfwering to the nature of their life.

The bark appears to be formed, firft, of longitudinal fibres, which Duhamel confiders as fo many lymphatic veffels; fecondly, by a kind of a filmy cellular tiffue, which have been confidered as a kind of bladders by fome, or as parenchymous by others; thirdly, of the vafa propria interiora, or interior juice veffels.

The longitudinal fibres are difpofed in ftrata, which lie one over the other. In that ftratum which is next the rind, or rather the cellular coat, we perceive a net of longitudinal fibres, the mefhes of which are large and eafily diftinguifhed, particularly when the cellular tiffue that fills up the interftices is removed. To do this, the branches fhould be macerated for a confiderable time; fome require to be kept in this ftate for years. It will then be eafy to feparate firft the rind, then the cellular coating, and afterwards this pulpy matter. It may fometimes be eafily removed after the branches have been boiled.

The moft exterior ftratum, when examined by the naked eye, feems to be formed of fimple fibres, which graft, folder, or anaftomofe one with the other; but when examined by a microfcope, each of thefe fibres will be found to be a bundle of filaments, which may be eafily feparated from each other.

Grew fays, that each filament, like the nerves in animals, confifts of twenty or thirty fmall contiguous tubes, which run uniformly from the extremity of the root, without fending off any branches,

branches, or ſuffering any change in their ſize and ſhape. Hence the bark may be tore or divided lengthways, with greater eaſe than in an horizontal direction; when macerated, they are capable of a very great degree of ſubdiviſion.

The filaments of a cortical veſſel are to be looked on (agreeable to what we have already obſerved) as ſo many little bundles placed near together, and at firſt growing parallel to each other; but ſoon quitting this direction, the filaments of one faſcicle parting from that to which they originally belonged, and inclining more or leſs obliquely towards another, ſometimes uniting with it, at others bending backwards, and uniting again with that from which it proceeded, or with ſome one that it meets with. In this manner new faſcicles are often formed, while other parcels are increaſed or diminiſhed by the additions of new filaments; by this means, a kind of irregular net is formed, and the fibres proceed in a ſerpentine line from the top to the bottom of the tree.

The thickneſs of the bark is entirely formed of ſtrata of theſe longitudinal fibres, which lie one over the other; each of theſe ſtrata is ſimilar to the exterior one, only the meſhes are ſmaller, and the fibres finer, in proportion as they are more interior, inſomuch that at laſt the meſhes are almoſt annihilated, and the fibres ſeem to lie quite parallel to each other.

There are ſome trees, however, where the meſhes are not viſible, and in which the fibres lie quite in a ſtrait direction. There are many other circumſtances in which they vary in different trees; in ſome the meſhes of each ſtratum correſpond with each other, diminiſh-

diminiſhing gradually in ſize as they are more interior, and forming as it were ſo many conical cells.

We may, I think, conclude from what has been ſaid, that the bark is compoſed of ſeveral thin membranes, which extend over the whole exterior ſurface of the tree. The moſt exterior membrane is the rind; under this is what Duhamel calls the cellular coat; next to this the cortical ſtratum or true bark of the tree, which is formed of lymphatic veſſels ranged more or leſs in a reticular form, and of the vaſa propria interiora. The meſhes are ſo conſtituted as to form large cavities next the rind, and ſmall ones near the wood. Theſe cavities are filled with a parenchymous ſubſtance or the cellular tiſſue, which being continued from the wood to the rind, joins and unites the cortical ſtratum, and afterwards ſpreading on the outſide thereof, forms what has been termed the cellular coat.

OF THE CELLULAR TISSUE.

We now proceed to give ſome account of the ſubſtance which fills up the vacant ſpaces that are left between the longitudinal fibres. It is called by Grew the parenchyma or pulp, by Malphigi, the veſicular tiſſue or web; both of them conſider it as formed of ſmall bladders or reticules, that are in contact with each other, lying in an horizontal poſition, or at right angles to the longitudinal fibres: they do not ſuppoſe them to be all of the ſame ſize, or even of the ſame figure: Grew compares it to the froth of beer or eggs. The fleſh of fruits conſiſts for the moſt part of this ſubſtance, very much filled with juice, though with conſiderable difference in it's organization. Be this as it may, the

the nature of this fubftance, it's form and ftructure, are at prefent but very little known. It is floccofe, and varies in colour in different fpecies.

OF THE VASA PROPRIA INTERIORA.

Befides the lymphatic veffels and the cellular fubftance, we find the juice veffels, or vafa propria, in the bark. In thofe trees which are famous for medicinal virtues, they are ufually very large; they carry the milky juices of the fumach, and in them is lodged the fineft and higheft-flavoured turpentine in all the kinds of pine. Dr. Hill thinks that a tree of that genus exhibits them beft, and the more, as the turpentine which fills them may be perfectly diffolved in fpirit of wine. The pinus orientalis is the fpecies in which thefe veffels are moft diftinctly feen.

OF THE BLEA.

This is that part of the tree which is forming into wood, and therefore lies between it and the bark, and may be feparated from them by maceration.

A longitudinal piece of the blea, when examined by the microfcope, exhibits a number of veffels running parallel to each other, the interftitial fpaces being filled with a floccofe, white, formlefs fubftance, of which Dr. Hill fufpects even the veffels themfelves to be formed. Innumerable fmall openings, or mouths, may be difcovered in thefe veffels, fuited to imbibe the moifture which is fo effential to the life and health of plants. Thefe mouths cannot be well difcerned, except when they are opened by the feafon of the year, either before the firft leaves of fpring, or in the midfummer fhooting time ; though a fmall quantity of moifture will keep them open at that time, yet no quantity would be fufficient at an improper feafon.*

The blea is a zone more or lefs perfect, which lies under the bark, and covers or furrounds the wood, and is principally diftinguifhed from it by being lefs denfe. In fome fpecies the difference between the blea and the wood is very remarkable, in others it is lefs fo.

The ancient botanifts, ftruck with the difference they obferved between the wood and the blea, compared this fubftance to the fat in animals. Malphigi, Grew, and Duhamel confider it as the wood not yet arrived to a ftate of perfection. It is organized in a manner fimilar to the wood, and poffeffing the fame veffels, difpofed nearly in the fame manner. The juice veffels of this part may be feparated from it by maceration; Dr. Hill fays, that in this ftate they appear perfect cylinders, with thick white coats, the furface perfectly uniform.

OF THE WOOD.

When the bark and the blea is taken away, we come to the wood, which is a folid fubftance, on which the ftrength of the tree depends, and which has been confidered by naturalifts as being to the tree what bones are to the animal. The wood, in a general view, may be confidered as formed of ftrata, which are inclofed one within the other; thefe ftrata confift of lignous fibres

* Hill's Conftruction of Timber.

fibres or lymphatic veffels, the cellular web or tiffue, vafa propria, and what have been called the air veffels. It is more difficult to inveftigate the conftruction of the wood than that of the other parts, becaufe the texture is in general much harder, and therefore not fo eafily feparated, requiring very long macerations, and many fubjects, before one may be found fit for examination.

If we examine a tranfverfe fection of almoft any kind of wood, we fhall perceive thefe ftrata very clearly and fenfibly diftinguifhed from one another. It has been generally fuppofed, that each of thefe is the product of one year's growth; though if we cut the fame wood obliquely, we fhall perceive that each of thefe ftrata is compounded of fmaller ones, which are, therefore, not fo eafy to difcover as the larger. By macerating rotten pieces of trees, the wood may be divided into an immenfe number of leaves, or ftrata, thinner than the fineft paper.

If the foregoing ftrata are examined in their detached ftate by the microfcope, we fhall find them to be compofed of longitudinal fibres; fome pieces of rotten wood, after maceration, will divide of themfelves into very fine longitudinal fibres; the exiftence of thefe is further proved by the facility with which wood may be fplit in the direction of thefe fibres. From hence we may collect, that the lignous ftrata are formed of fmall fibres or veffels, collected together in fafcicles, like the bark: in fome trees they are parallel to each other, in others they are difpofed more obliquely, croffing and forming an irregular kind of network. There is great probability that this reticular difpofition exifts in all trees, though it may be difficult to difcover it in many the glaſs in the direction D E; but when it comes to E, it will be as much refracted the contrary way. If the ray of light had fallen perpendicularly on the ſurface of the plane glaſs, it would have paſſed through it in a ſtrait line, and not have been refracted at all.

If parallel rays of light, as a b c d e f g, Fig. 6, Plate I. fall directly upon a convex lens A B, they will be ſo bent, as to unite in a point C behind it. For the ray d D, which falls perpendicularly upon the middle of the glaſs, will go through it without ſuffering any refraction: but thoſe which go through the ſides of the lens, falling obliquely on it's ſurface, will be ſo bent, as to meet the central ray at C. The further the ray a is from the axis of the lens, the more obliquely it will fall upon it. The rays a b c d e f g will be ſo refracted, as to meet or be collected in the point F, called the principal focus, whoſe diſtance, in a double convex lens, is equal to the radius or ſemi-diameter of the ſphere of the convexity of the lens. All the rays croſs the middle ray at C, and then diverge from it to the contrary ſide, in the ſame manner as they were before converged.

If another lens, of the ſame convexity, as A B, Fig. 6, Plate I. be placed in the rays, and at the ſame diſtance from the focus, it will refract them, ſo that after going out of it, they will all be parallel again, and go on in the ſame manner as they came to the firſt glaſs A B, but on the contrary ſides of the middle ray.

The rays diverge from any radiant point, as from a principal focus: therefore, if a candle be placed at C, in the focus of the convex lens A B, Fig. 6, Plate I. the rays diverging from it will

6 be

on account of the finenefs of the mefhes, the hardnefs of the wood, and the famenefs of colour in the conftituent fibres.

We are here only fpeaking of the lymphatic veffels or lignous fibres of the wood, which exift in it as well as in the bark, though in different ftates; for the lignous fibres are always harder and lefs flexible than the cortical ones. Malphigi thinks they differ in another particular, namely, that a juice or fluid iffues from the cortical, while none is found in thofe of the wood. In this it would appear from the obfervations of Duhamel, that he was miftaken.

A tranfverfe fection of wood generally appears formed of a number of rays proceeding from the corona to the bark, which are interfected at different diftances by concentric circles, interfperfed with veffels of varying magnitude: the variations in this ftructure afford much pleafure to the curious obferver, and throw confiderable light upon the nature and properties of timber; for it is by means of a variety of ftrainers that different juices are prepared from the fame mafs. Matter, confidered as matter, has no fhare in the qualities of bodies. It is from the arrangement of it, or the recipient forms given to it, that we have fo many different fubftances. According to the modifications that thefe receive, we fhall find the fame light, air, water, and earth, manifefting themfelves in one by a deadly poifon, and in another by the moft falubrious food. A lemon ingrafted upon an orange ftock, is capable of changing the fap of the orange into it's own nature, by a different arrangement of the nutritive juices. One mafs of earth will give life and vigour to the bitter aloe, to the fweet cane, the cool

cool houfe-leek, and the fiery muftard, the nourifhing grain, and the deadly night-fhade.

The wood may be confidered as compofed of two parts, lignous and parenchymous. We have already treated of the former; the latter is that which is difpofed into rays running as it were between the lignous fibres, and interweaving with them; it originates either with the pith or corona. There is a very great diverfity in thefe radial infertions, in fome trees there are very few, while they abound in others; in fome they are very fine, in others very thick. In texture they feem fimilar to the blebs of the bark, only that here they are fo crouded and ftretched out as to appear like parallel threads, fomething fimilar to a net when drawn tight.

OF THE CORONA.

Dr. Hill gives this name to that circle which furrounds the pith, and feparates it from the wood; although in his opinion it differs greatly from both, and in it's compofition has no refemblance to either. It is, according to him, the moft important part in the whole vegetable fabric, by which the propagation and increafe of the branches, buds, and fhoots, is carried on. *

It has been ufual to fuppofe the pith of vegetables to be the part in which thefe wonderful fources of increafe refides, but this is not the cafe; and he afferts, that fo far from being prior to the other parts, it is in reality pofterior to fome of them.

The

* Hill on the Conftruction of Timber, p. 55.

The corona is not fo uniform as the other parts, nor is it conftituted exactly fimilar in all trees. It is placed between the pith and wood in all vegetables, forming a ring, whofe outline is more or lefs regulated. The general circle is cellular, compofed of blebs and veffels, like the bark and the rind, and is perfectly fimilar to them, only that at different diftances oblong clufters of different veffels are placed amongft it. Thefe clufters are ufually eight or ten in number, and give origin to the angles of the corona. They are not uniform, or of one kind of veffels, as in the bark, but each has two diftinct forts, the exterior one anfwering to the blea, and the interior to the wood of trees; and within each of thefe are difpofed veffels not unlike thofe in the blea and wood, though often larger than they are found in thofe parts.

Thus each clufter is compofed of all the effential parts of the fucceeding branch, and the intermediate parts of the circle are abfolutely bark and rind; they are ready to follow and clothe the clufter when it goes off in the form of a fhoot, becaufe it will then need their covering and defence, though, in it's prefent inclofed ftate, it does not. It is from this conftruction that a tree is ready at all times, and in all parts, to fhoot out branches, and every branch in the fame manner to fend out others; for the whole trunk, and the branch in all it's length, have this courfe of effential veffels ready to be protruded out, and the proper and natural integuments as ready to cover them. In fome trees thefe parts are more evident, in others more obfcurely arranged. Dr. Hill fays, the bocconia, or parrot-wood of the Weft-Indies, and the greater celandine, are proper fubjects for opening this great

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myftery of nature. On the corona and it's clufters depend that property of vegetables, that they can be produced entire from every piece. Thefe clufters follow the courfe of the other portions of the tree; they are, therefore, every-where; they are always capable of growing, and their growth, even in a cutting of the fmalleft twig, cannot produce a leaf or any other part of a vegetable alone, but muft afford the whole, for they are complete bodies, and the whole is there waiting only for the opportunities of extenfion. For the knowledge we have of this part we are altogether indebted to Dr. Hill. It remains for future obfervers to confirm or difprove his obfervations.

OF THE PITH.

The pith is found in the center of every young fhoot of a tree; it is large in fome, lefs in others, but prefent in all. It is placed clofe within the corona.

It feems to be nothing more than a congeries of the cellular tiffue; it is generally found near the center of the tree, inclofed as it were within a tube; in general, the cells of the pith are larger than thofe of the cellular tiffue, with which, according to Duhamel, it communicates. For the rays which extend from the pith to the bark are, in his opinion, produced from it. Thus, though it may differ in name from the parenchymous parts of the bark, and the radial infertions in the wood, yet it is of the fame nature and texture, and is continuous with them; fo that, according to this idea, the fkin, the parenchyma, the infertions, and the

5 pith,

pith, are all one piece of work, filled up in divers manners with the vessels.

The bark and the wood grow thicker every year, while the pith, on the contrary, grows more slender, so that in a branch of one year it is of a larger size than it is in the same branch when two years old, and so on. In very young branches, while in an herbaceous state, the pith forms the greatest part of it's substance; but when the fibres are stronger, the pith becomes less succulent, and surrounded with a tube of wood; when the branch is arrived to a certain age, it is so compressed as to be almost annihilated. In examining different branches that proceed from others in their first state, a small communication between the pith of the one and the other will be found; but this communication is generally entirely closed up in the second or third year.* The cells of which the pith is formed are at first entirely one connected body; but as the plant grows up, it is often so broke and ruptured, as to remain no longer a continuous substance.

This, as well as many other particulars in the history of the pith, corroborates the opinion of Dr. Hill,† who thinks it is formed for the purpose of moistening the clusters of the corona, and regulating it's extension; it has been supposed coeval with, or primordial to all the other parts, but he thinks it is postnate, and comes after them in the order of time, as well as in it's uses. That exhaled air gives origin to it's blebs, and the thickness of the juices

* Duhamel Physique des Arbres, tom. 1, p. 38.

† Hill's Construction of Timber, p. 66.

juices cloathing the bubble, gives it form and fubftance. The firft feafon is the time of it's greateft ufe, and it immediately after begins to decay.

The pith has in general been reprefented as much more complex than it really is. It confifts of a range of bladders, lying one over the other. The membrane is fimple, the outline fingle; but as it is very difficult to procure it in this fimple ftate, it is often feen and reprefented under a variety of irregular, though pleafing forms, which are occafioned by the interfeƈtions of the outlines of the blebs, as feen one over another.

A clufter in any part of the corona, protruding itfelf onward and outward in the growing feafon,* carries a part of the circle out with it. The clufter itfelf is a perfeƈt piece of the wood and blea, and the bark which follows it out in it's progrefs perfeƈtly cloaths it: thus is the firft protrufion of the fhoot made, but all this while there is no pith. The continuation of growth is made by the extenfion of all the parts obliquely upwards; in the courfe of this extenfion they hollow themfelves into a kind of cylinder, of the form of the future branch, and by this difpofition a fmall vacancy is made in their center. This enlarges as they increafe, and as it enlarges it becomes filled with the exudation of thofe little bladders which remain and conftitute the pith, fed from the inner coat of the pith, which already begins to form itfelf into a new corona. Grew feemed to think, that in fome inftances the pith was of pofterior growth to the other parts, and derived it's origin from the bark; and that the infertions of the bark running

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* Hill's Conftruƈtion of Timber, p. 99.

in between the rays of the wood, meet in the center, and conſtitute the pith.

OF THE SAP VESSELS.

The moſt numerous and the largeſt apertures are generally to be found in the wood, which are perceived very diſtinctly in a tranſverſe ſection, in which the ends of the veſſels are ſeen as cut through by the knife. The ſcarlet oak of America is recommended as a proper object for exhibiting them. If a ſhort cylinder of a three years branch of this oak, a little macerated, be hollowed away with a chiſſel, we ſhall ſee what a large portion of the wood is occupied by theſe veſſels; they are thick and ſtrong, and it is eaſy, with ſome care and attention, to looſen ſeveral of them.

If a number of theſe, thus ſeparated, be put into a vial of rain water, and frequently ſhook for ſeveral days, ſome will at length be found perfectly clean, theſe are then to be put into ſpirit of wine, and when that has been two or three times changed, they will be in a condition to be viewed for underſtanding their ſtructure; another method of preparation has been already ſhewn in page 162.

Theſe are the veſſels which have been called by ſome writers air, by others tracheal veſſels. It is, however, to be remarked, that moſt of thoſe who have conſidered them as air veſſels, refer us to the tree while in a more herbaceous ſtate; in this caſe they ſay, that we ſhall find theſe parts filled with a fine ſpiral filament. As theſe veſſels are often to be found empty, they have been ſuppoſed to anſwer the purpoſes of lungs to the plant. Malphigi aſſerts,

aſſerts, that if they are examined in winter, they often exhibit a vermicular motion, which aſtoniſhes the ſpectator.

Thoſe who ſuppoſe the corona to contain the whole ſtructure of the tree in miniature, and that it is the embryo of future ſhoots, ſuppoſe it to contain the veſſels proper for each part, a ſubject that muſt be left to the deciſion of future obſervers.

Of the Vasa Propria Intima.

Theſe are the only veſſels which remain to be ſpoken of. They are large, conſpicuous, and important; their natural place is in the blea, though they are ſometimes repeated in the wood and the corona. Their coats are thicker than thoſe of any other veſſels.* It is not difficult, after a ſucceſsful maceration, to ſeparate ſome of theſe veſſels from the blea; in this ſtate they appear perfect cylinders, with thick white coats, of a firm, ſolid, and uniform texture.

It has generally been ſuppoſed, that each of thoſe concentric circles, which are to be obſerved in the tranſverſe ſection of almoſt every tree, was the product of one year, or the quantity of wood added to the tree in that ſpace; here, however, Dr. Hill differs again from the general opinion.

From what has been ſaid we may deduce the following general ideas relative to the organization of trees. The moſt obvious and remarkable parts of a plant, or tree, are the root, the ſtem, the

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* Hill's Conſtruction of Timber, p. 83 and 85.

the branches, the leaves, the flower, and the fruit. The component parts of these divisions are not complicated, they are simple when compared to those of an animal, and this because the offices of the vegetable are fewer than those of the animal.

The interior part may be considered as consisting of lignous fibres, interspersed with a vast number of bladders, which are here named the cellular tissue, the vasa propria, and the sap vessels; though these are considered by some writers as mere air vessels.

The lignous fibres are very fine tubes, proceeding nearly in a vertical direction from the top to the bottom of the tree; they are sometimes parallel to each other, sometimes they divaricate, and often leave oblong intervals or spaces. There is great reason for supposing them to be a species of lymphatic vessels. The vacant spaces between these fibres are filled up by a vesicular membrane, lying in an horizontal direction, and which is called in this chapter the cellular tissue.

The vasa propria are formed of lignous fibres, but differ from the foregoing in their size, and in the juices which they contain. In the part properly called the wood, we meet with the sap vessels; but as in some states they seem as if they were formed of a silver-coloured spiral membrane, and are found without any juices, they have been supposed to be air vessels, and called the trachea, making up an arterial system, and supplying the place of the heart in animals.

The

The interior part of the tree may be further confidered as divided into four principal concentric ftrata, the bark, the blea, the wood, and the pith: to thefe Dr. Hill has added the corona. Whatever part of a plant we examine, we find thefe and no more. The root, it's afcending ftalk, and defcending fibre, are formed of one, and not three different fubftances. Thus the whole vegetable is reduced to one entire body. And what appears in the flower to be formed of altogether diftinct parts, will be found to originate in thefe.

The bark, which is the exterior covering of the tree, is divided into two parts, a thin outer rind, and a much thicker inner one. The exterior one feems to be little more than a fine film of irregular mefhes, the inner one compofed of large blebs, leaving in fome fubjects large vacant fpaces, which form it's vafa propria. It is made up of feveral ftrata, laying one over the other.

Next to this is the blea, which is of an uniform ftructure. It is an imperfect wood, waiting only for the hand of time to be brought to perfection. The duration of the blea in this middle ftate depends on the internal powers and ftrength of the tree, being fo much fhorter as this is more vigorous.

The wood, including the corona, comes next; it differs in denfity and duration, both from the blea, the bark, and the wood. It is made up of ftrong fibres. The life of the vegetable feems to refide in it; from it all the other parts are produced. It fhoots a pith inwards, and a blea and a bark outwards.

Every

be ſo refracted by the lens, that after going out of it, they will become parallel. If the candle be placed nearer the lens than it's focal diſtance, the rays will diverge more or leſs, as the candle is more or leſs diſtant from the focus.

If any object, A B, Fig. 7, Plate I. be placed beyond the focus of the convex lens E F, ſome of the rays which flow from every point of the object, on the ſide next the glaſs, will fall upon it, and after paſſing through it, they will be converged into as many points on the oppoſite ſide of the glaſs; for the rays a b, which flow from the point A, will converge into *ab*, and meet at C. The rays c d, flowing from the point G, will be converged into *cd*, and meet at g; and the rays which flow from B, will meet each other again at D; and ſo of the rays which flow from any of the intermediate points: for there will be as many focal points formed, as there are radiant points in the object, and conſequently they will paint on a ſheet of paper, or any other light-coloured body, placed at D g c, an inverted image of the object. If the object is brought nearer the lens, the picture will be formed further off. If it be placed at the principal focus, the rays will go out parallel, and conſequently form no picture behind the glaſs.

The human eye is ſo conſtituted, that it can only have diſtinct viſion, when the rays which fall on it are parallel, or nearly ſo; becauſe the retina, on which the image is painted, is placed in the focus of the cryſtalline humor, which performs the office of a lens in collecting rays, and forming the image in the bottom of the eye.

The

Every tree may be confidered as confifting of numerou concentric ftrata, or flakes, forming fo many cones, infcribed one within the other, and whofe number is almoft indefinite. The moft exterior contain the rudiments of the bark, the more interior thofe of the wood. In the germ they are gelatinous, by degrees they become herbaceous, and in procefs of time it affumes the confiftency of wood. Thus the ftem, the root, and the branch, may be confidered as formed of a prodigious number of concentric vertical ftrata, each compofed of different fafcicles of fibres, which fibres are again formed of fmaller ones. The fpaces between thefe, and among the fibres, are filled up, interwoven with and connected by the cellular tiffue, of which the radial infertions are formed.

The ftrata harden fucceffively one after the other; the moft interior ftratum is that which hardens firft, this is then covered by another which is more ductile and herbaceous, and fo on. From the extenfion in breadth the tree acquires bulk, from that in length it gains it's height. The ftrata gradually diminifh in fize as they gain in length; from hence the conical figure of the root and ftem, and branch. All the parts of the plant are the fame, differing in nothing more than in fhape and fize. The roots are fharp and pointed, that they may make their way more readily through the earth. The leaves are broad, that they may more effectually catch the moifture from the atmofphere, &c. When the root of a tree is elevated above, inftead of being retained under the earth, it affumes the appearance of a perfect plant, with leaves and branches. Experiment fhews that a young tree may have it's branches placed in the earth, and it's roots elevated in the air, and in that inverted ftate it will continue to live and grow.

grow. The principal ſource of the phænomena of vegetation is the ſimplicity and uniformity of their organization.

The figures in Plate XXVII. XXVIII. XXIX. are portions of tranſverſe ſections of trees and herbs. The ſections were cut by Mr. Cuſtance, who firſt brought this art to perfection, and remains unrivalled as yet in theſe performances.

Fig. 1, Plate XXVII. a piece of an herb growing on dunghills, and known by the name of fat-hen; it is one of the ſpecies of orach. Fig. 2, a microſcopic view of the ſame. Fig. 3, a magnified repreſentation of a ſection of a reed that comes from Portugal. Fig. 4, the real ſize of the ſection.

Fig. 1, Plate XXVIII. a magnified view of a ſection of the althea frutex. Fig. 3, a ditto of the hazel. Fig. 5, a ditto from a branch of the lime-tree. Fig. 2, 4, 6, repreſent the real ſize of the ſections.

Plate XXIX. Fig. 5 a magnified view of a ſection of common cane. Fig. 3, one of the bamboo cane. Fig. 1, one of ſugar cane. Fig. 2, 4, 6, the real ſize of the ſections.

CHAP.

CHAP. X.

OF THE CRYSTALLIZATION OF SALTS, AS SEEN BY THE MICROSCOPE; TOGETHER WITH A CONCISE LIST OF OBJECTS.

CRYSTALLIZATION, in general, ſignifies the natural formation of any ſubſtance into a regular figure, reſembling that of natural cryſtal. Hence the phraſes of cryſtallized ores, cryſtallized ſalts, &c. and even the baſaltic rocks are now generally reckoned to be effects of this operation; the term, however, is moſt commonly applied to bodies of the ſaline kind; and their ſeparation in regular figures from the water, or other fluid in which they were diſſolved, is called their cryſtallization. If the word cryſtallization were to be confined to it's moſt proper ſenſe, as it ſeems to have been formerly, it could only be applied to operations by which certain ſubſtances are diſpoſed to paſs from a fluid to a ſolid ſtate, by the union of their parts, which ſo arrange themſelves, that they form tranſparent and regularly-figured

figured maffes, like native cryftal; from which refemblance the word cryftallization has evidently been taken.*

But modern chemifts and naturalifts have much extended this expreffion, and it now fignifies a regular arrangement of the parts of any body which is capable of it, whether the maffes fo arranged be tranfparent or not. Thus opake ftones, pyrites, and minerals, when regularly formed, are faid to be cryftallized, as well as tranfparent ftones and falts.

The opacity and tranfparency of fubftances are juftly difregarded, in confidering whether they be cryftallized or not; for thefe qualities are perfectly indifferent to the regular arrangement of the integrant parts of fubftances, which is the effential object of cryftallization.

This being eftablifhed, cryftallization may be defined, an operation by which the integrant parts of a body, feparated from each other by the interpofition of a fluid, are difpofed to unite again, and to form folid, regular, and uniform maffes.

To underftand as much as we can of the mechanifm of cryftallization, we muft remark,

1. That the integrant parts of all bodies have a tendency to each other, by which they approach, unite, and adhere together, when not prevented by an obftacle.

4 O 2. That

* Macquer's Dictionary of Chemiftry, Art. Cryftallization.

2. That in ſimple or little-compounded bodies, this tendency of integrant parts is more obvious and ſenſible than in others more compounded: hence the former are much more diſpoſed to cryſtallize.

3. That although we do not know the figure of the primitive integrant molecules of any body, we cannot doubt but that thoſe of every different body have a conſtantly uniform and peculiar figure.

4. That theſe integrant parts cannot have an equal tendency to unite indiſcriminately by any of their ſides, but by ſome preferably to others, excepting all the ſides of an integrant part of a body be equal and ſimilar; and probably the ſides, by which they tend to unite, are thoſe by which they can touch moſt extenſively and immediately.

The moſt general phænomena of cryſtallization may be conceived in the following manner:

Let a body be ſuppoſed to have it's integrant parts ſeparated from each other by ſome fluid; if a part of this fluid be taken away, theſe integrant parts will approach together; and as the quantity of intervening fluid diminiſhes, they will at laſt touch and unite. They may alſo unite when they come ſo near to each other, that their mutual tendency ſhall be capable of overcoming the diſtance betwixt them. If, beſides, they have time and liberty to unite with each other by the ſides moſt diſpoſed to this union, they will form maſſes of a figure conſtantly uniform and ſimilar. For the ſame reaſon, when the interpoſed fluid is haſtily taken

taken away, fo that the integrant parts fhall be approximated, and be brought into contact before they have taken the pofition of their natural tendency, then they will join confufedly by fuch fides as chance prefents to them; they will, in fuch circumftances, form folid maffes, whofe figures will not be determinate, but irregular and various.

Different falts affume different figures in cryftallization, and are, by this means, eafily diftinguifhed from one another. But befides the large cryftals produced in this way, each falt is capable of producing a very different appearance of the cryftalline kind, when only a drop of the faline folution is made ufe of, and the cryftallization viewed through a microfcope. For our knowledge of this fpecies of cryftallization we are indebted to Mr. Henry Baker, who was prefented by the Royal Society with a gold medal for the difcovery, in the year 1744. Thefe microfcopical cryftals he diftinguifhes from the larger ones by the name of configurations; but this term feems inaccurate, and the diftinction may be properly preferved by calling the large ones the COMMON, and the fmall ones the MICROSCOPICAL cryftals of the falt.

It has not yet been fhewn by any writer on the fubject, why falts fhould affume any regular figure, much lefs why every one fhould have a form peculiar to itfelf. Sir Ifaac Newton endeavoured to account for this, by fuppofing the particles of falt to be diffufed through the folvent fluid, at equal diftances from each other; and that then the power of the attraction between the faline particles could not fail to bring them together in regular figures, as foon as the diminution of heat fuffered them to act on

 each

each other.* But it is certain fome other agent muft be concerned in this operation befides mere attraction, otherwife all falts would cryftallize in the fame manner. Others have, therefore, had recourfe to fome kind of polarity in the particles of each falt, which determined them to arrange themfelves in fuch a certain form; but unlefs we give a reafon for this polarity, we only explain cryftallization by itfelf. One thing feems to have been overlooked by thofe who have endeavoured to inveftigate this fubject, namely, that the faline particles do not only attract one another, but they alfo attract fome part of the water which diffolves them.

Did they only attract each other, the falt, inftead of cryftallizing, would fall to the bottom as a powder; whereas, a faline cryftal is compofed of falt and water, as certainly as the body of an animal is compofed of flefh and blood, or a vegetable of folid matter and fap; if a faline cryftal is deprived of it's aqueous part, it will as certainly lofe it's cryftalline form as if it was deprived of the faline part. It is, therefore, not improbable, that cryftallization is a fpecies of vegetation, and is accomplifhed by the fame powers to which the growth of plants and animals are to be afcribed. Some kinds of cryftallization refemble vegetation fo much, that we can fcarce avoid attributing them to the fame caufe.

It has been imagined, that all the great operations in nature may be reduced to two principles, thofe of cryftallization and organization; but that often they are fo concealed as to be invifible.

* Encyclopædia Britannica, p. 2329.

visible. Hence cryſtallized ſubſtances have been often miſtaken for organized ones, and vice verſa. They differ, however, eſſentially in their growth and origin. Organized beings ſpring from a germ, in which all the eſſential parts are concentrated, and they grow by intuſception; whereas cryſtallized ſubſtances increaſe by the ſucceſſive appoſition of certain molecules, of a determined figure, which unite in one common maſs. Thus cryſtallized beings do not grow, properly ſpeaking; though their ſubſtance is augmented, they are not preformed, but formed daily.

We have already ſhewn, page 163, how to prepare the various ſalts for microſcopical obſervations. The beautiful cryſtallizations repreſented in Pl. XXX. and XXXI. were produced in the manner there deſcribed.

Fig. 2, Plate XXX. ſhews the microſcopical cryſtals of nitre. Theſe ſhoot from the edges with very little heat, in flattiſh figures, of various lengths, and exceedingly tranſparent, the ſides nearly parallel, though rather jagged, and tapering to a point; after a number of theſe are formed, they often diſſolve under the eye, and diſappear entirely; but in a little time new ſhoots will puſh out, and the proceſs go on afreſh. Beautiful ramifications are formed round the edge, and many regular figures are to be obſerved in different parts of the drop. Fig. 2 is the real ſize of the drop.

Fig. 3, Plate XXX. is a drop of diſtilled verdigreaſe, as it appeared when viewed by the microſcope. There is a difference in the

the appearance from this ſubſtance, according as the time of the application is nearer to or more diſtant from that in which the ſolution was made.

Fig. 1, Pl. XXXI. repreſents the microſcopical cryſtals of ſalt of wormwood. The ſhootings from the edges of this ſolution are often very thick in proportion to their length, their ſides full of notches, the ends generally acute; many ſpear-like forms are alſo to be obſerved, as well as little cryſtals of a variety of figures.

Fig. 2, Plate XXXI. the ſalt of amber. The ſhootings of this ſalt are highly entertaining, though the proceſs is very ſlow; many ſpicula ſhoot from the edge towards the middle of the ſolution, and from the pointed ends of the ſpicula, a great variety of diverſified branches may be obſerved, variouſly divided and ſubdivided, and forming at laſt, ſays Mr. Baker, a winter ſcene of trees without leaves.

Salt of hartſhorn, Fig. 3, Plate XXXI. This ſalt ſhoots out from the edge of the drop into ſolid, thick, and rather opake figures; from theſe it often ſhoots into branches of a rugged appearance, ſimilar to thoſe of ſome ſpecies of coral.

Fig. 4, Pl. XXXI. repreſents the configurations of ſal ammoniac. Theſe form a moſt beautiful object in the microſcope: a general idea may be more eaſily formed, by conſidering the figure here exhibited, than by any verbal deſcription.

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A CONCISE LIST OF OBJECTS FOR THE MICROSCOPE.

The ſhort liſt here preſented to the reader muſt, from the nature of the ſubject, be very imperfect; for the whole of the animal, vegetable, and mineral kingdoms, with all their numerous ſub-diviſions, furniſh objects for the microſcope; and there is not one of them that, when properly examined, will not afford inſtruction and entertainment to the rational inveſtigator of the works of creation. The Syſtema Naturæ of Linnæus may therefore be conſidered as a catalogue of univerſals for microſcopic obſervation, each of which involves a variety of particulars. The liſt here given can be conſidered as little more than a directory, to point out to thoſe who have only begun to ſtudy this part of natural hiſtory, a few of thoſe objects which merit their attention, and which, from their beauties, may incite them to purſue the ſtudy with greater ardor.

" Thoſe who rightly conſider natural things, will find them a ſhadow of heavenly things, a ſchool in which God is the teacher, and all the objects of ſenſe in heaven and earth, and under the earth, are as the letters of an univerſal language, in which all nations have a common intereſt. The Creator himſelf has made this uſe of it, revealing his will by it, and referring man to it for inſtruction. From hence the univerſal agreement between nature and revelation. Hence, alſo, he that can underſtand God as the fountain of truth, and the Saviour of men in the holy ſcriptures, will be better diſpoſed to underſtand and adore Him as the fountain of power and goodneſs in the natural creation. Whereſoever we go in divinity, the true philoſophy will follow us as a faithful

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The picture, formed by a convex lens, is either larger or less than the object, in proportion as it's distance from the lens is greater or less than it's distance from the object.

As an object becomes perceptible to us, by means of the image thereof which is formed on the retina, it will, therefore, be seen in that direction, in which the rays enter the eye to form the image, and will always be found in the line, in which the axis of a pencil of rays flowing from it enter the eye. We from hence acquire a habit of judging the object to be situated in that line. Note; as the mind is unacquainted with the refraction the rays suffer before they enter the eye, it judges them to be in the line produced back, in which the axis of a pencil of rays flowing from it is situated, and not in that in which it was before the refraction.

If the rays, therefore, that proceed from an object, are refracted and reflected several times before they enter the eye, and these refractions, or reflections, change considerably the original direction of the rays which proceed from the object; it is clear, that it will not be seen in that line, which would come strait from it to the eye; but it will be seen in the direction of those rays which enter the eye, and form the image thereof on it.

We perceive the presence and figure of objects, by the impression each respective image makes on the retina; the mind, in consequence of these impressions, forms conclusions concerning the size, position, and motion of the object. It must however be observed, that these conclusions are often rectified or changed by the mind, in consequence of the effects of more habitual impressions. For example; there is a certain distance, at which, in faithful witnefs, and fhew that the world was made, as the fcriptures were written, for our inftruction; and find the creation of God is the fchool of chriftians, if they ufe it aright."*

OF OPAKE OBJECTS.

Ores and minerals afford an immenfe variety of very beautiful and fplendid objects. From amongft thefe the obferver may felect the peacock, or coloured copper ore, green cryftallized ditto, lead ore, cryftallized ditto, cryftals of lead, fmall grained marcafites, coloured mundic, cinnabar, native fulphur, needle and other antimony, mofs copper, &c. A mixture of fmall pieces of ores, &c. of different kinds, produces a pleafing effect. Sands, in general, exhibit fomething not difcoverable with the naked eye. Sand from the fea-fhore is often intermixed with minute fhells, particularly that from Rimini, in Italy. Mr. Walker has publifhed a fpecimen of the fmall microfcopic fhells which are found on our own coaft. From this work we learn, that there are fhell-fifh as fmall as the minuteft infects, and poffeffed of beauties, of which we can form no conception till we have feen them. Mr. Walker's work is entitled, "A Collection of the minute and rare Shells found on the Sea-fhore near Sandwich." There is a fand from Africa full of fmall garnets. The ketton, or kettering ftone, is a pleafing object; when examined by the microfcope, we find the grain of it very different from that of other ftones, being compofed of innumerable minute balls, which barely touch each other, and yet form a fubftance much harder

* Jones's Lectures on the Figurative Language of the Holy Scriptures.

harder than free-ſtone; the grains are, in general, ſo firmly united together at the points of contact, that it is hardly poſſible to ſeparate them without breaking one or both of the grains. See Hooke's Micrographia.

INSECTS of all kinds, both foreign and domeſtic, are pleaſing objects; but as the foreign ones are not ſo eaſily met with, I ſhall mention but a few of them, confining myſelf principally to thoſe of this country. Among the exotic inſects none appear more beautiful in the microſcope than the curculio imperialis, Brazil, or diamond beetle; the bupreſtis ignita, a large beetle from China; the meloe veſicatorius, bliſter-fly, or cantharis of the ſhops; ſeveral ſpecies of locuſts, graſshoppers, &c. Among the Engliſh beetles we may reckon the ſcarabæus auratus, or roſe chaffer, ſcarabæus nobilis, ſcarabæus horticola, ſilpha aquatica, caſſida nobilis and nebuloſa. Coccinella, or lady-cow; of theſe there are great variety, both in ſize and colours, ſome red and black, others black and red, and ſome yellow and black. Chryſomela, graminis-faſtuoſa, nitidula, ſericea, melanopa, aſparagi, vide Plate XX. Fig. 2. Curculio-frumentarius, lapathi, betula, nucum, ſcrophularia, argenteus, a beautiful little inſect reſembling the diamond beetle, but in miniature; curculio albinus, very beautiful, but ſcarce in this country. Leptura aquatica, theſe are of various colours, as blue, purple, bronze, and crimſon. Arcuata arictis, very common, and is often called the waſp beetle. Cicendela campeſtris, on dry banks. Carabus nitens, found in Yorkſhire, a beautiful inſect, many ſmall carabi. Gryllus, gryllo talpa, or mole cricket; this inſect, and the graſshoppers, are many of them too large to be obſerved at one view, but the head, fore and hind feet, elytra, &c. viewed ſeparately, are fine objects. Cicada, sanguinolenta, nervosa, interrupta, notonecta striata, minutissima, head and claws of the nepa cinerea, or water-scorpion, and the whole variety of cimeces, or field bugs. The wings of butterflies and moths, the chrysalis of the common white butterfly, is extremely fine.

I wish it were in my power to invite the reader to consider the pupa state of these insects, as he would find them interesting in various points of view. Perhaps the following passage from an ingenious writer may have this effect.

"Some of these creatures crawl for a time as helpless worms upon the earth, like ourselves; they then retire into a covering, which answers the end of a coffin, or a sepulchre, wherein they are invisibly transformed, and come forth in glorious array, with wings and painted plumes, more like the inhabitants of the heavens than such worms as they were in their former state. This transformation is so striking and pleasant an emblem of the present, intermediate, and glorified state of man, that people of the most remote antiquity, when they buried their dead, embalmed and inclosed them in an artificial covering, so figured and painted, as to resemble the caterpillar in the intermediate state; and as Joseph was the first we read of that was embalmed in Egypt, where this custom prevailed, it was probably of Hebrew original."

The eggs of moths and butterflies, particularly the phalæna neustria, vide Plate X. Fig. 1 to 5. The bodies and heads of many libellulæ.

Many

Many of the ichneumon flies, fpheges and wafps, head of the hornet, fting of ditto, collectors of the bee, many forts of mufcæ, or flies with two wings, efpecially thofe whofe bodies are highly coloured; acari, or ticks; phalangium cancroides, vide Plate XVIII. Fig. 1 and 6. Some fpiders, but the eyes of all; the onifcus or wood loufe, julus, and fcolopendræ.

The feathers of peacocks, and many other birds, have a grand effect when viewed in the opake microfcope, as have alfo fome fpecies of ferns, moffes, and wood cut tranfverfely. Madrepores, millepores, fponges, corralines, &c. exhibit wonderful appearances, not difcernible to the naked eye. Parts of echini or fea eggs, fpines of ditto; thefe may alfo be cut tranfverfely, to fhew their conftruction. Minute fhells diffected, fkin of many fpecies of fifh, particularly the lump fifh, Plate XVIII. Fig. 2. Soal, and the rafp fifh from Otaheite, alfo the fkins of fnakes, lizards, guanas, &c. &c. An endlefs variety will be difcovered in feeds.

The exterior form, and even the internal ftructure of the generality of vegetable feeds, have been fuppofed by fome fo much alike in the feveral kinds, and of fo little curiofity and beauty in the whole, that they have fcarcely been regarded by the curious; but when nearly examined, with the help of microfcopes, they are found to be worthy of a greater attention; thofe which appear moft like to one another, when viewed by the naked eye, often proving as different when thus examined, in their feveral forms and characters, as the different genera of any other bodies of the creation. If their external forms carry all this variety and

4 P 2 beauty

beauty about them, their internal ſtructure, when laid open by different ſections, appears yet more admirable.

The ſeed of the muſk ſcabious is amazing in it's ſhape and ſtructure; it reſembles in figure an octagonal vaſe, with a ſcalloped brim; the whole is bell-faſhioned, having ribs or diviſions, which run down from the mouth of the vaſe, and thence becoming narrower, form the bottom. Between theſe ribs, down to the beginning of the narrow part, it is clear, though not wholly tranſparent, and from thence to the bottom the ribs are hairy. This vaſe contains a ſeed, which is like a peſtle ſtanding in a mortar. The peſtle ſtands looſe in an octagonal caſe, but the narrowneſs of the mouth of this vaſe hinders the peſtle's being drawn out, becauſe it's extremity within is rounded, and thicker than any other part of it. From it's upper end there ariſe five ſpiculated areſtæ, or awns, whoſe little thorns are directed upwards, and are thereby prepared to cauſe the ſeed to recede from any thing that might injure it on being touched. The baſon, from which theſe ariſtæ ariſe, is of a fine green colour, and they are of an elegant ſhining brown.

The ſeed of the great maple, which we commonly, but improperly, call the ſycamore tree, conſiſts of a pod and it's wing; two of theſe grow upon a pedicle, with the pods together, which makes them reſemble the body of an inſect with it's expanded wings: the wings are finely vaſculated, and the pods are winged with a fine white down, reſembling ſilk: this contains a round compact pellet, covered with a brown membrane, that ſticks very cloſely to it. When this is pulled off, inſtead of diſcerning a kernel,

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kernel, as in other feeds, there appears an entire green plant, folded up in a moft furprizing manner. The pedicle of this is about two-eighths of an inch long, and it's feminal leaves of about fix-eighths each; between thefe the germina of the next pair of leaves are plainly vifible to the naked eye, but with a microfcope they are feen with the greateft beauty and perfection. Thefe, and a number of fuch other beauties in this part of the creation, are defcribed at large by Dr. Parfons, in his work entitled, "A Microfcopic Theatre of Seeds." Moft kinds of feeds fhould be prepared for a microfcopical examination, by fteeping them in warm water till their coats are feparated, and their feminal leaves may then be opened without laceration. But feeds, while dry, and without any preparation, are of an almoft infinite variety of fhape, and afford a number of pleafing objects for the microfcope.

TRANSPARENT OBJECTS.

We may felect from the elytra, or upper wings of beetles, many beautiful objects; the conftruction of thefe will be found to differ very much; the membranaceous wings, as in the fcarabæus folftitialis, or fmall cock-chaffer; blatta americana, or cock-roach; all the grylli, as locufts, grafshoppers, &c. Among the cicadas, the elytra of the nervofa are the moft elegant, the nerves are elevated, and curioufly fpotted with brown. The elytra of the cimeces, or field bugs, which are a very numerous tribe, afford a great variety of objects; we may felect from thefe, as the moft beautiful, the elytra of the cimex baccarum, ftriatus, Plate XX. Fig. 2. The elytra of the fulgora candelaria, from China, differs effentially from all others.

The

The under, or more tranſparent wings of beetles excite our attention even more than the upper, or cruſtaceous ones; for whether we conſider the delicacy of their texture, the great weight that many of them are calculated to ſuſtain in the air, or the very curious manner in which they fold them up under the upper caſe, their mechaniſm muſt aſtoniſh and delight us; no two genera will be found alike, though every individual of the ſame genus will be exact; the wing of the forficula, or earwig, Plate XIX. Fig. 1, is an elegant ſpecimen of the manner of their folding; this wing folds under a caſe not one-eighth of it's ſize.

The under wing of the blatta orientalis, a beetle common in moſt kitchens, appears to unite the elytra and tranſparent wings, partaking in ſome degree of both.

Among the membranaceous or more tranſparent-winged inſects, the variety is endleſs, each genus differing eſſentially from the other, ſome appearing full of membranes, or nerves, curiouſly diſpoſed; others, again, with ſcarce any, like a clear piece of talc, or iſinglaſs; ſome exhibit a curious ground-work of points, which, on cloſe examination, prove ſhort hairs, while the nerves of others are furniſhed with little ſcales, or feathers, as in ſome ſpecies of the gnat. The wings of many muſcæ are coloured with black, brown, and white, in clouds, ſpots, ſtripes, &c. &c.

The libellulæ, or dragon-flies, alone afford a great variety, not only in form, but colour; theſe are all furniſhed with numerous and very ſtrong nerves, adapted to the velocity of their flight; the wings of the ephemera, or May flies, are much more delicate, theſe

these flies rest with their wings erect. The phryganeæ differ very much from the foregoing, and also from one another; their under wings fold, and the upper ones are of a stronger texture, many of them so much resembling small moths as not easily to be distinguished from them: these are all found in the vicinity of ponds or marshy places. In the hemerobii a wonderful degree of elegance is exhibited in the disposition of the nerves, which compose their wings, each nerve being adorned with hair in a beautiful manner; there are many species of these flies equally beautiful, a specimen is given in Plate XIII. Fig. 1. The ichneumon fly has four transparent wings, the inferior ones smaller, and more delicate than the superior; the tube through which the female deposits it's eggs, is an additional object well worth attention. The wings of wasps are folded longitudinally, the wings of the large bee are very curious. Gnats in general, and the various species of tipulæ, together with the clouded and variegated wings of the muscæ, tabani, &c. increase the catalogue beyond the power of enumeration; in short, there is not a wing but has it's particular beauties, and will amply repay the attentive observer. The current sphinx moth connects the transparent and farinaceous wings partaking of both, and the white plumed, and many plumed moths, exhibit wings totally different from all the rest; many other small moths furnish wings sufficiently transparent for observation, the fringe or edges being remarkably beautiful.

Many small insects that are not too opake, may be viewed and examined as transparent objects; as some of these have been particularly noticed by the early microscopic writers, it will be necessary to give some account of them, as without it the work might be deemed incomplete. Every one is acquainted with the agility and

and blood thirfty difpofition of the flea, of the caution with which it comes to the attack, and the readinefs with which it avoids purfuit. It belongs to the clafs aptera, has two eyes, fix feet, particularly conftructed for leaping, the feelers are filiform, the roftrum is inflected, fetaceous, and armed with a fting; the belly is compreffed. This creature is produced from eggs, which they depofit on the animals that afford them food, or affix them to the wool of blankets, rugs, &c. of thefe eggs are hatched white worms, which adhere clofely to the body of the animal, or other fubftance on which they are produced; in a fortnight they come to a tolerable fize, and are very lively and active; but if they are touched at this time, they roll themfelves up in a ball. After about eleven days from the time of their being hatched, they feek a place to hide in, and if viewed by a microfcope, will be found weaving a covering or bag, in which they affume the pupa ftate, where they continue from nine days to a fortnight, when having acquired fufficient ftrength, they burft from their confinement, perfectly formed, and armed with powers to difturb the peace of an emperor.

The flea when examined by the microfcope is not an unpleafing object: it is difficult, however, to obtain fuch a view of it as will difplay the mechanifm and apparatus belonging to the head. Thefe parts are but imperfectly reprefented in the celebrated drawing of Dr. Hooke. The neck is long, finely arched, and much refembles the tail of a lobfter; the body is covered all over with a fuit of fable armour, formed of a hard fhelly fubftance, curioufly jointed and folded over one another, and yet yielding to all the nimble motion of the little animal: the edges of the fcales are curioufly fet with fhort fpikes or hairs: it has two fharp ſharp eyes to look before it leaps, for which purpoſe it's legs are excellently adapted, for the joints are ſo conſtructed that it can fold them up as it were, and when it leaps, ſpring them out all at once, whereby it's whole ſtrength is exerted, and the body often raiſed two hundred times it's own diameter; there are ſeveral joints in the legs; they are alſo very hairy, and terminated by two long hooked ſharp claws; the two fore legs are placed very near the neck, and often conceal the proboſcis from our view, the other four join all at the breaſt: the flexure of the two fore ones is contrary to that of the hinder ones: the proboſcis, or ſucker, with which it penetrates the ſkin, is placed at the end of the ſnout, and is not eaſily ſeen, except the two fore legs are firſt removed; in it are included a couple of darts or lancets, which, after the proboſcis has made an entrance, are thruſt farther into the fleſh, and make the blood flow from the adjacent parts, and occaſion that round red ſpot, with a hole in the center of it, called a flea bite.

The bed bug is another nauſeous inſect, " that intrudes upon the peace of mankind, and often baniſhes that ſleep which even anxiety and ſorrow permitted to approach: the night is the ſeaſon when the bed bug iſſues from it's retreat to make it's depredations: by day it lurks in the moſt ſecret parts of the bed, takes the advantage of every chink and cranny to make a ſecure lodgement, and contrives it's habitation with ſo much art, that ſcarce any induſtry can diſcover it's retreat: but when darkneſs promiſes ſecurity, it then iſſues from every corner of the bed, drops from the teſter, and crawls from behind the arras, and travels to the unhappy patient, who vainly wiſhes for reſt and refreſhment."

in the general buſineſs of life, we are accuſtomed to ſee objects: now, though the meaſure of the image of theſe objects changes conſiderably when they move from, or approach nearer to us, yet we do not perceive that their ſize is much altered: but beyond this diſtance, we find the objects appear to be diminiſhed, or increaſed, in proportion as they are more or leſs diſtant from us.

For inſtance, if I place my eye ſucceſſively at two, at four, and at ſix feet from the ſame perſon, the dimenſions of the image on the retina will be nearly in the proportion of 1, of $\frac{1}{2}$, of $\frac{1}{3}$, and conſequently they ſhould appear to be diminiſhed in the ſame proportion; but we do not perceive this diminution, becauſe the mind has rectified the impreſſion received on the retina. To prove this, we need only conſider, that if we ſee a perſon at 120 feet diſtance, he will not appear ſo ſtrikingly ſmall, as if the ſame perſon ſhould be viewed from the top of a tower, or other building, 120 feet high, a ſituation to which we had not been accuſtomed.

From hence, alſo, it is clear, that when we place a glaſs between the object and the eye, which from it's figure changes the direction of the rays of light from the object, this object ought not to be judged as if it were placed at the ordinary reach of the ſight, in which caſe we judge of it's ſize more by habit than by the dimenſions of the images formed on the retina: but it muſt be eſtimated by the ſize of the image in the eye, or by the angle formed at the eye, by the two rays which come from the extremity of the object.

These insects are as disagreeable from their nauseous stench, as their unceasing appetites. Linnæus thinks that they are not originally of European growth, but were imported from some other country. It has two brown small prominent eyes, two antennæ, and a crooked proboscis, which lies close under the breast. Instead of wings, we find on the first ring of the belly, two flat pieces which entirely cover it, and extend towards the sides. These plates, the trunk and the head, are amply set with hairs. The proboscis is divided transversely into four parts, which are probably so many articulations; this piece is best seen on the underside of the bug. It has six legs, each of which has three joints; the skin is chagrined, and the separation of the rings usually marked by a smooth shining band. On the belly, at a small distance from the edge, you may perceive a set of circular spots, two on each ring, except the last; these are the spiracula. Examined internally we find one large artery, a stomach, and intestines. The instant it perceives the light it endeavours to gain it's habitation, and seldom fails in making good it's retreat.

Of the louse. Various as are the antipathies of mankind, all seem to unite in their dislike to this animal, and to regard it as their natural and most nauseous enemy. "Whenever wretchedness, disease, and hunger, seize upon man, the louse seldom fails to add itself to the tribe, and to increase in proportion to the number of his calamities."

When the human louse is examined by the microscope, it's deformity fills us with disgust. In the head we may distinguish two fine black eyes, near this are the two antennæ: the fore part of the head is rather long, the hinder more obtuse or rounder; there

there is a fmall part that projects from the nofe or fnout, this ferves as a fheath or cafe to the probofcis, which the creature thrufts into the fkin to draw out the blood and humours which are it's deftined food, for it has no mouth which opens in the common way.

This probofcis has been eftimated to be feven hundred times fmaller than a hair, and is contained in another cafe within the firft, and can be drawn in or thruft out at pleafure: the fkin is hard and tranfparent. From the under fide proceed fix legs, each of which has five joints, and terminates in two unequal hooked claws, thefe it ufes as we would a thumb and finger; there are hairs between the claws, as well as all over the legs; the body finifhes in a cloven tail, which is generally covered, and partly concealed by hairs.

From the extreme tranfparency of it's fkin, many of it's internal parts may be feen, as the various ramifications of the veins and arteries, and the periftaltic motion of the guts. When the loufe feeds, the blood is feen to rufh like a torrent into the ftomach, and it's greedinefs is fo great, that the excrement contained in the inteftines is ejected at the fame time, to make room for this new fupply. There is fcarce any animal that multiplies fo faft as this unwelcome intruder, the moment it is excluded from the egg it begins to breed.

It would be endlefs to defcribe the various creatures which go under the name of lice, and fwarm upon every part of nature. The reader who wifhes for a more particular account of thofe which

which infeft various animals, would do well to look into Rhedi's Treatife de Generatione Infectorum.

The fpider is another infect which is often examined by the microfcope, and certainly affords much matter for obfervation. "Formed for a life of rapacity, and incapable of living but by blood, all it's habits are calculated to deceive and furprize; it fpreads toils to entangle it's prey; it is endued with patience to expect it's coming, and is poffeffed of arms and ftrength to deftroy it when fallen into the fnare.

" ———— To heedlefs flies the window proves
A conftant death; where, gloomily retired,
The villian fpider lives, cunning and fierce,
Mixture abhorr'd; amid a mangled heap
Of carcafes, in eager watch he fits,
O'erlooking all his waving fnares around.
Near the dire cell the dreadlefs wanderer oft
Paffes, as oft the ruffian fhews his front;
The prey at laft enfnar'd, he dreadful darts
With rapid glide along the leaning line;
And, fixing in the wretch his cruel fangs,
Strikes backward grimly pleas'd: the flutt'ring wing
And fhriller found declare extreme diftrefs,
And afk the helping hofpitable hand."

The eyes of the fpider are a very beautiful microfcopic object, viewed either as tranfparent or opake; they have generally eight; two on the top of the head, that look directly upwards; two in the front, a little below the foregoing, to difcover what

paffes

paſſes before it; and on each ſide a couple more, one whereof points ſideways forward, the other ſideways backward; ſo that it can ſee almoſt all round it. They are immoveable, and ſeem to be formed of a hard, tranſparent, horny ſubſtance. The number of eyes is not the ſame in all the ſpecies of the ſpider. They have eight legs, with ſix joints, thickly beſet with hairs, and terminating in two crooked moveable claws, which have little teeth like a ſaw; at a ſmall diſtance from theſe claws, but placed higher up, is another, ſomewhat like a cock's ſpur, by the aſſiſtance of which it adheres to it's webs; but the weapon wherewith it ſeizes and kills it's prey is a pair of ſharp crooked claws, or forceps, placed in the fore-part of the head. They can open or extend theſe pincers as occaſion may require; when undiſturbed, they ſuffer them to lie one upon another. Mr. Leeuwenhoeck ſays, that each of theſe claws has a ſmall aperture, or ſlit, through which he ſuppoſes a poiſonous juice is injected into the wound it makes.

The exuviæ of the ſpider, which may be found in cobwebs, being tranſparent, is an excellent object; and the fangs, or forceps, may be eaſier ſeparated from it, and examined with more exactneſs than in a living ſpider. The contexture of the ſpider's web, and their manner of weaving them, have been diſcovered by the microſcope. The ſpider is ſupplied with a large quantity of glutinous matter within it's body, and five dugs, or teats, for ſpinning it into thread. This ſubſtance, when examined accurately, will be found twiſted into many coils, of an agate colour, and which, from it's tenacity, may be eaſily drawn out into threads. The five teats are placed near the extremity of the tail; from theſe the aforeſaid ſubſtance proceeds; it adheres to any

any thing it is preffed againft, and being drawn out, hardens in the air. The fpider can contract or dilate at pleafure the orifices through which the thread is drawn. The threads unite at a fmall diftance from the body, fo that thofe which appear to us fo fine and fingle, are notwithftanding compofed of five joined together, and thefe are many times doubled when the web is in formation.

The gnat is a beautiful object for the microfcope. We have already noticed the curious manner in which they difpofe their eggs upon the furface of the water. Thefe, as they come to maturity, fink deeper. There is no fpecies of infect more troublefome to mankind than the gnat: others give more pain with their ftings, but it is only by accident we are ftung by them; but the gnats thirft for our blood, and follow us in whole companies for it. There are many marfhy places in our country, where the legs and arms of the inhabitants are kept fwelled all the fummer by the biting of thefe infects: in many other countries they are yet more troublefome than with us. It is one of thofe infects which pafs through two ftates of life, feemingly quite oppofed to each other; in one condition fwimming in the water like fifh, in the other becoming like the birds, inhabitants of the air.

From the egg proceeds the larva, in which ftate it is moft happily fuited to fhew the feveral operations of life; for a moderate magnifying power will difcover what paffes within it's tranfparent body. It has a large fcaly head, with two large antennæ, befides feveral hairy parts, and articulated briftles near the mouth, which are in continual motion. If the worm be diffected, the feet of the gnat may be found folded up in the divifions

divifions of the thorax; the abdomen is divided into eight rings, from the edges of each of which three or four briftles proceed. The tail is divided into two parts, of very different forms; by one of thefe it can fteer itfelf any way, in the other we may difcover two pulmonary tubes, through which the infect breathes. The larva has a power of moiftening the tail with an oleaginous liquor, by which means it can fufpend itfelf on the furface of the water. On agitating the water, the worms defcend with precipitation to the bottom; but they foon return to the furface, to breathe the air through the tube that is annexed to their tail. They pafs from this ftate into that of the pupa, which is the gnat inclofed in a thin fkin, under which it is formed and ftrengthened, the organs of refpiration are changed, breathing in this ftate through a couple of horns, which are placed near the head, keeping itfelf rolled upon the furface of the water, though on the leaft motion it defcends, unrolling itfelf, aided by the oars near the tail.

From the fpoils of the pupa, a little winged infect proceeds, whofe every part is active to the laft degree, and whofe whole ftructure is the juft object of our admiration. It's head, adorned with feathers, is a fine microfcopic object; but the probofcis may be deemed one of the moft curious inftruments in the infect creation. It confifts of a fcaly fheath; at about two-thirds from the end of this there is an aperture, through which it darts four pieces; one of thefe is, however, no more than the cafe in which the others lie concealed. 5

The probofcis of the gnat confifts of a great number of extremely delicate pieces, all concurring to one purpofe; this is the inftrument with which it ftrikes the flefh, and fucks the blood of animal bodies. The only part exhibited to the naked eye is the fheath, which contains all the other pieces. The fheath is a cylindric tube, which is flit in fuch a manner, that the infect can feparate it from the dart, and bend it more or lefs in proportion as the dart is plunged into the wound. From this tube the fting is darted, which confifts of five or fix blades or lancets, lying one over the other; fome of thefe are fharpened like a two-edged fword, while others are barbed, and have a vaft number of cutting teeth. When this bundle of blades is introduced into a vein, the blood rifes up the blades as fo many capillary tubes. The moment the gnat lances it's dart into the flefh, two or three drops of a fluid are infinuated by it into the wound. It is this fluid which is fuppofed to caufe thofe infupportable itchings that we feel when ftung by this little creature.

Plate XVI. Fig. 1, is the probofcis, or that apparatus of a tabanus with which it pierces the fkin of horfes and oxen, and nourifhes itfelf with their blood. The fingular and compound ftructure, together with the admirable form and exquifite beauty of this apparatus, difcovers fuch a view of the wifdom, power, and greatnefs of it's infinite compofer, as muft ftrike with admiration every contemplative obferver, and lead him to reflect on the weaknefs, impotence, and nothingnefs of all human mechanifm, when compared with the immenfe fkill and inimitable finifhing difplayed in the fubject before us. The whole of this formidable apparatus is compofed of fix parts, (exclufive of the two guards, or feelers, a a,) all of which are inclofed in a flefhy cafe,

cafe, which in the figure is totally removed, as it contained nothing remarkably different from that of other infects with two wings. The guards or feelers, a a, are of a fpungy or flefhy fubftance, and are grey, covered with fhort hairs; they are united to the head by a little joint of the fame texture, which in this view of the object could not be fhewn. Thefe guards are a defence to the other parts of the apparatus, as they are laid upon it fide by fide whenever the animal ftings, and by that means preferve it from external injury. The two lancets, b b and B, evidently open the wound, and are of a delicate and tender ftructure, formed like the diffecting knife of the anatomift, with a fharp point and flender edge, but gradually increafing to the back. The two fhaped inftruments, c c and C, appear as if intended to enlarge the wound, by irritating the parts round it; to accomplifh which, they are jagged, or toothed; they may alfo ferve, from their hard and horny texture, to defend the tube e E, which is of a fofter nature, and tubular, to admit the blood, and convey it to the ftomach; this delicate part is inclofed in a cafe, d D, which entirely covers it. Thefe parts are drawn feparately at B, C, D, E. De Geer obferves, that it is only the females that fuck the blood of animals; and Reaumur declares, that having made one difgorge itfelf, the blood it threw up appeared to him to be more than the whole body of the infect could have contained.

The exuvia, or caft fkin of infects, being exceedingly tranfparent, are well adapted for obfervation, as they exhibit the outward appearance of the little animal; among thefe we may reckon thofe of fpiders and cimeces, but particularly the forficula, or earwig, which is an elegant exuvia. The ftings of infects vary not only in their form, but alſo in their apparatus; moſt of them require diſſection, as the ſtings (for they have generally two) are incloſed in a hard ſheath, or caſe, to which is added a pair of feelers. The ſtings of bees, waſps, &c. are barbed, while that of the chryſis is ſerrated, or notched like a ſaw.

The head of inſects is furniſhed with an inſtrument, or proboſcis, various as the inſects themſelves, but all deſerving the utmoſt attention, being admirably adapted to their different uſes and purpoſes. Among the moſt remarkable are the bed bug, flea, gnats, empis, conops, &c. to which we may add the ſingular one of the tabanus, which we have juſt now deſcribed. We have alſo ſo fully deſcribed the bee's apparatus, page 362, that it is unneceſſary to enlarge on it here.

The antennæ of moths, butterflies, and moſt other inſects, diſplay as great beauty in their formation as they are endleſs in their variety; the diſtinguiſhing characters of many of them have been deſcribed, page 175; and that of the lepas antifera in particular, page 359.

The eyes of inſects are ſingularly conſtructed, but this ſtructure is not diſcoverable without the aſſiſtance of the microſcope; the eyes of the libellula are hexagonal, vide Plate XVI. Fig. 3; while thoſe of lobſters are ſquare, as may be ſeen Plate XVI. Fig. 5.

Hair of animals, as the mouſe, goat, large bee, and many ſpecies of caterpillar, particularly the tufts on the head and tail of the larva of the phalæna antiqua, offer many beauties to the curious

curious obferver. The briftles of a hog, cut tranfverfely, appear tubular, and the root of hair is evidently bulbous.

The mufcular fibres, and every anatomical preparation that can be brought under the microfcope, are pleafing objects; the reader will meet with many curious and interefting obfervations on the hairs, the mufcles, nerves, and other parts of the human body, in Fontana's Treatife on the Venom of Vipers, printed for Murray.

The legs of all infects appear very much diverfified, and their mechanifm truly aftonifhing, according with their different occupations, as particularized page 179.

Scales of fifh, as foals, roach, dace, falmon, eels, &c. as alfo the fcales of fnakes, lizards, &c. &c. A fpecimen of fcales is given, Plates X. and XIX. The fcales form a light, but at the fame time a folid and fmooth covering to the fifh, they hinder the fluid from penetrating the body, for which purpofe they are laid in a kind of natural oil; they ferve alfo as a protection, and break the force of any accidental blow, which may be the reafon why river fifh have larger and ftronger fcales than fea fifh, being more liable to accidents.

Feathers, and parts of feathers, are not to be paffed by or unnoticed; but it is impoffible to point out any of thefe in preference to others, as each has it's peculiar beauties; the plumula of thefe have generally in the microfcope the appearance of a large feather; the pith contained in the quill, if cut tranfverfely, and examined, exhibits an admirable reticular texture. Many other parts of birds will afford a great variety of curious objects, par-

If the image of an object, formed after refraction, is greater or lefs than the angle formed at the eye, by the rays proceeding from the extremities of the object itfelf, the object will appear alfo proportionably enlarged or diminifhed; fo that if the eye approaches to, or removes from, the laft image, the object will appear to increafe or diminifh, though the eye fhould in reality remove from it in one cafe, or approach towards it in the other; becaufe the image takes place of the object, and is confidered inftead of it.

The apparent diftance of an object from the eye, is not meafured by the real diftance from the laft image; for, as the apparent diftance is eftimated principally by the ideas we have of their fize, it follows, that when we fee objects, whofe images are increafed or diminifhed by refraction, we naturally judge them to be nearer or further from the eye, in proportion to the fize thereof, when compared to that with which we are acquainted. The apparent diftance of an object is confiderably affected by the brightnefs, diftinctnefs, and magnitude thereof. Now as thefe circumftances are, in a certain degree, altered by the refraction of the rays, in their paffing through different mediums, they will alfo, in fome meafure, affect the eftimation of the apparent diftance.

In the theory of vifion, it is neceffary to be cautious not to confound the organs of vifion with the being that perceives, or with the perceptive faculty. The eye is not that which fees, it is only the organ by which we fee. A man cannot fee the fatellites of Jupiter but by a telefcope. Does he conclude from this, that it is the telefcope that fees thofe ftars? By no means; fuch a conclufion would be abfurd. It is no lefs abfurd to conclude, that ticularly the egg: Mr. Martin ſays, that the internal ſpungy ſubſtance of bones may be better obſerved in thoſe of birds than of any other animal; even the feathers or ſcales of a moth's wing amply repay the obſerver; theſe alſo vary in their texture and figure; but the largeſt, and moſt commonly applied, are from the body of the ſphinx ſtellatarum, or humming-bird moth; a ſpecimen is given, Plate XVI. Fig. E F H I.

Tranſverſe ſections of all kinds of wood, eſpecially thoſe of a pithy or ſoft nature; their beauty will be ſeen by the figures in Plates XXVII. XXVIII. XXIX.

The flowers of moſt graſſes, with all the varieties of moſſes; the farina of flowers; mouldineſs, which evidently appears to vegetate; all the kinds of ſpunge, ſea weeds, particularly the confervæ, which is jointed like a cane. The extenſive family of corallines preſent an elegant appearance; the moſt beautiful are the ſeå hair, ſea fir, ſickle, fox tail, &c. deſcribed by Ellis.

Diſſected leaves, which ſhew the fibres and nerves; the human inteſtine, injected with wax, is a fine object, as are many other anatomical preparations. The ſeed of the ſilver-rind birch appears like an inſect; ſeed of the quaking graſs is alſo much admired, as is the leaf which covers the ſeed of ſorrel. Among artificial productions, the edge of a razor, and point of a fine needle, as alſo fine cambrick, evidently diſcover the inferiority of the workman; particles from the colliſion of flint and ſteel, wire melted by the electric exploſion, &c. &c. &c.

The

The preceding objects being moſt of them eaſy to be procured by thoſe who have leiſure, and are frequently in the country, an endleſs variety may be added to them; but thoſe lovers of the icroſcope, who may have neither leiſure nor opportunity to ſearch for themſelves, may be ſupplied with all, or moſt of them, or indeed with objects to almoſt any extent, by applying to me, No. 60, Fleet-Street, London.

Beſides the above, there are an immenſity of objects which can only be examined alive, or when found, ſuch as polypes, minute aquatic inſects; animalcula, of various infuſions, as eels in paſte, vinegar, &c. The eyes and teeth of ſnails, the circulation of the blood in the tail of fiſhes, &c. The ſhooting of ſalts, &c.

The following extract from a truly philoſophical writer, will, I hope, prove acceptable to the reader, as well as form a proper concluſion to this work.

"How admirable are the works of God! how excellent the operation of his hands!

I conſidered plants, and animals; four-footed beaſts, and creeping things.

In all was manifeſted infinite wiſdom, and an excellent workmanſhip, that I could not comprehend.

Yet ſo much was made known unto me, as declared the power and goodneſs of God, and the continued agency of the great Creator, and Lord of all things.

I beheld

I beheld the caterpillar issuing from it's egg, on the very plant needful for it's support:

For there the parent fly had placed it, that it might have whereon to feed.

It enjoys the repast, it weaveth it's web, and, preparing for it's end, buildeth itself a rich tomb.

It resteth from it's labours, and sleepeth the sleep of death.

At the appointed time it is raised again, and the great Creator of all things giveth it a new life.

It leaveth it's ashes in the tomb, and ascends, with a more beauteous form, into the regions of the air.

How glorious are it's wings! and it's limbs how delicate!

It is covered with a rich plumage; and furnished with myriads of eyes, to behold all around.

With it's trunk it surpasseth the art of the chymist, and extracteth from flowers the most delicious sweets.

It forsakes the leaf whereon it was first nourished, rejoicing in the bounty of it's Maker.

But, at his command, it is mindful of it's offspring, and provides for the safety and sustenance thereof.

With

6

With anxious care it ſeeketh out the plant which God hath given for it's infant worms.

Though it feedeth not thereon, neither careth for the verdant leaves, yet is it led with unerring ſearch, and never faileth in it's choice.

It curiouſly ſpreadeth forth it's eggs; and without thought, fulfilleth it's appointed taſk.

The bee juſt raiſed to life, without a teacher ſkilfully forms her cell.

The ſage's art is known to her: ſhe has diſcovered the moſt capacious form, and the beſt diviſion of ſpace.

Without ſcale or compaſs ſhe nicely meaſureth her work, and with great care ſtrengtheneth it's foundations.

She layeth her foundations in the upper part; ſhe buildeth downwards, even unto the ground; and exquiſitely finiſheth her work, ſurpaſſing the art of man.

Behold! we perceive as yet but a ſmall portion of his works; we ſee the operations of his hands as through a glaſs darkly; yet how excellent do they appear!"*

* Hymns to the Supreme Being, in Imitation of the Eaſtern Songs.

F I N I S.

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Eels

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L

M

that it is the eye that fees. The telefcope is an artificial organ of fight, but it fees not. The eye is a natural organ of fight, by which we fee; but the natural organ fees as little as the artificial.

The eye is a machine, moft admirably contrived for refracting the rays of light, and forming a diftinct picture of objects upon the retina; but it fees neither the object nor the picture. It can form the picture after it is taken out of the head, but no vifion enfues. Even when it is in it's proper place, and perfectly found, it is well known, that an obftruction in the optic nerve takes away vifion, though the eye has performed all that belongs to it.*

For ufelefs was this textur'd † wonder made,
Were nature, beauteous object! undifplayed;
Thofe both in vain, the object and the fight,
Wrapt from the radiance of revealing light;
As vain the bright illuminating beam,
Unwafted by the medium's airy ftream:
Yet vain the textur'd eye, and object fair,
The funny luftre, and continuous air;
Annull'd and blank this grand illuftrious fcene,
All, all it's grace and lifelefs glories vain;
Till from th' ETERNAL fprung this effluent foul,
Form'd to infpect, and comprehend the whole.‡

F 2 Of

* Reid on the Intellectual Powers of Man, p. 78.

† The eye.

‡ Brooke's Univerfal Beauty, p. 88.

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Polypes,

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C A T A L O G U E

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E R R A T A.

Page 2, line 15, *for* animalculæ *read* animalcula.
8, — 22, *for* animalculæ *read* animalcula.
375, — 17, *for* eggs *read* chickens.

OF THE SINGLE MICROSCOPE.

The ſingle microſcope renders minute objects viſible, by means of a ſmall glaſs globule, or convex lens, of a ſhort focus. Let E Y, Fig. 11, Plate I. repreſent the eye; and O B, a ſmall object, ſituated very near to it, conſequently the angle of it's apparent magnitude very large. Let the convex lens R S be interpoſed between the eye and the object, ſo that the diſtance between it and the object may be equal to the focal length; and the rays which diverge from the object, and paſs through the lens, will afterwards proceed, and conſequently enter the eye parallel: after which, they will be converged, and form an inverted picture on the retina, and the object will be clearly ſeen; though, if removed to the diſtance of ſix inches, it's ſmallneſs would render it inviſible.

When the lens is not held cloſe to the eye, the object is ſomewhat more magnified; becauſe the pencils, which paſs at a diſtance from the center of the lens, are refracted inward toward the axis, and conſequently ſeem to come from points more remote from the center of the object, as may be ſeen in Fig. 12, Plate I. where the pencils which proceed from O and B are refracted inwards, and ſeem to come from the point i and m.

Fig. 8, Plate I. may, perhaps, give the reader a ſtill clearer view, why a convex lens increaſes the angle of viſion. Without a lens, as F G, the eye at A would ſee the dart B C under the angle b A c; but the rays B F and C G from the extremities of the dart in paſſing through the lens, are refracted to the eye in the directions f A and G a, which cauſes the dart to be ſeen under the

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the much larger angle D A E (the ſame as the angle f A g). And therefore, the dart B C will appear ſo much magnified, as to extend in length from D to E.

The object, when thus ſeen diſtinctly, by means of the ſmall lens, appears to be magnified nearly in the proportion which the focal diſtance of the glaſs bears to the diſtance of the objects, when viewed by the naked eye.

To explain this further, place the eye cloſe to the glaſs, that as much of the object may be ſeen at one view as is poſſible; then remove the object to and fro, till it appears perfectly diſtinct, and well defined; now remove the lens, and ſubſtitute in it's place a thin plate, with a very ſmall hole in it, and the object will appear as diſtinct, and as much magnified, as with the lens, though not quite ſo bright; and it appears as much more magnified in this caſe, than it does when viewed with the naked eye, as the diſtance of the object from the hole, or lens, is leſs than the diſtance at which it may be ſeen diſtinctly with the naked eye.

From hence we ſee, that the whole effect of the lens is to render the object diſtinct, which it does by aſſiſting the eye to increaſe the refraction of the rays in each pencil; and that the apparent magnitude is entirely owing to the object being ſeen ſo much nearer the eye than it could be viewed without it.

Single microſcopes magnify the diameter of the object, * as we have already ſhewn, in the proportion of the focal diſtance (to the limits

* Cyclopedia art microſcope.

limits of diſtinct viſion with the naked eye) to eight inches. For example, if the ſemi-diameter of a lens, equally convex on both ſides, be half an inch, which is alſo equal to it's focal diſtance, we ſhall have as $\frac{1}{2}$ is to 8, ſo is 1 to 16; that is, the diameter of the object in the proportion of ſixteen to one. 2. As the diſtance of eight inches is always the ſame, it follows, that by how much the focal diſtance is ſmaller, there will be a greater difference between it and the eight inches; and conſequently, the diameter of the object will be ſo much the more magnified, in proportion as the lenſes are ſegments of ſmaller ſpheres. 3. If the object be placed in the focus of a glaſs globule or ſphere, and the eye be behind it in the focus, the object will be ſeen diſtinct in an erect ſituation, and magnified as to it's diameter, in the proportion of $\frac{3}{4}$ of the diameter of the globule to eight inches; thus ſuppoſe the diameter of the ſphere to be $\frac{1}{10}$ of an inch, then $\frac{3}{4}$ of this will be equal to $\frac{3}{40}$; conſequently, the real diameter of the object to the apparent one, as $\frac{3}{40}$ to 8, or as 3 to 320, or as 1 to 160 nearly.

OF THE DOUBLE OR COMPOUND MICROSCOPE.

In the compound microſcope, the image is viewed inſtead of the object, which image is magnified by a ſingle lens, as the object is in a ſingle microſcope. It conſiſts of an object lens, L N, Fig. 5, Plate I. and an eye glaſs F G. The object O B is placed a little further from the lens than it's principal focal diſtance, ſo that the pencils of rays proceeding from the different points of the object through the lens, may converge to their reſpective foci, and form an inverted image of the object at P Q; which image is viewed by the eye through the eye glaſs F G, which is ſo ſo placed, that the image may be in it's focus on one ſide, and the eye at the ſame diſtance on the other. The rays of each pencil will be parallel, after paſſing out of the glaſs, till they reach the eye at E, where they will begin to converge by the refractive powers of the humours; and after having croſſed each other in the pupil, and paſſed through the chryſtalline and vitreous humours, they will be collected in points on the retina, and form a large inverted image thereon.

It will be eaſy, from what has been already explained, to underſtand the reaſon of the magnifying power of a compound microſcope. The object is magnified upon two accounts; firſt, becauſe if we viewed the image with the naked eye, it would appear as much larger than the object, as the image is really larger than it, or as the diſtance f R is greater than the diſtance f b; and ſecondly, becauſe this picture is again magnified by the eye glaſs, upon the principle explained in the foregoing article on viſion, by ſingle microſcopes.

But it is to be noted, that the image formed in the focus of a lens, as is the caſe in the compound microſcope, differs from the real object in a very eſſential particular; that is to ſay, the light being emitted from the object in every direction, renders it viſible to an eye placed in any poſition; but the points of the image formed by a lens, emitting no more than a ſmall conical body of rays, which arrives from the glaſs, can be viſible only when the eye is ſituate within it's confine. Thus the pencil, which emanates from o in the object, and is converged by the lens to M, proceeds afterwards diverging towards H, and therefore, never arrives at the lens F G, nor enters the eye at E. But the pencils

pencils which proceed from the points o and b, will be received on the lens F G, and by it carried parallel to the eye; consequently, the correſpondent points of the image Q P will be viſible; and thoſe which are ſituate farther out towards H and I, will not be ſeen. This quantity of the image Q P, or viſible area, is called the field of view.

Hence it appears, that if the image be large, a very ſmall part of it will be viſible; becauſe the pencils of rays will for the moſt part fall without the eye glaſs F G. And it is likewiſe plain, that a remedy which would cauſe the pencils, which proceed from the extremes O and B of the object, to arrive at the eye, will render a greater part of it viſible; or, in other words, enlarge the field of view. This is effected by the interpoſition of a broad lens D E (Fig. 5.) of a proper curvature, at a ſmall diſtance from the focal image. For, by that means, the pencil D M, which would otherwiſe have proceeded towards H, is refracted to the eye, as delineated in the figure, and the mind conceives from thence the exiſtence of a radiant point at Q, from which the rays laſt proceeded. In like manner, and by a parity of reaſon, the other extreme of the image is ſeen at P, and the intermediate points are alſo rendered viſible. On theſe conſiderations it is, that compound microſcopes are uſually made to conſiſt of an object lens L N, by which the image is formed, enlarged, and inverted; an amplifying lens D E, by which the field of view is enlarged, and an eye glaſs or lens, by means of which the eye is allowed to approach very near, and conſequently to view the image under a very great angle of apparent magnitude. It is now cuſtomary to combine two or more lenſes together at the eye glaſs, in the manner of Euſtachio Divini and M. Joblot; by which

which means, the aberration of light from the figure is in ſome meaſure corrected, and the apparent field increaſed.

Of the Solar Microscope.

In this inſtrument, the image of the object is thrown upon a ſcreen in a darkened room. It may be conſidered under two diſtinct heads: 1ſt, the mirror and lens, which are intended to reflect the light of the ſun upon the object; and 2dly, that part which conſtitutes the microſcope, or which produces the magnified image of the object, Fig. 10, Plate I. Let N O repreſent the ſide of a darkened chamber, G H a ſmall convex lens, fixed oppoſite to a perforation in the ſide N O, A B a plane mirror, or looking-glaſs, placed without the room to reflect the ſolar rays on the lens C D, by which they are converged and concentrated on the object fixed at E F.

2. The object being thus illuminated, the ray which proceeds from E will be converged by the lens G H to a focus K, on the ſcreen L M; and the ray which comes from F will be converged to I, and the intermediate points will be delineated between I and K; thus forming a picture, which will be as much larger than the object, in proportion as the diſtance of the ſcreen exceeds that of the image from the object.

From what has been ſaid, it appears plainly, the advantages we gain by microſcopes are derived, firſt, from their magnifying power, by which the eye is enabled to view more diſtinctly the parts of minute objects: ſecondly, that by their aſſiſtance, more light is thrown into the pupil of the eye, than is done without them. The advantages procured by the magnifying power, would be exceedingly circumſcribed, if they were not accompanied by the latter: for if the ſame quantity of light is diffuſed over a much larger ſurface, it's force is proportionably diminiſhed; and therefore the object, though magnified, will be dark and obſcure. Thus, ſuppoſe the diameter of the object to be enlarged ten times, and conſequently the ſurface one hundred times, yet, if the focal diſtance of the glaſs was eight inches, (provided this was poſſible) and it's diameter only about the ſize of the pupil of the eye, the object would appear one hundred times more obſcure when viewed through the glaſs, than when it was ſeen by the naked eye; and this even on the ſuppoſition, that the glaſs tranſmitted all the light which fell upon it, which no glaſs can do. But if the glaſs was only four inches focal diſtance, and it's diameter remained as before, the inconvenience would be vaſtly diminiſhed; becauſe the glaſs could be placed twice as near the object as before, and would conſequently receive four times as many rays as in the former caſe, and we ſhould therefore ſee it much brighter than before. By going on thus, diminiſhing the focal diſtance of the glaſs, and keeping it's diameter as large as poſſible, we ſhall perceive the object proportionably magnified, and yet remain bright and diſtinct. Though this is the caſe in theory, yet there is a limit in optical inſtruments, which is ſoon arrived at, but which cannot be paſſed. This ariſes from the following circumſtances.*

1. The quantity of light loſt in paſſing through the glaſs.

2. The

* Encyclopedia Britannica, vol. viii. p. 5635.

2. The diminution in the diameter of the glafs or lens itfelf, by which it receives only a fmall quantity of rays.

3. The extreme fhortnefs of the focal diftance of great magnifiers, whereby the free accefs of the light to the object we wifh to view is impeded, and confequently the reflection of the light from it is weakened.

4. The aberration of the rays, occafioned by their different refrangibility.

To make this more clear, let us fuppofe a lens made of fuch dull kind of glafs, that it tranfmits only one half the light that falls upon it. It is evident, that fuppofing this lens to be of four inches focus, and to magnify the diameter of the object twice, and it's own breadth equal to that of the pupil of the eye, the object will be four times magnified in furface, but only half as bright as if it was feen by the naked eye at the ufual diftance; for the light which falls upon the eye from the object at eight inches diftance, and likewife the furface of the object in it's natural fize, being both reprefented by 1, the furface of the magnified object will be 4, and the light which makes it vifible only 2; becaufe though the glafs receives four times as much light as the naked eye does at the ufual diftance of diftinct vifion, yet one half is loft in paffing through the glafs. The inconvenience, in this refpect, can only be removed fo far as it is poffible to increafe the tranfparency of the glafs, that it may tranfmit nearly all the rays which fall upon it; and how far this can be done, has not been yet afcertained.

 The

The second obstacle to the perfection of microscopic glasses, is the small size of great magnifiers; by which means, notwithstanding their near approach to the object, they receive a smaller quantity of light than might be expected. Thus, suppose a glass of only one-tenth of an inch focal distance, such a glass would increase the visible diameter eighty times, and the surface 6400 times. If the breadth of the glass could at the same time be preserved as great as the pupil of the eye, which we shall suppose one-tenth of an inch, the object would appear magnified 6400 times, and every part would be as bright as it appears to the naked eye. But if we suppose the lens to be only $\frac{1}{20}$ of an inch diameter, it will then only receive $\frac{1}{4}$ of the light which would otherwise have fallen upon it; therefore, instead of communicating to the magnified object a quantity of light equal to 6400, it would communicate an illumination suited only to 1600, and the magnified object would appear four times as dim as it does to the naked eye. This inconvenience can, however, be in a great degree removed, by throwing a much larger quantity of light on the object. Various methods of effecting this purpose will be pointed out in the course of the work.

The third obstacle arises from the shortness of the focal distance in large magnifiers; this inconvenience can, like the former, be remedied in some degree by artificial means of accumulating light; but still the eye is so strained, as it must be brought nearer the glass than it can well bear, which in some measure supersedes the use of very deep lenses, or such as are capable of magnifying beyond a certain degree.

The

The fourth obſtacle which ariſes from the different refrangibility of the rays of light, and which frequently cauſes ſuch deviations from truth in the appearance of things, that many have imagined themſelves to have made ſurprizing diſcoveries, and have communicated them as ſuch to the world; when, in fact, they have been only optical deceptions, owing to the unequal refraction of the rays. In teleſcopes, this error has been happily corrected by Mr. Dollond's valuable diſcovery of achromatic glaſſes; but how far this invention is applicable to the improvement of microſcopes, has not yet been aſcertained; and indeed there is ſome reaſon for ſuppoſing, they cannot be ſucceſsfully applied to them; ſo that this obſtacle remains yet to be remedied, before microſcopes can be ſaid to have received their ultimate degree of perfection.

OF THE MAGNIFYING POWERS OF THE MICROSCOPE.

We have already treated of the apparent magnitude of objects, and ſhewn that they are meaſured by the angles under which they are ſeen, and that this angle is greater or ſmaller, according as the object is nearer to, or further from, the eye; and conſequently, the leſs the diſtance at which it can be viewed, the larger it will appear: but from the limits of natural viſion, the naked eye cannot diſtinguiſh an object that is very near to it; yet, when aſſiſted by a convex lens, diſtinct viſion is obtained, however ſhort the focus of the lens, and conſequently, how near ſoever the object is to the eye; and the ſhorter the focus of the lens is, the greater will be the magnifying power thereof. From theſe conſiderations, it will not be difficult to eſtimate the magnifying power of any lens uſed as a ſingle microſcope; for this

this will be in the ſame proportion that the limits of natural ſight bear to the focus of the lens. If, for inſtance, the convex lens is of one inch focus, and the natural ſight of eight inches, an object ſeen through that lens will have it's diameter apparently increaſed eight times; but as the object is increaſed in every direction, we muſt ſquare this apparent diameter, to know how much the object is really magnified; and thus multiplying 8 by 8, we find the ſuperficies is magnified 64 times.

From theſe principles, the following general rule for aſcertaining the magnifying power of ſingle lenſes, is deduced. Place a ſmall thin tranſparent object on the ſtage of the microſcope, adjuſt the lens till the object appears perfectly diſtinct, then meaſure the diſtance accurately between the lens and the object, reduce the meaſure thus found to the hundredths of an inch, and calculate how many times this meaſure is contained in eight inches, firſt reducing the eight inches into hundredths, which will give you the number of times the diameter of the object is magnified; which number multiplied into itſelf, or ſquared, gives the apparent ſuperficial magnitude of the object.

As only one ſide of an object can be viewed at a time, it is ſufficient, in general, to know how much the ſurface thereof is magnified: but when it is neceſſary to know how many minute objects are contained in a larger, as for inſtance, how many given animalcula are contained in the bulk of a grain of ſand, then we muſt cube the firſt number, by which means we ſhall obtain the ſolidity or magnified bulk.

The

The foregoing rule has been alfo applied to eftimate the magnifying power of the compound microfcope. To this application, Mr. Magny, in the "Journal d'Economie pour les mois d'Aout 1753," has made feveral objections: one or two of thefe I fhall juft mention: the firft is the difficulty of afcertaining with accuracy the precife focus of a fmall lens; the fecond is the want of a fixed or known meafure, with which to compare the focus when afcertained. Thefe confiderations, though apparently trifling, will be found of importance in the calculations which are relative to deep magnifiers. To this it may be further added, that the fame ftandard or fixed meafure cannot be affumed for a fhort-fighted, that is, ufed for a well-conftituted eye. To obviate thefe difficulties, and fome errors in the methods which were recommended by Meff. Baker and Needham, Mr. Magny offers the following

PROPOSITION.

All convex lenfes, of whatfoever focus, double the apparent diameter of an object, provided that the object is at the focus of the glafs on one fide, and the eye is at the fame diftance, or on the focus of the glafs, at the oppofite fide.

EXPERIMENT.

Take a double convex lens, of fix or eight inches focus, and fix it as at A, Fig. 1, (Plate II. A,) into the piece A, which is fixed perpendicular to the rule F G, and may be flid along it by means of it's focket: the rule is divided into inches and parts. Pafte a piece of white paper, two or three tenths of an inch broad, and

6 three

three inches long, on the board D; draw three lines with ink on this piece of paper, ſo as to divide it into four equal parts, taking care that the middle of the paper correſponds with the center of the lens. There is alſo a ſliding eye-piece, which is repreſented at e.

Take this apparatus into the darkeſt part of the room, but oppoſite to the window; direct the glaſs towards any remarkable and diſtant object which is out of doors, and move the ſliding piece B, until the image of the object on the paper is ſharp and clear. The diſtance between the face of the paper and the lens, (which is ſhewn on the ſide of the rule by the diviſions thereon) is the focus of the glaſs; now ſet the eye-piece e E to the ſame diſtance on the other ſide of the glaſs, then with one eye cloſe to the ſight at e, look at the magnified image of the lines, and with the other eye at the lines themſelves: the image, ſeen by means of the glaſs, and expreſſed in the figure by the dotted lines, will be double the breadth of the ſame object ſeen by the natural eye. This will be found to be true, whatſoever is the focus of the lens with which the experiment is made.

This experiment is rendered more ſimple to thoſe who are not accuſtomed to obſerve with both eyes at the ſame time, by making uſe of half a lens, and placing the diameter perpendicular to the rule, as they may then readily view the magnified image and real object with the ſame glance of the eye, and thus compare them together with eaſe and accuracy.

Let the angle A F B, Fig. 3, Plate II. A, repreſent that which is formed at the naked eye, by the rays of light which paſs from the extremities

extremities of the object, and unite at the eye in the point F. The angle DFE is formed of the two rays, which at first proceeded parallel to each other from the extremities of the object, but that were afterwards so refracted, or bent, by passing through the glass, as to unite at it's focal point F. C O is equal to the focal distance of the lens on the side next the object, C F equal thereto on the side next the eye, F O the distance of the eye.

From the allowed principles of optics, it is evident, that the object would appear double the size to the eye at C, that it would to the eye when placed at F; because the distance F O is double the distance C O. We have only to prove then, that the angle A C B is equal to the angle I F K, in order to establish the proposition.

The optical axis is perpendicular to the glass and the surface of the object. The rays A I, B K, which flow from the points A B, are parallel to each other, and perpendicular to the glass, till they arrive at it; they are then refracted, and proceed to F, where they form the triangle I F K, resting on the base I K: now as C F is equal to C O, and I K is equal to A B, the two triangles ACB IFK are similar, and consequently the angle at C is equal to the angle F. If the visual rays are continued to the surface of the object, they will form the triangle D F E, equiangled to the triangle A B C; and therefore, as C O is to A B, so is F D to D E; and consequently, the apparent diameter of the object seen through the lens, is double the size that it is when viewed by the naked eye. No notice is here taken of the double refraction of the rays, as it does not affect the demonstration.

If you advance towards M, half the focal diftance, the apparent diameter will be only increafed one-third. If, on the contrary, the point of fight is lengthened to double the diftance of it's focus, then the magnified diameter will appear to be three times that of the real object. Mr. Magny concludes from hence, that there is an impropriety in eftimating the magnifying power of the eye glafs of compound microfcopes, by feeing how often it's focus is contained in eight or ten inches; and to obviate thefe defects, he recommends two methods to be ufed, which reciprocally confirm each other.

The firft and moft fimple method to find how much any compound microfcope magnifies an object, is the fame which is defcribed by Dr. Hooke in his Micrographia, and is as follows: place an accurate fcale, which is divided into very minute parts of an inch, on the ftage of your microfcope; adjuft the microfcope, till thefe divifions appear diftinct; then obferve with the other eye how many divifions of a rule, fimilarly divided and held at the ftage, are included in one of the magnified divifions: for if one divifion, as feen with one eye through the microfcope, extends to thirty divifions on the rule, which is feen by the naked eye, it is evident, that the diameter of the object is increafed or magnified thirty times.

For this purpofe, we often ufe a fmall black ebony rule, (fee Fig. 4, Plate II. A,) three or four tenths of an inch broad, and about feven inches long; at each inch is fixed a piece of ivory, the firft inch is entirely of ivory, and fubdivided into ten equal parts.

2. A

2. A piece of glafs, Fig. 2, fixed in a brafs or ivory flider; on the diameter of this are drawn two parallel lines, about three-tenths of an inch long; each tenth being divided, one into three, the fecond into four, the third into five parts. To ufe this, place the glafs, Fig. 2, on the middle of the ftage, and the rule, Fig. 4, on one fide, but parallel to it; then look into the microfcope with one eye, keeping the other open, and obferve how many parts one-tenth of a line in the microfcope takes in upon the parts of the rule feen by the naked eye. For inftance, fuppofe with a fourth magnifier, that one-tenth of an inch magnified anfwers in length to forty tenths or parts on the rule, when feen by the naked eye, then this magnifier increafes the diameter of the object forty times.

This mode of actual admeafurement is, without doubt, the moft fimple that can be ufed; by it we comprehend, as it were, at one glance, the different effects of combined glaffes; it faves the trouble, and avoids the obfcurity that attends the ufual modes of calculation; but many perfons find it exceedingly difficult to adopt this method, becaufe they have not been accuftomed to obferve with both eyes at once. We fhall therefore proceed to defcribe another method, which has not this inconvenience.

OF THE NEEDLE MICROMETER.

Fig. 8, Plate II. A, reprefents this micrometer. The firft of this kind was made by my father, and was defcribed by him in his Micrographia Illuftrata. It confifts of a fcrew, which has fifty threads to an inch; this fcrew carries an index, which points to the divifions on a circular plate, which is fixed at right angles to the axis of the ſcrew. The revolutions of the ſcrew are counted on a ſcale, which is an inch divided into fifty parts; the index to theſe diviſions is, a flower de luce marked upon the ſlider, which carries the needle point acroſs the field of the microſcope. Every revolution of the micrometer ſcrew meaſures $\frac{1}{50}$ part of an inch, which is again ſubdivided by means of the diviſions on the circular plate, as this is divided into twenty equal parts, over which the index paſſes at every revolution of the ſcrew; by which means, we obtain with eaſe the meaſure of one thouſandth part of an inch: for 50, the number of threads on the ſcrew in one inch, being multiplied by 20 the diviſions on the circular plate, are equal to 1000; ſo that each diviſion on the circular plate ſhews, that the needle has either advanced or receded one thouſandth part of an inch.

To place this micrometer on the body of the microſcope, open the circular part F K H, Fig. 8, Plate II. A, by taking out the ſcrew G, throw back the ſemicircle F K which moves upon a joint at K, then turn the ſliding tube of the body of the microſcope, ſo that the ſmall holes which are in both tubes may exactly coincide, and let the needle g of the micrometer have a free paſſage through them; after this, ſcrew it faſt upon the body by the ſcrew G.

The needle will now traverſe the field of the microſcope, and meaſure the length and breadth of the image of any object that is applied to it. But further aſſiſtance muſt be had, in order to meaſure the object itſelf, which is a ſubject of real importance; for though we have aſcertained the power of the microſcope, and know that it is ſo many thouſand times, yet this will be of little aſſiſtance affiftance towards afcertaining an accurate idea of it's real fize; for our ideas of bulk being formed by the comparifon of one object with another, we can only judge of that of any particular body, by comparing it with another whofe fize is known: the fame thing is neceffary, in order to form an eftimate by the microfcope; therefore, to afcertain the real meafure of the object, we muft make the point of the needle pafs over the image of a known part of an inch placed on the ftage, and write down the revolutions made by the fcrew, while the needle paffed over the image of this known meafure; by which means, we afcertain the number of revolutions on the fcrew, which are adequate to a real and known meafure on the ftage. As it requires an attentive eye to watch the motion of the needle point, as it paffes over the image of a known part of an inch on the ftage, we ought not to truft to one fingle meafurement of the image, but ought to repeat it at leaft fix times; then add the fix meafures thus obtained together, and divide their fum by fix, or the number of trials; the quotient will be the mean of all the trials. This refult is to be placed in a column of a table, next to that which contains the number of the magnifiers.

By the affiftance of the fectoral fcale, we obtain with eafe a fmall part of an inch. This fcale is fhewn at Fig. 5, 6, 7, Plate II. A, in which, the two lines ca cb, with the fide a b, form an ifofceles triangle; each of the fides is two inches long, and the bafe one-tenth of an inch. The longer fides may be of any given length, and the bafe ftill only of one-tenth of an inch. The longer lines may be confidered as the line of lines upon a fector opened to one-tenth of an inch. Hence, whatever number of equal parts ca cb are divided into, their tranfverfe meafure will be be ſuch a part of one-tenth, as is expreſſed by their diviſions. Thus, if it be divided into ten equal parts, this will divide the inch into one hundred equal parts; the firſt diviſion next c will be equal to one hundredth part of an inch, becauſe it is the tenth part of one-tenth of an inch. If theſe lines are divided into twenty equal parts, the inch will be by that means divided into two hundred equal parts. Laſtly, if ab ca are made three inches long, and divided into one hundred equal parts, we obtain with eaſe the one thouſandth part. The ſcale is repreſented as ſolid at Fig. 6, but as perforated at Fig. 5 and 7; ſo that the light paſſes through the aperture, when the ſectoral part is placed on the ſtage.

To uſe this ſcale, firſt, fix the micrometer, Fig. 8, Plate II. A, to the body of the microſcope; then fit the ſectoral ſcale, Fig. 7, in the ſtage, and adjuſt the microſcope to it's proper focus or diſtance from the ſcale, which is to be moved till the baſe appears in the middle of the field of view; then bring the needle point g, Fig. 8, (by turning the ſcrew L) to touch one of the lines c a exactly at the point anſwering to 20 on the ſectoral ſcale. The index a of the micrometer, Fig. 8, is to be ſet to the firſt diviſion, and that on the dial plate to 20, which is both the beginning and end of it's diviſions: we are then prepared to find the magnifying power of every magnifier in the compound microſcope which we are uſing.

Example; every thing being prepared agreeable to the foregoing directions, ſuppoſe you are deſirous of aſcertaining the magnifying power of the lens marked No. 4; turn the micrometer ſcrew, until the point of the needle has paſſed over the magnified image

image of the tenth part of one inch; then the divifion, where the two indices remain, will fhew how many revolutions, and parts of a revolution, the fcrew has made, while the needle point traverfed the magnified image of the one-tenth of an inch; fuppofe the refult to be twenty-fix revolutions of the fcrew, and fourteen parts of another revolution, this is equal to 26 multiplied by 20, added to 14; that is, 534 thoufandth parts of an inch.

The twenty-fix divifions found on the ftrait fcale of the micrometer, while the point of the needle paffed over the magnified image of one-tenth part of an inch, were multiplied by 20, becaufe the circular plate C D, Fig. 8, is divided into 20 equal parts; this produced 520; then adding the fourteen parts of the next revolution, we obtain the 534 thoufandth parts of an inch, or 5 tenths and 34 hundredth parts of another tenth, which is the meafure of the magnified image of one-tenth of an inch, at the aperture of the eye glaffes, or at their foci. Now if we fuppofe the focus of the two eye glaffes to be one inch, the double thereof is two inches; or if we reckon in the thoufandth part of an inch, we have two thoufand parts for the diftance of the eye from the needle point of the micrometer. Again, if we take the diftance of the image from the object at the ftage at fix inches, or fix thoufandths, and add thereto two thoufand, double the diftance of the focus of the eye glafs, we fhall have eight thoufand parts of an inch for the diftance of the eye from the object; and as from the propofition, page 55, we gather that the glaffes double the image, we muft double the number 534 found upon the micrometer, which then makes 1068: then, by the following analogy, we fhall obtain the number of times the microfcope microſcope magnifies the diameter of the object; ſay, as 240, the diſtance of the eye from the image of the object, is to 800, the diſtance of the eye from the object; ſo is 1068, double the meaſure found on the micrometer, to 3563, or the number of times the microſcope magnifies the diameter of the object. By working in this manner, the magnifying power of each lens uſed with the compound microſcope, may be eaſily found, though the reſult will be different in different compound microſcopes, varying according to the combination of the lenſes, their diſtance from the object and one another, &c.

Having diſcovered the magnifying power of the microſcope, with the different object lenſes that are uſed therewith, our next ſubject is to find out the real ſize of the objects themſelves, and their different parts; this is eaſily effected, by finding how many revolutions of the micrometer-ſcrew anſwer to a known meaſure on the ſectoral ſcale, or other object placed on the ſtage; from the number thus found, a table ſhould be conſtructed, expreſſing the value of the different revolutions of the micrometer with that object lens, by which the primary number was obtained. Similar tables muſt be conſtructed for each object lens. By a ſet of tables of this kind, the obſerver may readily find the meaſure of any object he is examining; for he has only to make the needle point traverſe over this object, and obſerve the number of revolutions the ſcrew has made in it's paſſage, and then look into his table for the real meaſure which correſponds to this number of revolutions, which is the meaſure required.

CHAP.

CHAP. III.

A DESCRIPTION OF THE MOST APPROVED MICROSCOPES, AND THE METHOD OF USING THEM.

IN the preceding chapter I have endeavoured to give a comprehenfive view of the theory of the microfcope, and the principles on which the wonderful effects of this inftrument depend. I fhall now proceed to defcribe the various inftruments themfelves, their apparatus, and the moft eafy and ready mode of applying them to ufe; felecting for defcription thofe, that from fome peculiar advantage in their conftruction, or from the reputation of the authors who have recommended and ufed them, are in moft general ufe. What is faid of thefe will, I hope, be fufficient to enable the reader to manage any other kind that may fall in his way.

DESCRIPTION OF ADAMS'S IMPROVED AND UNIVERSAL LUCERNAL MICROSCOPE, Fig. 1, Plate III.

This microfcope was originally thought of, and in part executed by my father; I have, however, fo improved and altered it, both in conftruction and form, as to render it altogether a different inftrument. The approbation it has received from the moft experienced microfcopic obfervers, as well as the great

demand

demand I have had for them, has fully repaid my pains and expences, in bringing it to it's preſent ſtate of perfection.

As the far greater part of the objects which ſurround us are opake, and very few are ſufficiently tranſparent to be examined by the common microſcopes, an inſtrument that could be readily applied to the examination of opake objects, has always been a deſideratum. Even in the examination of tranſparent objects, many of the fine and more curious portions are loſt, and drowned as it were in the light which muſt be tranſmitted through them; while different parts of the ſame object appear only as dark lines or ſpots, becauſe they are ſo opake, as not to permit any light to paſs through them. Theſe difficulties, as well as many more, are obviated in the lucernal microſcope; by which, opake objects, of various ſizes, may be ſeen with eaſe and diſtinctneſs; the beautiful colours with which moſt of them are adorned, are rendered more brilliant, without changing in the leaſt the real tint of the colour. The concave and convex parts of an object retain alſo their proper form.

The facility with which all opake objects are applied to this inſtrument, is another conſiderable advantage, and almoſt peculiar to itſelf; as the texture and configuration of the more tender parts are often hurt by previous preparation, every object may be examined by this inſtrument, firſt, as opake, and afterwards, if the texture will admit of it, as tranſparent.

The lucernal microſcope does not in the leaſt fatigue the eye; the object appears like nature itſelf, giving eaſe to the ſight, and pleaſure

pleasure to the mind: there is also, in the use of this instrument, no occasion to shut that eye which is not directed to the object.

A further advantage peculiar to this microscope is, that by it the outlines of every object may be taken, even by those who are not accustomed to draw; while those who can draw well, will receive great assistance, and execute their work with more accuracy, and in less time than they would otherwise have been able to have performed it in. Most of the designs for this work were taken with the lucernal microscope; and, I hope, the accuracy with which they are executed, will be deemed a sufficient testimony in favour of the instrument. In this point of view, it will, I think, be found of great use to the anatomist, the botanist, the entomologist, &c. as it will enable them not only to investigate the object of their researches, but to convey to others accurate delineations of the subject they wish to describe.

By the addition of a tin lanthorn to this apparatus, transparent objects may be thrown on a screen, and exhibited at one view to a large company, as by the solar microscope.

Transparent objects may be examined with this instrument in three or four different modes; from a blaze of light almost too great for the eye to bear, to that which is perfectly easy to it.

When this instrument is fitted up in the best way, we generally send a small double and single microscope with it.

Fig. 1, Plate I. represents the IMPROVED LUCERNAL MICROSCOPE, mounted to view opake objects; A B C D E is a large

 mahogany

mahogany pyramidical box, which forms the body of the microſcope; it is ſupported firmly on the braſs pillar F G, by means of the ſocket H, and the curved piece I K.

L M N is a guide for the eye, in order to direct it in the axis of the lenſes; it conſiſts of two braſs tubes, one ſliding within the other, and a vertical flat piece, at the top of which is the hole for the eye. The outer tube is ſeen at M N, the vertical piece is repreſented at L M. The inner tube may be pulled out, or puſhed in, to adjuſt it to the focus of the glaſſes. The vertical piece may be raiſed or depreſſed, that the hole, through which the object is to be viewed, may coincide with the center of the field of view; it is fixed by a milled ſcrew at M, which could not be ſhewn in this figure.

At N is a dove-tailed piece of braſs, made to receive the dove-tail at the end of the tubes M N, by which it is affixed to the wooden box A B C D E. The tubes M N may be removed from this box occaſionally, for the convenience of packing it up in a leſs compaſs.

O P a ſmall tube which carries the magnifiers.

O one of the magnifiers; it is ſcrewed into the end of a tube, which ſlides within the tube P; the tube P may be unſcrewed occaſionally from the wooden body.

Q R S T V X a long ſquare bar, which paſſes through the ſockets Y Z, and carries the ſtage or frame that holds the objects; this bar may be moved backward or forward, in order to adjuſt it to the focus, by means of the pinion which is at a.

b e

b e is a handle furniſhed with an univerſal joint, for more conveniently turning the pinion. When the handle is removed, the nut, Fig. 2, may be uſed in it's ſtead.

d e is a braſs bar, to ſupport the curved piece K I, and keep the body A B firm and ſteady.

f g h i is the ſtage for opake objects; it fits upon the bar Q R S T by means of the ſocket h i, and is brought nearer to, or removed further from, the magnifying lens, by turning the pinion a: the objects are placed in the front ſide of the ſtage, (which cannot be ſeen in this figure) between four ſmall braſs plates; the edges of two of theſe are ſeen at k l. The two upper pieces of braſs are moveable; they are fixed to a plate, which is acted on by a ſpiral ſpring, that preſſes them down, and confines the ſlider with the objects; this plate, and the two upper pieces of braſs, are lifted up by the ſmall nut m.

At the lower part of the ſtage, there is a ſemicircular lump of glaſs n, which is deſigned to receive the light from the lamp, Fig. 3, and to collect and throw it on the concave mirror O, from whence it is to be reflected on the object.

The upper part, f g r s, of the opake ſtage takes out, that the ſtage for tranſparent objects may be inſerted in it's place.

Fig. 4, repreſents the ſtage for tranſparent objects; the two legs, 5 and 6, fit into the top of the under part r s h i of the ſtage for opake objects; 7 is the part which confines or holds the ſliders, and through which they are to be moved; 9 and 10 a braſs brafs tube, which contains the lenfes for condenfing the light, and throwing it upon the object; there is a fecond tube within that, marked 9 and 10, which may be placed at different diftances from the object by the pin 11.

When this ftage is ufed as a fingle microfcope, without any reference to the lucernal, the magnifiers, or object lenfes, are to be fcrewed into the hole 12, and to be adjufted to a proper focus by the nut 13.

N. B. At the end A B of the wooden body, there is a flider, which is reprefented as partly drawn out at A; when quite taken out, three grooves will be perceived, one of which contains a board that forms the end of the box, the next contains a frame with a greyed glafs, the third, or that fartheft from the end A B, two large convex lenfes.

OF THE LAMP.

Fig. 3, reprefents one of ARGAND's lamps, which are the moft fuitable for microfcopic purpofes, on account of the clearnefs, the intenfity, and the fteadinefs of the light. The following account of the method of managing them, with other obfervations, is copied from an account given by Mr. Parker with thofe he fells.

The principle on which the lamp acts, confifts in difpofing the wick in thin parts, fo that the air may come into contact with all the burning fuel, by which means, together with an increafe of the current of air occafioned by rarefaction in the glafs tube, the whole of the fuel is converted into flame.

6 The

The wicks are circular, and, the more readily to regulate the quantity of light, are fixed on a braſs collar with a wire handle, by means of which they are raiſed or depreſſed at pleaſure.

To fix the wick on, a wood mandril is contrived, which is tapered at one end, and has a groove turned at the other.

The wick has a ſelvage at one end, which is to be put foremoſt on the mandril, and moved up to the groove; then putting the groove into the collar of the wick-holder, the wick is eaſily puſhed forward upon it.

The wick-holder and wick being put quite down in their place, the ſpare part of the wick ſhould, while dry, be ſet alight, and ſuffered to burn to the edge of the tubes; this will leave it more even than by cutting, and, being black by burning, will be much eaſier lighted: for this reaſon, the black ſhould never be quite cut off.

The lamp ſhould be filled an hour or two before it is wanted, that the cotton may imbibe the oil and draw the better.

The lamps which have a reſervoir and valve, need no other direction for filling than to do it with a proper trimming pot, carefully obſerving when they are full; then pulling up the valve by the point, the reſervoir, being turned with the other hand, may be replaced without ſpilling a drop.

Thoſe lamps which fill in the front like a bird-fountain, muſt be reclined on the back to fill, and this ſhould be done gently, that

that the oil in the burner may return into the body when ſo placed and filled; if, by being too full, any oil appears above the guard, only move the lamp a little, and the oil will diſappear; the lamp may then be placed erect, and the oil will flow to it's proper level.

The oil muſt be of the ſpermaceti kind, commonly called chamber oil, which may generally be diſtinguiſhed by it's paleneſs, tranſparency, and inoffenſive ſcent; all thoſe oils which are of a red and brown colour, and of an offenſive ſcent, ſhould be carefully avoided, as their glutinous parts clog the lamp, and the impurities in ſuch oil not being inflammable, will accumulate and remain in the form of a cruſt on the wick. Seal oil is nearly as pale and ſweet as chamber oil; but being of a heavy ſluggiſh quality, is not proper for lamps with fine wicks.

Whenever bad oil has been uſed, on changing it, the wick muſt alſo be changed, becauſe after having imbibed the coarſe particles in it's capillary tubes, it will not draw up the fine oil.

To obtain the greateſt degree of light, the wick ſhould be trimmed exactly even, the flame will then be completely equal.

There will be a great advantage in keeping the lamp clean, eſpecially the burner and air tubes; the neglect of cleanlineſs in lamps is too common: a candleſtick is generally cleaned every time it is uſed, ſo ſhould a lamp; and if a candleſtick is not to be objected to becauſe it does not give light after the candle is exhauſted, ſo a lamp ſhould not be thought ill of, if it does not give light when it wants oil or cotton; but this laſt has often happened, becauſe the deficiency is leſs viſible.

The

The glafs tubes are beft cleaned with a piece of wafh leather.

If a fountain-lamp is left partly filled with oil, it may be liable to overflow; this happens by the contraction of the air when cold, and it's expanfion by the warmth of a room, the rays of the fun, or the heat of the lamp when re-lighted: this accident may be effectually prevented by keeping the refervoir filled, the oil not being fubject to expanfion like air. On this account, thofe with a common refervoir are beft adapted for microfcopic purpofes.

TO EXAMINE OPAKE OBJECTS WITH THE LUCERNAL MICROSCOPE.

The microfcope is reprefented as mounted, and entirely ready for this purpofe, in Fig. 1, Plate III.

To render the ufe of this inftrument eafy, it is ufually packed with as many of the parts together as poffible; it occupies on this account rather more room, but is much lefs embarraffing to the obferver, who has only three parts to put on after it is taken out of it's box, namely, the guide for the eye, the ftage, and the tube with it's magnifier.

But to be more particular, take out the wooden flide A, then lift out the cover and the grey glafs from their refpective grooves under the flide A.

Put the end N of the guide for the eye L M N into it's place, fo that it may ftand in the pofition which is reprefented in this figure.

Place the ſocket, which is at the bottom of the opake ſtage, on the bar Q X T, ſo that the concave mirror o may be next the end D E of the wooden body.

Screw the tubes P O into the end D E. The magnifier you intend to uſe is to be ſcrewed on the end o of theſe tubes.

The handle G b, or milled nut, Fig. 2, muſt be placed on the ſquare end of the pinion a.

Place the lamp lighted before the glaſs lump n, and the object you intend to examine between the ſpring plates of the ſtage, and the inſtrument is ready for uſe.

In all microſcopes, there are two circumſtances which muſt be particularly attended to; the modification of the light, or the proper quantity to illuminate the object; ſecondly, the adjuſtment of the inſtrument to the focus of the glaſſes and the eye of the obſerver. In the uſe of the lucernal microſcope there is a third circumſtance, which is, the regulation of the guide for the eye, each of which I ſhall conſider by itſelf.

1. To throw the light upon the object. The flame of the lamp is to be placed rather below the center of the glaſs lump n, and as near it as poſſible; the concave mirror o muſt be ſo inclined and turned, as to receive the light from the glaſs lump, and reflect it thence upon the object; the beſt ſituation of the concave mirror, and

and the flame of the lamp, depends on a combination of circumſtances, which a little practice will diſcover.

2. To regulate the guide for the eye, or to place the center of the eye-piece L, ſo that it may coincide with the focal point of the lenſes, and the axis of viſion. Lengthen and ſhorten the tubes M N by drawing out or puſhing in the inner tube, and raiſing or depreſſing the eye-piece M L, till you find the large lens (which is placed at the end A B of the wooden body) filled by an uniform field of light, without any priſmatic colours round the edge; for till this piece is properly fixed, the circle of light will be very ſmall, and only occupy a part of the lens: the eye muſt be kept at the center of the eye-piece L, during the whole of the operation; which may be rendered ſomewhat eaſier to the obſerver, on the firſt uſe of the inſtrument, if he holds a piece of white paper parallel to the large lens, removing it from, or bringing it nearer to them, till he finds the place, where a lucid circle, which he will perceive on the paper, is brighteſt and moſt diſtinct, then to fix the center of the eye-piece to coincide with that ſpot; after which a very ſmall adjuſtment will ſet it perfectly right.

3. To adjuſt the lenſes to their focal diſtance. This is effected by turning the pinion a, the eye being at the ſame time at the eye-piece L. I often place the grey glaſs before the large lenſes, while I am regulating the guide for the eye, and adjuſting for the focal diſtance.

If the obſerver, in the proceſs of his examination of an object, advances rapidly from a ſhallow to a deep magnifier, he will ſave himſelf ſome labour by pulling out the internal tube at O.

 The

The upper part f g r s of the ſtage, is to be raiſed or lowered occaſionally, in order to make the center of the object coincide with the center of the lens at O.

To delineate objects, the grey glaſs muſt be placed before the large lenſes; the picture of the object will be formed on this glaſs, and the outline may be accurately taken, by going over the picture with a pencil.

The opake part may be uſed in the day-time without a lamp, provided the large lenſes at A B are ſcreened from the light.

TO USE THE LUCERNAL MICROSCOPE IN THE EXAMINATION OF TRANSPARENT OBJECTS.

The microſcope is to remain as before: the upper part f g s of the opake ſtage muſt be removed, and the ſtage for tranſparent objects, repreſented at Fig. 4, put in it's place; the end, Fig. 9 and 10, to be next the lamp.

Place the greyed glaſs in it's groove at the end A B, and the objects in the ſlider-holder at the front of the ſtage; then tranſmit as ſtrong a light as you are able on the object, which you will eaſily do by raiſing or lowering the lamp.

The object will be beautifully depicted on the grey glaſs: it muſt be regulated to the focus of the magnifier, by turning the pinion a.

The

The object may be viewed either with or without the guide for the eye; a single observer will see an object to the greatest advantage by using this guide, which is to be adjusted as we have described, page 75. If two or three wish to examine the object at the same time, the guide for the eye must be laid aside.

Take the large lens out of the groove, and receive the image on the grey glass; in this case, the guide for the eye is of no use: if the grey glass is taken away, the image of the object may be received on a paper screen.

Take out the grey glass, replace the large lenses, and use the guide for the eye; attend to the foregoing directions, and adjust the object to it's proper focus. You will then see the object in a blaze of light almost too great for the eye, a circumstance that will be found very useful in the examination of particular objects; the edges of the object in this mode will be somewhat coloured, but as it is only used in this full light for occasional purposes, it has been thought better to leave this small imperfection, than by remedying it, to sacrifice greater advantages; the more so, as this fault is easily corrected, and a new and interesting view of the object is obtained, by turning the instrument out of the direct rays of light, and permitting them to pass through only in an oblique direction, by which the upper surface is in some degree illuminated, and the object is seen partly as opake, partly as transparent. It has been already observed, that the transparent objects might be placed between the slider-holders of the stage for opake objects, and then be examined as if opake.

Some

Some tranſparent objects appear to the greateſt advantage when the lens at 9 and 10 is taken away; as, by giving too great a quantity of light, it renders the edges leſs ſharp.

The variety of views which may be taken of every object, by means of the improved lucernal microſcope, will be found to be of great uſe to an accurate obſerver: it will give him an opportunity of correcting or confirming his diſcoveries, and inveſtigating thoſe parts in one mode, which are inviſible in another.

TO THROW THE IMAGE OF TRANSPARENT OBJECTS ON A SCREEN, AS IN THE SOLAR MICROSCOPE.

It has been long a microſcopical deſideratum, to have an inſtrument by which the image of tranſparent objects might be thrown on a ſcreen, as in the common ſolar microſcope; and this not only becauſe the ſun is ſo uncertain in this climate, and the uſe of the ſolar microſcope requires confinement in the fineſt part of the day, when time ſeldom hangs heavy on the mind, but as it alſo affords an increaſe of pleaſure, by diſplaying it's wonders to ſeveral perſons at the ſame inſtant, without the leaſt fatigue to the eye.

This purpoſe is now effectually anſwered, by affixing the tranſparent ſtage of the lucernal to a lanthorn, with one of Argand's lamps.—The lamp is placed within the lanthorn, and the end 9, 10 of the tranſparent ſtage is ſcrewed into a female ſcrew, which is rivetted in the ſliding part of the front of the lanthorn; the magnifying lenſes are to be ſcrewed into the hole repreſented at 12; they are adjuſted by turning the milled nut. The quantity of of light is to be regulated, by raiſing and lowering the ſliding-plate, or the lamp. N. B. This part, with it's lanthorn and lamp, may be had ſeparate from the lucernal microſcope.

APPARATUS WHICH USUALLY ACCOMPANIES THE IMPROVED LUCERNAL MICROSCOPE.

The ſtage for opake objects, with it's ſemicircular lump of glaſs, and concave mirror.

The ſtage for tranſparent objects, which fits on the upper part of the foregoing ſtage.

The ſliding tube, to which the magnifiers are to be affixed; one end of theſe is to be ſcrewed on the end B of the wooden body; the magnifier in uſe is to be ſcrewed to the other end of the inner tube.

Eight magnifying lenſes; theſe are ſo conſtructed, that they may be combined together, and thus produce a very great variety of magnifying powers.

A fiſh-pan, ſuch as is repreſented at I, Plate IX.

A ſteel wire L, with a pair of nippers at one end.

A ſmall cylinder of ivory 1 at the other.

A ſlider of braſs N, containing a flat glaſs ſlider, and a braſs ſlider, into which are fitted ſome ſmall concave glaſſes.

A pair

A pair of forceps.

Six large ivory ſliders, with tranſparent objects, and ſix ſmall ditto with ditto.

Fourteen wooden ſliders, with four opake objects in each ſlider, and two ſpare ſliders.

Some capillary tubes, for viewing ſmall animalcula.

The uſe and manner of uſing the articles of the apparatus will be more particularly explained when we deſcribe the figures which are delineated in Plate IX.

DESCRIPTION OF CUFF'S DOUBLE-CONSTRUCTED MICROSCOPE, REPRESENTED AT Fig. 1, Plate VII. A.

This inſtrument was firſt deſcribed by Mr. Baker, and recommended by him. It was alſo deſcribed by my father in the fourth edition of his Micrographia Illuſtrata, page xix.

A B C repreſents the body of this microſcope; it contains an eye-glaſs at A, a broad lens at B, and a magnifier which is ſcrewed on at C.

The body of the microſcope is ſupported by the arm D E, from which it may be removed at pleaſure.

The arm D E is fixed on the ſliding bar F, and may be raiſed or depreſſed to any height within it's limits.

6 The

The main pillar a b is fixed in the box b e, and by means of the brafs foot d is fcrewed to the mahogany pedeftal x Y, in which is a drawer containing all the apparatus.

O, a milled-headed fcrew, to tighten the bar F when the adjufting fcrew c g is ufed.

p q is the ftage, or plate, which carries the objects; it has a hole at the center n.

G a concave mirror, that may be turned in any direction, to reflect the light of the candle, or the fky, upon the object.

To use this Microscope.

Screw the magnifier you intend to ufe to the end c of the body, place the flider-holder P in the hole n, and the flider with the object between the plates of the flider-holder; fet the upper edge of the bar D E to coincide with the divifions which correfpond to the magnifier you have in ufe, and pinch the milled nut; now reflect a proper quantity of light upon the object, by means of the concave mirror G, and regulate the body exactly to the eye and the focus of the glaffes, by the adjufting fcrew c g.

To view opake objects, take away the flider-holder P, and place the object on a flat glafs under the center of the body, or on one end of the jointed nippers o. Then fcrew the filver concave fpeculum to the end of the cylinder L, and flide this cylinder on the lower part of the body, fo that the upper edge thereof may coincide with the line which has the fame mark with the magnifier that is then ufed; reflect the light from the concave mirror G to the filver fpeculum, from which it will again be reflected on the object. The glaffes are to be adjufted to their focal diftance as before directed.

A LIST OF THE APPARATUS OF CUFF'S DOUBLE-CONSTRUCTED MICROSCOPE.

H a convex lens, to collect the rays of light from the fun or a candle, and condenfe them on the object.

L a cylindrical tube, open at each fide, with a concave fpeculum fcrewed to the lower end h.

P the flider-holder; it confifts of a cylindrical tube, in which an inner tube is forced upwards by a fpiral fpring, it is ufed to receive an ivory flider K, which is to be flid between the plates h and i. The cylinder P fits the hole n in the ftage: the hollow part at k is defigned to receive a glafs tube N.

R is a brafs cone, to be put under the bottom of the cylinder P, to intercept occafionally fome of the rays of light.

S a box containing a concave and a flat glafs, between which a fmall living infect may be confined; it is to be placed over the hole n.

T a flat glafs, to lay any occafional object upon; there is alfo a concave one for fluids.

O a

O a long ſteel wire, with a ſmall pair of pliers at one end, and a point at the other, deſigned to ſtick or hold objects; it ſlips backwards and forwards in the ſhort tube o; the pin p fits into the hole of the ſtage.

W a little round ivory box, to hold a ſupply of talc and rings for the ſliders.

Z a hair bruſh, to wipe any duſt off the glaſſes, or to take up by the other end a drop of any liquid.

V a ſmall ivory cylinder, that fits on the pointed end of the ſteel wire O; it is deſigned for opake objects. Light-coloured ones are to be ſtuck upon the dark ſide, and vice verſa.

Y a common magnifying glaſs, for any occaſional purpoſe.

M a fiſh-pan, whereon to faſten a ſmall fiſh, to view the circulation of the blood: the tail is to be ſpread acroſs the oblong hole at the ſmall end, and tied faſt, by means of a ribband fixed thereto; the knob l is to be ſhoved through the ſlit made in the ſtage, that the tail may be brought under the magnifier.

The Description and Use of Adams's improved double and single Microscope, represented Fig. 1, Plate IV.

It is the compound microſcope, which is at preſent in moſt general uſe. The improvements, though few in number, are eſſential to the uſe thereof. The field of view is conſiderably larger than in the former microſcope. The ſtage and the mirrors are both moveable, ſo that their reſpective diſtances may be eaſily varied. There is alſo a condenſing glaſs to the ſtage, for increaſing the denſity of the light, when it is reflected by the mirror from a candle or lamp. It is furniſhed with two mirrors, one plane, and the other concave, and may be uſed as a ſingle microſcope.

A B, Fig. 1, Plate IV. repreſents the body of the microſcope, containing a double eye glaſs, and a body glaſs; it is here ſhewn as ſcrewed to the arm C D, from whence it may be occaſionally removed, either for the convenience of packing, or when the inſtrument is to be uſed as a ſingle microſcope.

The eye glaſſes and the body glaſſes are contained in a tube which fits into the exterior tube A B; by pulling out a little this tube, when the microſcope is in uſe, the magnifying power of each lens is increaſed.

The body A B of the microſcope is ſupported by the arm C D, this arm is fixed to the main pillar C F, which is ſcrewed firmly to the mahogany pedeſtal G H; there is a drawer to this pedeſtal, which holds the apparatus.

N I S is the plate or ſtage which carries the ſlider-holder K L, this ſtage is moved up or down the pillar C F, by turning the milled nut M; this nut is fixed to a pinion, that works in a toothed rack cut on one ſide of the pillar. By means of this pinion, the ſtage may be gradually raiſed or depreſſed, and the object adjuſted to the focus of the different lenſes.

K L.

K L is the ſlider-holder, which fits into a hole that is in the middle of the ſtage N I S; it is uſed to confine and guide either the motion of the ſliders which contain the objects, or the glaſs tubes that are deſigned to confine ſmall fiſhes, for viewing the circulation of the blood. The ſliders are to be paſſed between the two upper plates, the tubes through the bent plates.

L is a braſs tube, to the upper part of which is fixed the condenſing lens before ſpoken of; it fits into the under part of the ſlider-holder N I, and may be ſet at different diſtances from the object, according to it's diſtance from the mirror or the candle. This tube is ſeen further drawn out in Fig. 2, Plate IV.

O is the frame which holds the two reflecting mirrors, one of which is plane, the other concave. Theſe mirrors may be moved in various directions, in order to reflect the light properly, by means of the pivots on which they move, in the ſemicircle Q S R, and the motion of the ſemicircle itſelf on the pin S; the concave mirror generally anſwers beſt in the day-time; the plane mirror combines better with the condenſing lens, and a lamp or candle. At D there is a ſocket for receiving the pin of the arm Q, Plate IX. to which the concave ſpeculum, for reflecting light on opake objects, is fixed.

At S is a hole and ſlit for receiving either the nippers L, Plate IX. or the fiſh-pan I; when theſe are uſed, the ſlider-holder muſt be removed.

T, a hole to receive the pin of the convex lens M, Plate IX.

To

To use the improved Double Microscope.

Take the microfcope out of the box. Screw the body into the round end of the upper part of the arm C D.

Place the brafs fliders, which contain the magnifiers, into the dove-tailed flit which is on the under fide of the aforefaid arm, as feen at E, Fig. 1, Plate IV. and flide it forwards, until the magnifier you mean to ufe is under the center of the body: oppofite to each magnifier in this flide there is a notch, and in the dove-tailed part of the arm C D there is a fpring, which falls into the above-mentioned notch, and thus makes each magnifier coincide with the center of the body.

Pafs the ivory flider you intend to ufe between the upper plates of the flider-holder K L, and then reflect as ftrong a light as you can on the object, by means of one of the mirrors; after this, adjuft the object to the focus of the magnifier and your eye, by turning the milled fcrew M; the motion of this raifes and depreffes the ftage N I S. The degree of light neceffary for each object, and the accuracy required in the adjuftment of the lens to their proper focal diftance from the object, will be eafily attained by a little practice.

When opake objects are to be examined, remove the flider-holder, and place the object on a flat glafs, or fix it to the nippers L, Plate IX. the pin of thefe fit into the hole on the ftage; fcrew the concave fpeculum R, Plate IX. into the arm Q, Plate

4 IX.

IX. and then paſs the pin of this arm through the ſocket D, Fig. 1, Pl. IV. the light is now to be reflected from the concave mirror to the ſilver ſpeculum, and from this down on the object. No exact rule can be given for reflecting the light on the object; we muſt therefore refer the reader to the mother of all aptneſs, practice. The ſpeculum muſt be moved lower or higher, to ſuit the focus of the different magnifiers, and the nature of the object.

The preceding directions apply equally to the uſing of this inſtrument as a single microscope, with this difference only, that the body A B is then removed, and the eye is applied to the upper ſurface of the arm C D, exactly over the magnifiers.

A List of the Apparatus of the improved Compound Microscope.

The ſlider, with the magnifiers.

The body of the microſcope.

The ſlider-holder.

The tube, with the condenſing lens.

The pin and arm for the ſilver ſpeculum.

The ſilver ſpeculum.

A braſs box for the ſilver ſpeculum.

A braſs

A braſs cone to place under the ſlider-holder.

The jointed nippers.

A cylinder of ivory, to fix on the pointed end of the nippers.

Six ivory ſliders, five of which are filled with objects.

A magnifier for the hand.

A fiſh pan.

A round braſs box, with glaſs ends, for confining living objects.

An ivory box, to hold ſpare rings and talc for the ſliders.

A round flat glaſs, fitted to the hole in the ſtage.

A concave ditto.

A ſlider of braſs, containing a flat glaſs ſlider, and a braſs ſlider, into which are fitted ſmall concave glaſſes.

Some glaſs tubes.

A ſmall pair of forceps.

A ſlip or two of flat glaſs.

A ſmall bruſh, or hair pencil.

The

The uſe of each article of the apparatus, and the method of applying it to uſe, will be deſcribed in the latter end of this chapter.

OF THE IMPROVED COMPOUND MICROSCOPE, REPRESENTED AT Fig. 2, Plate IV.

The advantages of this over the preceding compound microſcope, conſiſts, firſt, in the motion which may be given to the body, the ſtage, and the mirrors, by means of the joint c d, which has both a vertical and horizontal motion; ſo that the microſcope may be placed either in an horizontal or inclined ſituation, and thus be adapted to the eaſe of the obſerver, and be uſed when he is ſitting down. If the mirror Q O R is taken off, the light will be conveyed in a direct line to the object, without any reflection. Secondly, that the body may be moved over any part of the ſtage, and thus over the object. The arm which carries the body, moves to the right or left on a central pin, and may alſo be moved backwards or forwards by the milled nut b. Thirdly, the concave and flat mirrors are much larger than thoſe of Fig. 1. In every other reſpect, the microſcope is ſimilar to the foregoing, and may be managed by the deſcription thereof; for which purpoſe, ſimilar letters are affixed to the ſame parts.

A DESCRIPTION OF CULPEPER'S, OR THE THREE-PILLARED MICROSCOPE, Fig. 3, Plate IV.

This inſtrument is recommended by it's ſimplicity and cheapneſs; it is eaſily managed, and gives a pleaſing view of an ob-

M jeƈt.

ject. It is true, it is precluded by it's form from some of the advantages of the two foregoing instruments, because both the stage and the mirror are confined.

This microscope consists of a large exterior body A B C D, supported on three small scroles, which are fixed to the stage E F; the stage is supported by three larger scroles, that are screwed to the mahogany pedestal G H. There is a drawer in the pedestal which holds the apparatus. The concave mirror is fitted to a socket in the center of the pedestal. The lower part L M C D of the body forms an exterior tube, into which the upper part of the body A B L M slides, and may be moved up or down, so as to bring the magnifiers, which are screwed on at N, nearer to, or further from the object.

TO USE CULPEPER'S MICROSCOPE.

Screw one of the buttons which contains a magnifying lens, to the end N of the body; place the slider, with the objects, between the plates of the slider-holder. Then, to attain distinct vision, and a pleasing view of the object, adjust the body to the focus of the lens you are using, by moving the upper part gently up and down, and regulate the light by the concave mirror.

For opake objects, two additional pieces must be used; the first is, a cylindrical tube of brass, represented at X, Plate IX. which fits on the cylindrical part at N of the body; the second piece is the concave speculum H, Plate IX. this is to be screwed to the lower end of the aforesaid tube: the upper edge of this tube should be made to coincide with the line, which has the same

. 4 number

number affixed to it, as to the magnifier you are uſing; ex. gr. if you are making uſe of the magnifier marked 5, ſlide the tube to the circular line on the tube N, that is marked alſo with No. 5.

The ſlider-holder ſhould be removed when you are going to view opake objects, and a plane glaſs ſhould be placed on the ſtage in it's ſtead to receive the object; or it may be placed in the nippers L, Plate IX. the pin of which fits into the hole in the ſtage.

A LIST OF THE APPARATUS TO CULPEPER'S MICROSCOPE.

Five magnifiers, each fitted in a braſs button; one of theſe is ſeen at B, Plate IX.

Six ivory ſliders, five of them with objects.

A braſs tube X, Plate IX. to hold the concave ſpeculum.

The concave ſpeculum in a braſs box.

A fiſh-pan.

A ſet of glaſs tubes.

A flat glaſs fitted to the ſtage.

A concave glaſs fitted to the ſtage.

A pair of forceps.

A ſteel wire, with a pair of nippers at one end, and a point at the other.

A ſmall ivory cylinder, to fit on the pointed end of the aforeſaid nippers.

A convex lens, moveable in a braſs ſemicircle; this is affixed to a long braſs pin, which fits into a hole on the ſtage.

If the reader wants a more particular deſcription of any of the articles of this apparatus, he will find it at the latter end of this chapter.

A DESCRIPTION OF THE IMPROVED SOLAR MICROSCOPE, WHICH IS CONSTRUCTED TO EXHIBIT TRANSPARENT AND OPAKE OBJECTS, Fig. 1, Plate V.

The ſolar microſcope is generally ſuppoſed to afford the moſt entertainment, on account of the wonderful extent of it's magnifying power, and the eaſe with which ſeveral perſons may view each ſingle object at the ſame time. The uſe of it was, however, confined for many years only to tranſparent objects. About the year 1774, Mr. B. Martin ſo far improved this inſtrument, as to render it applicable to opake, as well as to tranſparent objects, exhibiting the magnified image of either kind on a large ſcreen. Speaking of it himſelf, he ſays, "With this inſtrument all opake objects, whether of the animal, vegetable, or mineral kingdom, may be exhibited in great perfection, in all their native beauty; the

the lights and ſhades, the prominencies and cavities, and all the varieties of different hues, tints, and colours, heightened by the reflection of the ſolar rays condenſed upon them." Tranſparent objects are alſo ſhewn with greater perfection than in the common ſolar microſcope.

Fig. 1, Plate V. repreſents the ſolar opake microſcope, mounted for exhibiting opake objects.

Fig. 2, is the ſingle tooth and pinion microſcope, which is uſed for ſhewing tranſparent objects; the cylindrical tube Y thereof being made to fit into the tube F E, Fig. 1.

Fig. 3, the ſlider which contains the magnifiers; it fits into a dove-tail which is at the upper part of the microſcope, Fig. 2.

A B C D E F, Fig. 1, repreſents the body of the ſolar microſcope; one part thereof, A B C D, is conical, the other, C D E F, is cylindrical. The cylindrical part receives the tube G of the opake box, or the tube Y of the ſingle microſcope, Fig. 2.

At the large end A B of the conical part, there is a lens to receive the rays from the mirror, and refract them towards the box H I K L.

N O P is a braſs frame, which is fixed to the moveable circular plate a b c; in this frame there is a plane mirror, to reflect the ſolar rays on the afore-mentioned lens.

This mirror may be moved into the moſt convenient poſition for reflecting the light, by means of the nuts Q and R. By

By the nut Q it may be moved from eaſt to weſt; it may be elevated or depreſſed by the nut R.

d e, two ſcrews to faſten the microſcope to a window-ſhutter.

The box for opake objects is repreſented at H I K L; it contains a plane mirror M, for reflecting the light that it receives from the large lens to the object, and thereby illuminating it; S is a ſcrew to adjuſt this mirror, or place it at a proper angle for reflecting the light.

V X two tubes of braſs, one ſliding within the other, the exterior one in the box H I K L; theſe carry the magnifying lenſes: the interior tube is ſometimes taken out, and the exterior one is then uſed by itſelf. Part of this tube may be ſeen in the plate within the box H I K L.

At H there is a braſs plate, the back part of which is fixed to the hollow tube h, in which there is a ſpiral wire, which keeps the plate always bearing againſt the ſide H of the braſs box H I K L. The ſliders, with the opake objects, paſs between this plate and the ſide of the box; to put them there, the plate is to be drawn back by means of the nut g.

i k, a door to one ſide of the opake box.

The foregoing pieces conſtitute the ſeveral parts neceſſary for viewing opake objects. I ſhall now proceed to deſcribe the ſingle microſcope, which is uſed for tranſparent objects: but in order to examine theſe, the box H I K L muſt be firſt removed, and in it's it's place we muſt inſert the tube Y of the ſingle microſcope that we are now going to deſcribe.

Fig. 2, Plate V. repreſents a large tooth and pinion microſcope; at m, within the body of this microſcope, are two thin plates, that are to be ſeparated, in order to let the ivory ſliders paſs between them; they are preſſed together by a ſpiral ſpring, which bears up the under plate, and forces it againſt the upper one.

The ſlider, Fig. 3, that contains the magnifiers, fits into the hole n; any of the magnifiers may be placed before the object, by moving the aforeſaid ſlider: when the magnifier is at the center of the hole P, a ſmall ſpring falls into one of the notches which is on the ſide of the ſlider, Fig. 3.

Under the plate m are placed two lenſes, for enlarging the field of view on the ſcreen: the ſmaller of the two is fixed on a piece of braſs, and is neareſt the plate m; this is to be taken out, when the magnifiers, No. 4, 5, or 6, are uſed, or when the megalaſcope lens, Fig. 4, is uſed; but is to be replaced for No. 1, 2, 3.

This microſcope is adjuſted to the focus, by turning the milled nut O.

To use the Solar Microscope.

Make a round hole in the window-ſhutter, a little larger than the circle a b c; paſs the mirror C N P through this hole, and apply the ſquare plate to the ſhutter; then mark with a pencil the

the places which correſpond to the two holes through which the ſcrew is to paſs; take away the microſcope, and bore two holes at the marked places, ſufficiently large to let the milled ſcrews paſs through them.

Theſe ſcrews are to paſs from the outſide of the ſhutter, to go through it, and being then ſcrewed into their reſpective holes in the ſquare plate, they will, when ſcrewed home, hold it faſt againſt the inſide of the ſhutter, and thus ſupport the microſcope.

Screw the conical tube A B C D to the circle a b c, and then ſlide the tube G of the opake box into the cylindrical part C D E F of the body, if opake objects are to be examined; but if they be tranſparent objects you mean to ſhew, then place the tube Y within the tube C D E F.

The room is to be darkened as much as poſſible, that no light may enter but what paſſes through the body of the microſcope; for, on this circumſtance, together with the brightneſs of the ſunſhine, the perfection and diſtinctneſs of the image in a great meaſure depend.

I ſhall firſt conſider the microſcope as going TO BE USED FOR OPAKE OBJECTS. 1. Adjuſt the mirror N O P, ſo as to receive the ſolar rays, by means of the two finger ſcrews or nuts, Q, R; the firſt, Q, turns the mirror to the right or left; the ſecond, R, raiſes or depreſſes it: this you are to do till you have reflected the ſun's light through the lens at A B, ſtrongly upon a ſcreen of white paper, placed at ſome diſtance from the window, and formed thereon a round ſpot of light. An unexperienced obſerver will find it more conve-

convenient to obtain the light, by forming this ſpot before he puts on either the opake box, or the tooth and pinion microſcope.

Now put in the opake box, and place the object between the plates at H; open the door i k, and adjuſt the mirror M, till you have illuminated the object ſtrongly. If you cannot effect this by the ſcrew S, you muſt move the ſcrews Q, R, in order to get the light reflected ſtrongly from the mirror N O P, or the mirror M, without which the latter cannot illuminate the object.

The object being ſtrongly illuminated, ſhut the door i k, and a diſtinct view of the object will ſoon be obtained on your ſcreen, by adjuſting the tubes V X, which is effected by moving them backwards or forwards.

A round ſpot of light cannot always be procured in northern latitudes, the altitude of the ſun being often too low; neither can it be obtained when the ſun is directly perpendicular to the front of the room.

As the ſun is continually changing it's place, it will be neceſſary, in order to keep his rays full upon the object, to keep them continually directed through the axis of the inſtrument, by the two ſcrews Q and R.

To view tranſparent objects, remove the opake box, and inſert the tube Y of Fig. 2, Plate V. in it's place; put the ſlider, Fig. 3, Plate V. into it's place at n, and the ſlider, with the objects between the plates, at m; then adjuſt the mirror N O P, as before directed, by the ſcrews Q, R, ſo that the light may paſs through

N the

the object; regulate the focus of the magnifier by the screw O. The most pleasing magnifiers in use are the fourth and fifth.

The size of the object may be increased or diminished, by altering the distance of the screen from the microscope: five or six feet is a convenient distance.

TO EXAMINE TRANSPARENT OBJECTS OF A LARGER SIZE, or to render the instrument what is usually called a megalascope, take out the slider, Fig. 3, from it's place at n, and screw the button, Fig. 4, into the hole at P, Fig. 2, and remove the glass which is under the plate at m, and regulate the light and focus agreeable to the foregoing directions.

N. B. At the end of the tube G there is a lens for increasing the density of the rays, for the purpose of burning or melting any combustible or fusible substance; this lens must be removed in most cases, lest the objects should be burnt. The intensity of the light is also varied by moving this tube backwards or forwards.

APPARATUS OF THE OPAKE SOLAR MICROSCOPE.

The large square plate and mirror.

The body of the microscope.

The opake box and it's tube.

The tooth and pinion microscope.

The

The ſlider with the magnifiers.

The megalaſcope magnifier.

The two ſcrews Q and R.

Some ivory ſliders.

Some ſliders with opake objects.

A braſs frame, with a bottom of ſoft deal to ſtick any object on.

A braſs cylinder K, Plate IX. for confining opake objects.

DESCRIPTION OF THE COMMON SOLAR MICROSCOPE, Fig. 4, Plate VI.

The foregoing deſcription will, in a great part, anſwer for this microſcope; and I once intended to have made only ſome general references to the former, in order to avoid that prolixity which muſt ever attend the detail of deſcription: but when I conſidered, that one of theſe inſtruments might be purchaſed by thoſe who would probably never ſee the other; and that a ſmall difference in conſtruction would embarraſs the young practitioner, it appeared to me more eligible to give a deſcription of the common ſolar at full length, than to curtail it through an affectation of brevity.

This inſtrument is repreſented in Plate VI. at the Figures 4, 5, 6, 7, 8.

A B C D, Fig. 4, repreſents the body of the microſcope, conſiſting of two braſs tubes. E F is the top of the inner moveable tube; the end e f of the ſingle tooth and pinion microſcope, Fig. 5, ſcrews into the top of this inner tube; at the end A B of the external tube there is a lens, to receive the light of the ſun from the mirror K L, and to collect and condenſe it on the object; the end A B ſcrews into the circular plate G H L.

K L, a long frame fixed to the moveable circular plate; in this frame there is a plane mirror to reflect the rays of the ſun on the lens at A B.

An endleſs worm or ſcrew, which is cut on the lower part of the nut M, works in a ſmall wheel which is fixed to the frame K L, ſo that by turning the nut, the frame K L is moved up or down: the nut N moves the mirror to the right or left.

O, P, two ſcrews to faſten the ſquare plate to the window-ſhutter.

Fig. 5, the ſingle microſcope; e f the end which ſcrews on to the upper part E of the internal tube of the body; q the dove-tailed ſlit for receiving the ſlider, Fig. 8.

g, the hole in which the megalaſcope magnifier, Fig. 6, is to be ſcrewed, when the ſlider, Fig. 8, is removed.

At h are the moveable plates, between which the ſliders are placed; under the lowermoſt of theſe the lens repreſented at Fig. 7 is

7 is to be placed, when the magnifiers, No. 1, 2, 3, and 4, are to be uſed.

e k is a ſmall piece of rack work, which is moved backwards and forwards by the pinion that is fixed to the lower end of the milled nut b: by the gradual motion of this rack, the objects are adjuſted to the foci of the different lenſes.

Fig. 8 is a braſs ſlider, with four or ſix lenſes or magnifying glaſſes; it is to be inſerted into the hole at q; either of the magnifiers may be placed before the object, by ſliding it one way or the other: you may perceive when the glaſs is in the center of the eye-hole by a ſmall ſpring falling into a notch which is made on the ſide of the ſlider oppoſite to each lens.

TO USE THE SOLAR MICROSCOPE.

Faſten the ſquare plate againſt the inſide of a window-ſhutter, by the two ſcrews O, P, which are to go from the outſide of the window-ſhutter through it, and then be ſcrewed into their reſpective holes in the ſquare plates G H I. The mirror is to be on the outſide of the ſhutter, paſſing through a hole made for that purpoſe.

Darken the room; then place a ſcreen at a convenient diſtance from the window, the farther it is from it the larger is the image: now move the mirror K L by the two nuts M, N, till the ſun's rays come through the inſtrument in an horizontal direction to the ſcreen, forming a round ſpot thereon; ſcrew the microſcope, Fig. 5, into it's place E F; put the ſlider, with the lens, Fig. 8, in in it's proper ſituation, and the object ſlider between the plates at h; adjuſt the object to the focus of the magnifying lens by the ſcrew b, till the object appears diſtinct and clear on the ſcreen. By moving the internal tube of the body, the object may be placed at different diſtances from the lens which is fixed at A B, ſo as to be ſufficiently illuminated, and yet not ſcorched by the ſolar rays.

APPARATUS BELONGING TO THE COMMON SOLAR MICROSCOPE.

Square plate and mirror.

The body, conſiſting of two tubes, one within the other.

The ſingle microſcope.

The megalaſcope lens, Fig. 6.

The ſlider, Fig. 8, with ſix lenſes.

The two ſcrews O, P.

Six ivory ſliders and a talc box.

Some glaſs tubes.

A ſlider, or braſs caſe, containing a plane piece of glaſs, and a braſs ſlider with holes, into which are cemented ſmall concave glaſſes, deſigned for confining ſmall inſects between the plane and concave glafs, which are thus preferved from being crufhed, and prevented from wandering out of the field of view.

THE SCREW BARREL, OR WILSON'S SINGLE POCKET MICROSCOPE, Fig. 1 and 2, Plate II. B.

This microfcope of Mr. Wilfon's is an invention of many years ftanding, and was in fome meafure laid afide, till Dr. Lieberkuhn introduced the folar apparatus, to which he applied it, there being no other inftrument at that time which would anfwer his purpofe fo well; fince which time it has been revived, and much efteemed, though very troublefome in many cafes.

The body of the microfcope is reprefented by A B, Fig. 1, and is made either of filver, brafs, or ivory.

C C is a long fine-threaded male fcrew that turns into the body of the microfcope.

D, a convex glafs at the end of the faid fcrew, on which may be placed, as occafion requires, one of the two concave pieces of thin brafs, with holes of different diameters in the center of them, to cover the faid glafs, and thereby diminifh the aperture when the greateft magnifiers are ufed.

E, three thin plates of brafs within the body of the microfcope, one whereof is bent femicircularly in the middle, fo as to form an arched cavity for the reception of a tube of glafs.

F, a

F, a piece of wood or brafs, arched in the manner of the faid plate, and faftened thereto.

G, the other end of the microfcope, where a hollow female fcrew is adapted to receive the different magnifiers.

H, a fpiral fpring of fteel between the faid end G and the plates of brafs E, intended to keep the plates in a due pofition, and counteract againft the long fcrew C.

I, a fmall turned handle, for the better holding the inftrument, which fcrews on and off at pleafure.

To this microfcope belong feven different magnifying glaffes, fix of which are fet either in filver, brafs, or ivory, as in the figure K, and are marked 1, 2, 3, 4, 5, 6: obferve, the loweft numbers are the greateft magnifiers. L is the feventh magnifier, fet in the manner of a little barrel, to be held in the hand for viewing any larger object.

M is a flat flip of ivory, called a flider, with four round holes through it, wherein to place objects between two mufcovy talcs.

Six fuch ivory fliders, and one of brafs, are ufually fold with this microfcope, fome with objects placed in them, and others empty, for viewing any thing that may offer; but whoever pleafes to make a large collection of objects, may have as many as he defires. There is alfo a brafs flider, not expreffed in the figure, to confine any fmall object, that it may be viewed without crufhing or deftroying it.

N is

N is a pair of forceps, or pliers, for the taking up of insects or other objects, and adjusting them in the glasses.

O, a little hair brush or pencil, wherewith to take up and examine a small drop of liquid.

P is a tube of glass to confine living objects, such as frogs, fishes, &c. in order to discover the circulation of the blood.

When you would view an object, thrust the ivory slider, in which the said object is placed, between the two flat brass plates, observing always to put that side of the slider where the brass rings are farthest from the eye; then screw in the magnifying glass you intend to use at the end of the instrument G, and looking through it against the light, turn the long screw C C till your object is brought to the true focal distance, which you will know by it's appearing perfectly clear and distinct.

The way of examining any object accurately, is to look at it, first, through a magnifier that will shew the whole at once, and afterwards to inspect the several parts more particularly with one of the greatest magnifiers; for thus you will gain a true idea of the whole, and all it's parts: and though the greatest magnifiers can shew but a minute portion of any object at once, such as the claw of a flea, the horn of a louse, or the like, yet by gently moving the slider that contains your object, the eye will gradually see the whole; and if any part should be out of the focal distance, the screw C C will easily bring it to the true focus.

As objects muſt be brought very near the glaſſes when the greateſt magnifiers are uſed, be particularly careful not to ſcratch them, by rubbing the ſlider againſt them as you move it in or out. A few turns of the ſcrew C C will eaſily prevent this miſchief, by giving it room enough.

DESCRIPTION OF A SCROLE FOR FIXING WILSON'S POCKET MICROSCOPE, AND REFLECTING LIGHT TO IT BY A MIRROR.

A B C, Fig. 2, is a braſs ſcrole, which, for the better conveniency of carriage, is ſo ordered as to take into three parts, and put into the drawer upon which it ſtands, with it's reflecting mirror and Wilſon's pocket microſcope.

The top part of the ſcrole is taken off at B, by unſcrewing half a turn of the ſcrew; then lift it up, and it comes out of the ſocket. The lower part unſcrews at C, and the baſe unſcrews at E.

The mirror lifts out at F, which, with the ſcrole, lie in one partition of the box.

To apply this ſcrole to uſe, fix the body of the microſcope to the top thereof by the ſcrew A, as in Fig. 2, by ſcrewing it in the ſame hole as the ivory handle.

The braſs or ivory ſlider being fixed as before deſcribed, and the microſcope placed in a perpendicular poſition, move the reflecting glaſs D in ſuch a manner as to caſt the light of the ſky,

4 the

the ſun, or a candle, directly upwards through the microſcope; by which means it is made to anſwer moſt of the ends of a double reflecting microſcope.

It is alſo rendered more uſeful for viewing opake objects by ſcrewing the arm Q R, Fig. 1, into the body of the microſcope at G; then ſcrewing into the round hole R that magnifier which you think will beſt ſuit your object, and putting the concave ſpeculum S, on to the outſide of the ring R, you will find in the body of the microſcope, between the wood or braſs F, and the end of the male ſcrew C C, a ſmall hole u, through which ſlides the long wire T, which has a point at one end and forceps at the other, that may be uſed occaſionally, as your object requires: when you have fixed this, and your object on it, turn the arm R, which is performed by two motions, till the magnifier is brought over the object; it may be then adjuſted to the true focus, by turning the male ſcrew C C in the ſame manner as before deſcribed. It muſt alſo be turned exactly over the ſpeculum, by twiſting the upper part of the ſcrole to one ſide, till your object and the two ſpeculums are in one line, as will be found by trial; and then fix it by the ſcrew B, at which time the upper ſurface of the object will be ſo exceedingly enlightened by the light reflected upward from the mirror to the concave ſpeculum, as to be ſeen as clear and diſtinct as any tranſparent one.

DESCRIPTION OF A SMALL MICROSCOPE FOR OPAKE OBJECTS, Fig. 3 and 4, Plate II. B.

A, Fig. 4, is a fixed arm, through which paſſes a ſcrew B, the other end whereof is faſtened to the moveable arm C.

D is a nut fitted to the faid fcrew, which, when turned, will either feparate or bring together the two arms A C.

E is a fteel fpring, that feparates the two fides when the nut is unfcrewed.

F, a piece of brafs turning round in a focket, whence proceeds a fpringing tube, moving on a rivet, through which runs a fteel wire, one end of which finifhes in a point G, and the other end hath a pair of pliers H foldered to it; thefe are either to thruft into, or to take up and hold any object, and may be turned round as required.

I, a ring of brafs, with a female fcrew fixed on an upright piece of the fame metal, which turns on a rivet, that it may be fet at a due diftance when the leaft magnifiers are ufed, and ferves the fcrews of all the magnifiers.

K, a concave fpeculum of filver, polifhed as bright as poffible, in the center of which a double convex lens is placed, with a proper aperture to look through it. On the back of this fpeculum a male fcrew L is made to fit the brafs ring I, which may be fcrewed into the faid ring at pleafure.

Four of thefe concave fpecula, of different depths, are fitted to four glaffes of different magnifying powers, to be ufed as the objects to be examined may require. The greateft magnifiers have the leaft apertures.

M, a

M, a round object plate, one ſide white, and the other black, intended to render objects the more viſible, by placing them, if black, upon the white, and if white, on the black ſide.

A ſteel ſpring N turns down on each ſide, to make any object faſt: from the object plate there is a hollow pipe, to ſcrew it on the needle's point G.

O, a ſmall box of braſs, with a glaſs on each ſide, contrived to confine any living object in order to examine it; this alſo has a pipe to ſcrew upon the end of the needle at G.

P, a turned handle of ivory, to ſcrew into the inſtrument when it is made uſe of.

Q, a pair of pliers to take up any object, or manage it with conveniency.

R, a ſoft hair bruſh, to clean the glaſſes or ſpecula.

When you would view any object, ſcrew the ſpeculum, with the magnifier you intend to uſe, into the braſs ring I; place your object either on the needle G, in the pliers H, on the object plate M, or in the braſs hollow box O, as may be moſt convenient, according to the nature and condition of it; then holding up your inſtrument by the handle P, look againſt the light through the magnifying lens, and by means of the nut D, together with the motion of the needle, by managing it's lower end, the object may be turned about, raiſed or depreſſed, brought nearer the glaſs, or put farther from it, till you hit the true focal diſtance,

diſtance, and the light be ſeen reflected from the ſpeculum ſtrongly upon the object, by which means it will appear very diſtinct and clear.

OF ELLIS'S SINGLE OR AQUATIC MICROSCOPE, Plate VII. B.

This inſtrument takes it's name from Mr. John Ellis, author of "An Eſſay towards a Natural Hiſtory of Corallines," and of the "Natural Hiſtory of many curious and uncommon Zoophytes." This was the inſtrument that he made uſe of, and by which he was enabled to explain many ſingularities in the œconomy and conſtruction of theſe wonderful productions of nature. To the practical botaniſt this inſtrument is recommended, by the reſpectable authority of Mr. Curtis, author of the Flora Londinenſis, a work which does credit to the author and the nation. This microſcope is ſimple in it's conſtruction, eaſy in it's uſe, and very portable; theſe advantages, as well as ſome others which it alſo has over every other portable microſcope, have accelerated the ſale thereof, and cauſed it to be very much adopted.

DESCRIPTION OF THE VARIOUS PARTS OF THE MICROSCOPE.

K, the box which contains the whole apparatus; it is generally made of fiſh-ſkin; on the top of the box there is a female ſcrew, for receiving the ſcrew which is at the bottom of the pillar A, a pillar of braſs which is ſcrewed on the top of the box K.

D, a braſs pin which fits into the pillar; on the top of this pin is a hollow ſocket to receive the arm which carries the magnifiers; the

the pin is to be moved up and down, in order to adjuſt the lenſes to their focal or proper diſtance from the object.

N.B. In the repreſentation of this microſcope, Plate VII. B. Fig. 1, the pin D is delineated as paſſing through a ſocket at one ſide of the pillar A; whereas it is uſual at preſent to make it paſs down a hole bored through the middle of the pillar.

E, the bar which carries the magnifying lens; it fits into the ſocket X which is at the top of the pillar D. This arm may be moved backwards and forwards in the ſocket X, and ſideways by the pin D, ſo that the magnifier, which is ſcrewed into the ring at the end E of this bar, may be eaſily made to traverſe over any part of the object that lays on the ſtage or plate B.

E F is a poliſhed ſilver ſpeculum, with a magnifying lens, placed at the center thereof, which is perforated for this purpoſe. The ſilver ſpeculum ſcrews into the arm E as at F.

G, another ſpeculum, with it's lens, which is of a different magnifying power from the former.

H, the ſemicircle which ſupports the mirror I; the pin R, affixed to the ſemicircle H, paſſes through the hole which is towards the bottom of the pillar A.

B, the ſtage, or the plane, on which the objects are to be placed; it fits into the ſmall dove-tailed arm which is at the upper end of the pillar D A.

C, a

C, a plane glaſs, with a ſmall piece of black ſilk ſtuck on it; this glaſs is to lay in a groove made in the ſtage B.

M, a hollow glaſs, to be laid occaſionally on the ſtage inſtead of the plane glaſs C.

L, a pair of nippers. Theſe are fixed to the ſtage by the pin R; the ſteel wire of theſe nippers ſlides backwards and forwards in the ſocket, and this ſocket is moveable upwards and downwards by means of the joint, ſo that the poſition of the object may be varied at pleaſure. The object may be fixed in the nippers, ſtuck on the point, or affixed by a little gum water, &c. to the ivory cylinder N.

O, a ſmall pair of forceps to take up ſmall objects.

P, a bruſh to clean the glaſſes.

TO USE ELLIS'S MICROSCOPE.

Take all the parts of the apparatus out of the box; then begin by ſcrewing the pillar A to the cover thereof; paſs the pin R of the ſemicircle which carries the mirror through the hole that is near the bottom of the pillar A; puſh the ſtage into the dove-tail at B, ſlide the pin into the pillar, (ſee the N. B. above) then paſs the bar E through the ſocket which is at the top of the pin D, and ſcrew one of the magnifying lenſes into the ring at F. The microſcope is now ready for uſe; and though the enumeration of the articles may lead the reader to imagine the inſtrument to be of a complex nature, we can ſafely affirm, that he will find it it otherwiſe. The inſtrument has this peculiar advantage, that it is difficult to put any of the pieces in a place which is appropriated to another.

Let the object be now placed either on the ſtage or in the nippers L, and in ſuch manner, that it may be as nearly as poſſible over the center of the ſtage: bring the ſpeculum F over the part you mean to obſerve; then throw as much light on the ſpeculum as you can, by means of the mirror I L, and the double motion of which it is capable; the light received on the ſpeculum is reflected by it on the object. The diſtance of the lens F from the object is regulated by moving the pin D up and down, until a diſtinct view of it is obtained. The rule which I obſerve is, to place the lens beyond it's focal diſtance from the object, and then gradually ſlide it down, till the object appears ſharp and well defined. The adjuſtment of the lenſes to their focus, and the diſtribution of the light on the object, are what require the moſt attention; on the firſt the diſtinctneſs of the viſion depends; the pleaſure ariſing from a clear view of the parts under obſervation, is due to the modification of the light. No preciſe rule can be given for attaining accurately theſe points; it is from practice alone that ready habits of obtaining theſe neceſſary properties can be acquired; with the aſſiſtance of this no difficulty will be found.

Theſe microſcopes are ſometimes fitted up with a toothed rack and pinion, for the more ready adjuſtment of the glaſſes to their proper focus.

DESCRIPTION OF LYONET'S ANATOMICAL MICROSCOPE, Fig. 3, Plate VI.

Fig. 3 reprefents the inftrument with which M. Lyonet made his microfcopical and wonderful diffection of the chenille de faule, of which a fpecimen is given in Plate XII. Fig. 1, &c. of this work. This little inftrument needs no further recommendation; aided by it, other obfervers may be enabled to diffect other infects with the fame accuracy as M. Lyonet, and thus advance the knowledge of comparative anatomy, by which alone the characteriftic, nature, and rank of animals, can be truly afcertained.

A B is the anatomical table, which is fupported by the pillar N O; this is fcrewed on the foot C D. The table A B is prevented from turning round, by means of two fteady pins; in this table or board there is a hole G, which is exactly over the center of the mirror E F, that is to reflect the light on the object; the hole G is defigned to receive a flat or concave glafs, on which the objects are to be placed that you defign to examine.

R X Z is an arm formed of feveral balls and fockets, by which means it may be moved in every poffible fituation; it is fixed to the board by means of the fcrew H; the laft arm I Z has a female fcrew, into which a magnifier may be fcrewed as at Z. By means of the fcrew H, a fmall motion may be occafionally given to the arm I Z, for adjufting the lens with accuracy to it's focal diftance from the object.

Another chain of balls is fometimes ufed, carrying a lens to throw light upon the object; the mirror is alfo fo mounted, as to be be taken from it's place at K, and fitted on a clamp, by which it may be fixed to any part of the table A B.

TO USE THE DISSECTING TABLE.

Let the operator ſet with his left ſide near a light window ; the inſtrument being placed on a firm table, the ſide D H towards the ſtomach, the obſervations ſhould be made with the left eye ; this poſition is well adapted for obſerving drawing or writing. In diſſecting, the two elbows are to be ſupported by the table on which the inſtrument reſts, the hands reſting againſt the board A B ; in order to give it greater ſtability, (as a ſmall ſhake, though imperceptible to the naked eye, is very viſible in the microſcope) the diſſecting inſtruments are to be held one in each hand, between the thumb and two fore-fingers. Other circumſtances will be learnt from practice ; and more will be ſaid on the mode of diſſecting ſmall objects in the following chapter.

DESCRIPTION OF DR. WITHERING'S BOTANICAL MICROSCOPE, Fig. 1, Plate VI.

This little inſtrument is repreſented at Fig. 1, Plate VI. It conſiſts of three braſs plates, A, B, C, which are parallel to each other ; the wires D and E are rivetted into the upper and lower plate, which are by this means united to each other ; the middle plate or ſtage is moveable on the aforeſaid wires, by two little ſockets which are fixed to it.

 The

The two upper plates each contain a magnifying lens, but of different powers: one of these confines and keeps in their places the fine point F, the forceps G, and the small knife H.

To use this instrument, unscrew the upper lens, and take out the point, the knife, and the forceps; then screw the lens on again, place the object on the stage, and then move it up or down till you have gained a distinct view of the object, as one lens is made of a shorter focus than the other; and spare lenses, of a still deeper focus, may be had if required. This little microscope is the invention of Dr. Withering, and is described by him in his "Botanical Arrangements." It's principal merit is it's simplicity.

COMMON BOTANICAL MICROSCOPE.

This little instrument is represented at Fig. 2, Plate VI. It appears to me preferable to Dr. Withering's, being equally simple, more extensive in it's application, and the stage unincumbered; though that of M. Lyonet seems better adapted than either to the purposes of dissection.

A B, a small arm, carrying the two magnifiers, one fixed to the upper part as at B, the other to the lower part of the arm at C; these may be used separately or combined together. The arm A B is supported by the square pillar I K, the lower end of which fits into the socket E of the foot F G; the stage D L is made to slide up and down the square pillar; H, a concave mirror for reflecting light on the object.

To

To uſe this microſcope, place the object on the ſtage, reflect the light on it from the concave mirror, and regulate it to the focus, by moving the ſtage nearer to or further from the lens at B. The ivory ſliders paſs through the ſtage; other objects may be fixed in the nippers L M, and then brought under the eye-glaſſes; or they may be laid on one of the glaſſes which fit the ſtage.

The apparatus to this inſtrument conſiſts of three ivory ſliders, a pair of nippers, a pair of forceps, a flat glaſs, and a concave ditto, both fitted to the ſtage.

BOTANICAL MAGNIFIERS.

Since botany has been cultivated with ſo much ardor, it has been found neceſſary to contrive ſome very portable inſtrument, by which the botaniſt might inveſtigate the object of his purſuits, as it riſes before him. Figures 7 and 8, Plate VIII. repreſent two, the moſt convenient of this kind.

In the caſe, Fig. 8, are three lenſes, *g*, *h*, *i*, of different magnifying powers, that all turn up and ſhut into the caſe.

Fig. 7 contains alſo three lenſes, *a*, *b*, *d*, of different foci, which are all made to turn into the caſe, and may be uſed combined or ſeparately.

The three lenſes in themſelves afford three different magnifying powers; by combining two and two we make three more; the three together make a ſeventh magnifying power with three lenſes

lenses. When the three lenses are used together, it is best to turn them into the case, and look through the hole, as this combined magnifying power is so great, that it requires to have a portion of the light which falls on the lenses excluded, in order to attain distinct vision. Further, the eye is also by this means made to coincide more easily with the axis of the glasses.

DESCRIPTION OF A PORTABLE MICROSCOPE AND TELESCOPE, Fig. 1, 2, 3, 4, 5, 6, Plate VIII.

The telescope is one of those which are composed of several sliding drawers or tubes, for the convenience of being put in the pocket; the sliding tubes are made of thin brass, the outside tube of mahogany.

The sliding tubes are contrived to stop when drawn out to a proper length, so that by applying one hand to the outside tube, and the other hand to the end of the smallest tube, the telescope may be at one pull drawn out it's whole length; then any of the tubes (that next the eye is most generally used) may be pushed in gradually while you are looking through, till the object is rendered distinct to the sight.

To make the tubes slide properly, they all pass through short springs or tubes; these springs may be unscrewed from the ends of the sliding tubes by means of the milled edges which project above the tubes, and the tubes taken from each other if required, and the spring set closer if it is too weak.

Fig.

Fig. 5 reprefents the exterior tube of the telefcope, which is to be unfcrewed from the reft, as it does not make any part of the microfcope; the cover k, which protects the object-glafs, ferves alfo as a box to contain the fliders with the objects, and a fmall mirror.

Fig. 4 is a view of this cover when taken off: unfcrew the top part of it, and the mirror, Fig. 6, may be taken out; unfcrew the cover of the lower part, and you will find therein the two circular fliders reprefented at Fig. 1 and 2.

Fig. 3 reprefents the three internal tubes of the telefcope, which conftitute the microfcopic part thereof. Draw the tubes out in the manner that is feen in Fig. 3; then on the infide, but at the lower end of the exterior tube, you will find a fhort tube, which ferves as a ftage to hold the object and fupport the mirror; pull this tube partly out, and turn it, fo that a circular hole which is pierced in it may coincide with a fimilar hole in the exterior tube. This tube is reprefented as drawn out at Fig. 3, the mirror, Fig. 4, placed therein at L M, and the tranfparent flider fixed at N O.

Fig. 1 reprefents the flider with tranfparent objects.

Fig. 2, that with opake. They are made of ivory, and turn on a pin at the center; the flit end of this pin fits on the edge of the tube, which is then to be pufhed up, fo that the lower end of the exterior tube may bear lightly on the upper fide of the flider, agreeable to the view which is given at Fig. 3. Now pufh down the fecond tube till the milled part falls on the milled edge of the exterior tube, being careful of the circular hole in the exterior one. Nothing now remains to be done but to adjust for the focus, which is effected by pushing down the tube T V till the object appears distinct.

The instrument may be used in two ways for transparent objects; first, in a vertical position, when the light is to be thrown on the object by the mirror L M; or it may be examined by looking up directly at the light; in the latter case the mirror must be taken away.

In viewing opake objects the mirror is of no use; as much light as possible must be let fall on them through the circular holes of the tubes.

Any object may be viewed by first pushing the tube I R, and then bringing the tube T to it's focal distance from the object.

A DESCRIPTION OF THOSE PARTS OF A MICROSCOPICAL APPARATUS, WHICH ARE DELINEATED IN Plate IX.

A and B represent the brass cells which contain the magnifiers belonging to the different kinds of compound microscopes. The magnifiers are sometimes contained in a slider like that which is delineated at Fig. 3, Plate V. The lenses of A and B are confined by a small cap; on unscrewing this, the small lens may be taken out and cleaned. The magnifiers A of the lucernal microscope are so contrived, that any two of them may be screwed together, by which means a considerable variety of magnifying power is obtained.

To

To get at the lenſes in the ſlider, Fig. 3, Plate V. take out the two ſcrews which hold on the cover.

C, Plate IX. repreſents the general form of the ſlider-holder. It conſiſts of a cylindrical tube, in which an inner tube is forced up by a ſpring. It is uſed to receive the ivory or any other ſlider, in which the tranſparent objects are placed; theſe are to be ſlid between the two upper plates: the hollow part in one of the plates is deſigned for the glaſs tubes.

D, the condenſing lens and it's tube, which fits into the ſlider-holder C, and may be moved up and down in it. When this piece is puſhed up as far as it will go, it condenſes the light of a candle, which is reflected on it by the plain mirror of the compound microſcope, and ſpreads it uniformly over the object; in this caſe it is beſt adapted to the ſhalloweſt magnifiers. If the deeper lenſes are uſed, it ſhould be drawn down, or rather removed further from the object, that it may concentrate the light in a ſmall compaſs, and thus render it more denſe. The condenſing lens is ſometimes fitted up differently, but the principle being the ſame, it will be eaſy to apply it to uſe, notwithſtanding ſome variations in the mechaniſm.

E, a braſs cone; it fixes under the ſlider-holder. It is uſed to leſſen occaſionally the quantity of light which comes from the mirror to any object.

F, a box, with two flat glaſſes, which may be placed at different diſtances from each other, in order to confine a ſmall living inſect.

G, a ſmall braſs box to hold the ſilver ſpeculum H.

H, a ſmall ſilver concave ſpeculum, deſigned to reflect the light from the mirror on opake objects; it ſhould only be uſed with the ſhallow magnifiers. It is applied in different ways to the compound microſcope; ſometimes to a tube ſimilar to that repreſented at X, which ſlides on the lower part of the body; ſometimes it is ſcrewed into the ring of the piece Q; the pin of this generally fits into one of the holes in the ſtage. When this ſpeculum is uſed, the ſlider-holder ſhould be removed.

I, a fiſh-pan, whereon a ſmall fiſh may be faſtened, in order to view the circulation of the blood; it's tail is to be ſpread acroſs the oblong hole at the ſmalleſt end, and tied faſt by means of the ribbon fixed thereto, by ſhoving the knob which is on the back of it through the ſlit made in the ſtage; the tail of the fiſh may be brought under the lens which is in uſe.

K, a cylindrical piece, intended for the ſolar opake microſcope; by pulling back the ſpiral ſpring, ſmaller or larger objects may be confined in it.

L, a long ſteel wire, with a ſmall pair of pliers at one end, and a ſteel point at the other; the wire ſlips backwards or forwards in a ſpring tube, which is affixed to a joint, at the bottom of which is a pin to fit one of the holes in the ſtage; this piece is uſed to confine ſmall objects.

l, a ſmall ivory cylinder that fits on the pointed end of the ſteel wire L; it is deſigned to receive opake objects. Light-coloured

coloured ones are to be ſtuck on the dark ſide, and vice verſa.

K 2 is a pair of triangular nippers, for taking hold and confining a large object.

M, a convex lens, which fits the ſtage by means of the long pin adhering to it; it is deſigned to collect the light from the ſun or a candle, and to throw them on any object placed on the ſtage: this piece is very little uſed at preſent.

N, a braſs ſlider, into which is fitted a flat piece of glaſs, and a braſs ſlider, containing one or two ſmall concave glaſſes, the others flat; it is deſigned to confine ſmall living objects, and when uſed is to be placed between the two upper plates of the ſlider-holder.

O, a glaſs tube to receive a ſmall fiſh, &c.

P repreſents one of the ivory-ſliders, wherein objects are placed between two pieces of talc, and confined by a braſs ring.

Q, a piece to hold the ſpeculum H; this piece is generally fitted to the microſcopes which are repreſented at Fig. 1 and 2, Plate IV.

R, a pair of forceps, to take up any occaſional object.

S, a camel's hair pencil to bruſh the duſt off the glaſſes; the upper part of the quill is ſcooped out, to take up a drop of any fluid, and place it on either of the glaſſes for examination.

T, an inſtrument for cutting thin tranſverſe ſections of wood. It conſiſts of a wooden baſe, which ſupports four braſs pillars; on the top of the pillars is placed a flat piece of braſs, near the middle of which there is a triangular hole.

A ſharp knife, which moves in a diagonal direction, is fixed on the upper ſide of the afore-mentioned plate, and in ſuch a manner, that the edge always coincides with the ſurface thereof.

The knife is moved backwards and forwards by means of the handle a. The piece of wood is placed in the triangular trough which is under the braſs plate, and is to be kept ſteady therein by a milled ſcrew which is fitted to the trough; the wood is to be preſſed forward for cutting by the micrometer ſcrew b.

The pieces of wood ſhould be applied to this inſtrument immediately on being taken out of the ground, or elſe they ſhould be ſoaked for ſome time in water, to ſoften them ſo that they may not hurt the edge of the knife.

When the edge of the knife is brought in contact with the piece of wood, a ſmall quantity of ſpirits of wine ſhould be poured on the ſurface of the wood, to prevent it's curling up; it will alſo make it adhere to the knife, from which it may be removed by preſſing a piece of blotting-paper on it.

Y is

Y is an appendage to the cutting engine, which is to be uſed inſtead of the micrometer ſcrew, being preferred by ſome practitioners to it. It is placed over the triangular hole, and kept flat down upon the ſurface of the braſs plate, while the piece of wood is preſſed againſt a circular piece of braſs which is on the under ſide of it.

This circular piece of braſs is fixed to a ſcrew, by which it's diſtance from the flat plate on which the knife moves may be regulated.

Z, an ivory box, containing at one end ſpare talc for the ivory ſliders, and at the other ſpare rings, for preſſing the talcs together and confining them to the ſlider.

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CHAP.

CHAP. IV.

GENERAL INSTRUCTIONS FOR USING THE MICROSCOPE, AND PREPARING THE OBJECTS.

AS the advantages which are obtained from any inſtrument are conſiderably increaſed, if it be uſed by a perſon who is maſter of it's properties, attentive to it's adjuſtments, and habituated by practice to the minutiæ of management, it is the deſign of this chapter to point out thoſe circumſtances which require moſt the attention of the obſerver, and to give ſuch plain directions, as may enable him to examine any object with eaſe; to ſhew how he may place it in the beſt point of view, and, if neceſſary, prepare it for obſervation.

A ſmall degree of attention will render the obſerver maſter of every neceſſary rule, and a little practice will make them familiar and habitual: the pains he takes to acquire theſe habits will be rewarded by an increaſing attachment to his inſtrument, and the wonders it diſplays. Let him only perſevere till he has overcome that natural indolence which oppoſes the advancement of every kind of knowledge, and he will ſurely find himſelf moſt amply recompenſed, by the pleaſure of a ſcience that has the unlimited treaſures of INFINITE WISDOM for the object of it's

6 reſearches:

researches: and his mind being ſtrengthened by the victory it has gained, will be more keen in perceiving, and more patient in the inveſtigation of truth.

It has long been a complaint,* that many of thoſe who purchaſe microſcopes are ſo little acquainted with their general and extenſive uſefulneſs, and ſo much at a loſs for objects to examine by them, that after diverting their friends ſome few times with what they find in the ſliders, which generally accompany the inſtrument, or perhaps two or three common objects, the microſcope is laid aſide as of little further value: whereas no inſtrument has yet appeared in the world capable of affording ſo conſtant, various, and ſatisfactory an entertainment to the mind. This complaint will, I hope, be obviated by theſe eſſays, in which I have endeavoured to make the uſe of the microſcope eaſy, point out an immenſe variety of objects, and direct the obſerver how to prepare them for examination.

The ſubject treated of in this chapter naturally divides itſelf into three heads: 1. concerning the neceſſary preparation and adjuſtment of the microſcope; the 2nd, treating of the proper quantity of the light, and beſt method of adapting it to the objects under examination; the 3d, ſhewing how to prepare and preſerve the various objects, that their nature, organization, and texture, may be properly underſtood.

OF

* Baker's Microſcope made Eaſy, p. 51.

OF THE NECESSARY PREPARATION OF THE MICROSCOPE FOR OBSERVATION.

We have in the laſt chapter explained thoſe particulars that conſtitute the difference of one microſcope from another, and ſhewn how each inſtrument is to be uſed, and how the ſeveral parts are to be applied to it. We ſhall now proceed to give ſome general directions applicable to every microſcope. The obſerver is therefore ſuppoſed to have made himſelf maſter of his inſtrument, and to know how to adapt the different parts of the apparatus to their proper places.

The firſt circumſtance neceſſary to be examined into is, whether the different glaſſes belonging to the microſcope are perfectly clean or not; if they are not clean, they muſt be taken out and wiped with a piece of waſh leather, taking care at the ſame time not to ſoil the ſurface of the glaſs with the fingers: in replacing the glaſſes, you muſt alſo be careful not to lay them in an oblique ſituation.

The object ſhould be brought as near the center of the field of view as poſſible, for there only will it be exhibited in the greateſt perfection.

The eye ſhould be moved up and down from the eye-glaſs of a compound microſcope, till you find that ſituation where the largeſt field and moſt diſtinct view of the object is obtained. Every perſon ought to adjuſt the microſcope to his own eye, and not depend upon the ſituation it was placed in by another.

Care

Care muſt be taken not to let the breath fall upon the eye-glaſs, nor to hold that part of the body of the microſcope where the glaſſes are placed with a warm hand, becauſe the damp that is expelled from the metal by the heat will be attracted and condenſed by the glaſſes, and obſtruct the ſight of the object.

The obſerver ſhould always begin with a ſmall magnifying power; with this he will gain an accurate idea of the ſituation and connection of the whole, and will therefore be leſs liable to form any erroneous opinion, when the parts are viewed ſeparately by a deeper lens. By a ſhallow magnifier he will alſo diſcover thoſe parts which merit a further inveſtigation.

Every object ſhould, if poſſible, be examined firſt in that poſition which is moſt natural to it: if this circumſtance is neglected, very inadequate ideas of the ſtructure of the whole, as well as of the connection and uſe of the parts, will be formed. If it be a living animal, care muſt be taken not to ſqueeze, hurt, or diſcompoſe it.

There is a great difference between merely viewing an object by the microſcope, and inveſtigating it's nature: in the firſt we only conſider the magnified repreſentation thereof, in the ſecond we endeavour to analyſe and diſcover it's nature and relation to other objects. In the firſt caſe, we receive the impreſſion of an image formed by the action of the glaſſes; in the ſecond, we form our judgment by inveſtigating this image. It is eaſy to view the image which is offered to the eye, but not ſo eaſy to form a judgment of the things that are ſeen; an extenſive knowledge of the ſubject, great patience, and many experiments, will be found neceſſary for this purpoſe: for there are many circumſtances where the images ſeen may be very ſimilar, though originating from ſubſtances totally different; it is here the penetration of the obſerver will be exerciſed, to diſcover the difference, and avoid error.*

Hence Mr. Baker † cautions us againſt forming an opinion too ſuddenly of any microſcopic object, and not to draw our inferences till after repeated experiments and examinations of the object, in all lights and various poſitions; to paſs no judgment upon things extended by force, or contracted by dryneſs, or in any manner out of a natural ſtate, without making ſuitable allowances.

The true colour of objects cannot be properly determined when viewed through the deepeſt magnifiers; for, as the pores and interſtices of an object are enlarged, according to the magnifying power of the glaſſes made uſe of, the component particles of it's ſubſtance will appear ſeparated many thouſand times farther aſunder than they do to the naked eye: it is, therefore, very probable, that the reflection of the light from theſe particles will be very different, and exhibit different colours.

Some conſideration is alſo neceſſary in forming a judgment of the motion of living creatures, or even of fluids, when ſeen through the microſcope; for as the moving body, and the ſpace wherein it moves, are magnified, the motion will alſo be increaſed.

If

* Fontana ſur les Poiſons, vol. ii. p. 245.
† Baker's Microſcope made Eaſy, p. 62.

If an object is ſo opake as not to ſuffer any light to paſs through it, as much as poſſible muſt be thrown on it's upper ſurface by that part of the apparatus which is peculiarly adapted for opake objects. As the apertures of deep magnifiers are but ſmall, and conſequently admit but little light, they are not proper for the examination of opake objects: this, however, naturally leads us to our ſecond head.

OF THE MANAGEMENT OF THE LIGHT.

The pleaſure ariſing from a juſt view of a microſcopic object, the diſtinctneſs of viſion, &c. depend on a due management of the light, and adapting the quantity of it to the nature of the object, and the focus of the magnifier: therefore an object ſhould always be viewed in various degrees of light. For, as Dr. Hooke has well obſerved, it is difficult to diſtinguiſh in ſome objects between a prominency and a depreſſion, between a ſhadow and a black ſtain; and in colour, between a reflection and a whiteneſs: a truth which the reader will find fully exemplified in the examination of the eye of the libella, and other flies, which will be found to appear exceedingly different in one poſition of the light from what they do in another.

The brightneſs of an object depends on the quantity of light; the diſtinctneſs of viſion, on regulating the quantity to the object; for ſome will be loſt, and drowned, as it were, in a quantity of light that is ſcarce ſufficient to render another viſible. A ſtrong light may be thrown on an object various ways; firſt, by means of the ſun and a convex lens; for this purpoſe, place the microſcope about three feet from a ſouthern window; take a deep convex lens, that is mounted in a ſemicircle and fixed on a ſtand, ſo that it's poſition may be eaſily varied; place this lens between the object and the window, ſo that it may collect a conſiderable number of the ſolar rays, and refract them on the object, or the mirror of the microſcope. If the light thus collected from the ſun is too powerful, it may be tempered, by placing a piece of oiled paper, or a glaſs lightly greyed, between the object and the lens: by this means, a convenient degree of light may be obtained, and diffuſed in an equal manner over the whole ſurface of an object, a circumſtance that ſhould be particularly attended to; for if the light be thrown in an irregular manner, that is, larger portions of it on ſome parts than on others, it will not be diſtinctly exhibited.

Where the ſolar light is preferred, it will be found very convenient to darken the room, and to reflect the rays of the ſun on the above-mentioned lens, by means of the mirror of a ſolar microſcope fitted to the window-ſhutter; for by this apparatus the obſerver will be enabled to preſerve the light on his object, notwithſtanding the motion of the ſun.

Cutting off the adventitious light as much as poſſible, by darkening the room where you are uſing the microſcope, and admitting the light only through a hole in the window-ſhutter, or at moſt keeping one window only open, will alſo be found very conducive towards producing a diſtinct view of the object.

As the motion of the ſun, and the variable ſtate of our atmoſphere, renders ſolar obſervations both tedious and inconvenient, it will be proper for the obſerver to be furniſhed with a large tin lanthorn,

lanthorn, made ſomething like the common magic lanthorn, fit to contain one of Argand's lamps.* The lanthorn ſhould have an aperture in the front, that may be moved up and down, and capable of holding a lens; by this a pleaſing uniform denſe light may be eaſily procured. The lamp ſhould move on a rod, that it may be readily elevated or depreſſed. The lanthorn may be uſed for many other purpoſes, as for viewing of pictures, exhibiting microſcopic objects on a ſcreen, &c.

Many tranſparent objects are ſeen beſt in a weak light; among theſe we may place the prepared eyes of flies and animalcula in fluids; the quantity of light from a lamp or candle may be leſſened by removing the microſcope to a greater diſtance from them, or it may be more effectually leſſened by cutting off a part of the cone of rays that fall on the object, either by placing the cone, Fig. E, Plate IX. under the ſtage, or by forming circular apertures of black paper, of different ſizes, and placing either a larger or ſmaller one on the reflecting mirror, as occaſion may require.

There is an oblique ſituation of the mirrors, and conſequently of the light, which is eaſily diſcovered by practice, but for which no general rule can be given, that will exhibit an object more beautifully and more diſtinctly than any other poſition, ſhewing the ſurface, as well as thoſe parts through which the light is tranſmitted.

A better

* The lamp ſhould not be of the fountain kind, becauſe the rarefaction of the air in the lanthorn will often force the oil over.

A better view of moſt objects is obtained by a candle, or lamp, than by day-light; it is more eaſy to modify the former than the latter, and to throw it on the object with different degrees of denſity. From what has been ſaid, the reader will have obſerved the importance of being able to examine the object in the greateſt variety of poſitions and appearances, which cannot be effected with equal convenience by any microſcope but the improved lucernal.

OF THE PREPARATION OF OBJECTS FOR THE MICROSCOPE.

In the preparation of objects, no man was more ſucceſsful nor more indefatigable than Swammerdam, in minutely anatomizing, in patient inveſtigation, and in curiouſly exhibiting the minute wonders of creation; he ſtands unrivalled, far exceeding all thoſe that preceded, as well as thoſe which have ſucceeded him. Deeply impreſſed and warmly animated by the amazing ſcenes that he continually diſcovered, his zeal in purſuit of truth was not to be abated by diſappointment, or alarmed by difficulty; and was never contented till he had attained a rational and clear idea of the organization of the object, whoſe ſtructure he wiſhed to explore.

We have only to regret that we are ignorant of the methods he employed. To diſcover theſe, the great Boerhaave examined with a ſcrupulous attention all the letters and manuſcripts of Swammerdam, and has communicated the reſult of his reſearches, which, though but ſmall, may enable us to form ſome idea of this great labourer in the field of ſcience.

For

For diffecting of fmall infects he had a brafs table, which was made by that excellent artift S. Muffchenbrock; to this table were affixed two brafs arms, moveable at pleafure to any part of it. The upper portion of thefe arms was conftructed fo as to have a flow vertical motion, by which means the operator could readily alter their height, as he faw moft convenient to his purpofe; the office of one of thefe arms was to hold the little bodies, and that of the other to apply the lens or microfcope.

His microfcopes, or lenfes, were of various foci, diameters, and fizes, from the leaft to the greateft, and the beft that could be procured in regard to the exactnefs of the workmanfhip, and tranfparency of the fubftance. His way was, to begin his obfervations with the fmalleft magnifiers, and from thence proceed by degrees to the greateft. By nature and ufe he was fo incomparably dexterous in the management of thefe inftruments, that he made every obfervation fubfervient to the next, and all tend to confirm each other, and complete the defcription.

His chief art feems to have been in conftructing very fine fciffars, and giving them an extreme fharpnefs: thefe he made ufe of to cut very minute objects, becaufe they diffected them equally; whereas knives and lancets, let them be ever fo fine and fharp, are apt to diforder delicate fubftances, as in going through them, they generally draw after and difplace fome of the filaments. His knives, lancets, and ftyles, were fo very fine, that he could not fee to fharpen them without the affiftance of a magnifying glafs; but with them he could diffect the inteftines of bees with the fame accuracy and diftinctnefs that the moft celebrated anatomift does thofe of large animals. He was particularly dexterous in the management of ſmall glaſs tubes, which were no thicker than a briſtle, and drawn to a very fine point at one end, but thicker at the other. Theſe he made uſe of to ſhew and blow up the ſmalleſt veſſels diſcovered by the microſcope, to trace, diſtinguiſh, ſeparate their courſes and communications, or to inject them with very ſubtil coloured liquors.

He uſed to ſuffocate the inſects in ſpirit of wine, in water, or ſpirit of turpentine, and likewiſe preſerved them for ſome time in theſe liquids; by which means he kept the parts from putreſying, and conſequently collapſing and mixing together; and added to them beſides ſuch ſtrength and firmneſs, as rendered the diſſections more eaſy and agreeable. When he had divided tranſverſly with his fine ſciſſars the little creature he intended to examine, and had carefully noted every thing that appeared without further diſſection, he then proceeded to extract the viſcera in a very cautious and leiſurely manner, with other inſtruments of great fineneſs; firſt taking care to waſh away and ſeparate, with very fine pencils, the fat with which inſects are very plentifully ſupplied, and which always prejudice the internal parts before it can be extracted. This operation is beſt performed upon inſects while in the nympha ſtate.

Sometimes he put into water the delicate viſcera of the inſects he had ſuffocated; and then ſhaking them gently, he procured himſelf an opportunity of examining them, eſpecially the air veſſels, which by this means he could ſeparate from all the other parts whole and entire, to the great admiration of all thoſe who beheld them; as theſe veſſels are not to be diſtinctly ſeen in any other manner, or indeed ſeen at all without damaging them, he often

often made use of water, injected by a syringe, to cleanse thoroughly the internal parts, then blew them up with air and dried them, by which means he rendered them durable, and fit for examination at a proper opportunity. Sometimes he has examined with the greatest success, and made the most important discoveries, in insects that he had preserved in balsam, and kept for years together in that condition. Again, he has frequently made punctures in other insects with a very fine needle, and after squeezing out all their moisture through the holes made in this manner, he filled them with air, by means of very slender glass tubes, then dried them in the shade, and last of all anointed them with oil of spike, in which a little rosin had been dissolved, by which means they retain their proper forms a long time. He had a singular secret, whereby he could so preserve the nerves of insects, that they used to continue as limber and perspicuous as ever they had been.

He used to make a small puncture or incision in the tail of worms, and after having gently and with great patience squeezed out all their humours, and great part of their viscera, he then injected them with wax, so as to give and continue to them all the appearance of healthy vigorous living creatures. He discovered that the fat of all insects was perfectly dissolvible in oil of turpentine; thus he was enabled to shew the viscera plainly; only after this dissolution he used to cleanse and wash them well and often in clean water. He frequently spent whole days in thus cleansing a single caterpillar of it's fat, in order to discover the true construction of this insect's heart. His singular sagacity in stripping off the skin of caterpillars, that were upon the point of spinning their cones, deserves particular notice. This he effected, by letting them drop by their threads into ſcalding water, and ſuddenly withdrawing them; for by this means the epidermis peeled off very eaſily; and when this was done, he put them into diſtilled vinegar and ſpirit of wine, mixed together in equal portions, which, by giving a proper firmneſs to the parts, gave him an opportunity of ſeparating them, with very little trouble, from the exuviæ, or ſkins, without any danger to the parts; ſo that by this contrivance, the nymph could be ſhewn to be wrapped up in the caterpillar, and the butterfly in the nymph. Thoſe who look into the works of Swammerdam, will be abundantly gratified, whether they conſider his immenſe labour and unremitted ardour in theſe purſuits, or his wonderful devotion and piety. On one hand, his genius urged him to examine the miracles of the great Creator in his natural productions; whilſt on the other, the love of that ſame all-perfect Being rooted in his mind, ſtruggled hard to perſuade him that God alone, and not the creatures, were worthy of his reſearches, love, and attention.

M. Lyonet always drowned firſt thoſe inſects he intended to anatomize, as by this means he was enabled to preſerve both the ſoftneſs and tranſparency of the parts. If the inſect, &c. is very ſmall, ex. gr. one-tenth of an inch, or a little more in length, it ſhould be diſſected in water, on a glaſs which is a little concave; if after a few days there is any fear that the inſect will putrefy, it ſhould be placed in weak ſpirit of wine, inſtead of water. In order to fix the little creature, it muſt be ſuffered to dry, and then be faſtened by a piece of ſoft wax; after which it may be again covered with water.

Larger

Larger objects require a different process; they should be placed in a small trough of thin wood; the bottom of a common chip box will answer very well, by surrounding the edge of it with soft wax, to keep in the water or spirit of wine. The insect is then to be opened, and if the parts are soft like those of a caterpillar, they should be turned back and fixed to the trough by small pins; the pins are to be set by a pair of small nippers: the skin being stretched at the same instant by another pair of finer forceps, the insect must then be placed in water, and dissected therein, and after two or three days it should be covered with spirits of wine, which should be renewed occasionally; by this means the subject is preserved in perfection, and it's parts may be gradually unfolded, without any other change being perceived than that the soft elastic parts become stiff and opake, and some others lose their colour.

M. Lyonet used the following instruments in his curious dissection of the chenille de saule. As small a pair of scissars as could be made, the arms long and fine; a small and sharp knife, the end brought to a point; a pair of forceps, the ends of which had been so adjusted, that they would easily lay hold of a spider's thread or a grain of sand. But the most useful instruments were two fine steel needles, fixed in small wooden handles, about $2\frac{1}{4}$ of an inch in length.

An observation of Dr. Hooke's may be very useful, if attended to, for fixing objects intended to be designed by the microscope. He found no creature more troublesome to draw than the ant or pismire, not being able to get the body quiet in a natural posture. If, when alive, it's feet were fettered with wax or glue, it would ſo twiſt and twine it's body, that it was impoſſible any way to get a good view of it; if it was killed, the body was ſo ſmall, that the ſhape was often ſpoiled before it could be examined. It is the nature of many minute bodies, when their life is deſtroyed, for the parts to ſhrivel up immediately; this is very obſervable in many ſmall plants, as well as in inſects; the ſurface of theſe ſmall bodies, if porous, being affected by almoſt every change of the air; and this is particularly the caſe with the ant. But if the little creature is dropped in well rectified ſpirit of wine, it is immediately killed; and when taken out, the ſpirit of wine evaporates, leaves the animal dry and in it's natural poſture; or at leaſt ſo conſtituted, that you may eaſily place it with a pin in what poſture you pleaſe.*

Having thus given a general account of the methods uſed by Swammerdam and Lyonet, in their examination and diſſection of inſects, we ſhall proceed to ſhew how to prepare ſeveral of their parts for the microſcope, beginning with the WINGS. Many of theſe are ſo tranſparent and clear, as to require no previous preparation; but the under wings of thoſe that are covered with elytra or cruſtaceous caſes, being conſtantly folded up when at reſt, they muſt be unfolded before they can be examined by the microſcope: for this purpoſe, a conſiderable ſhare of dexterity, and ſome patience is neceſſary; for the natural ſpring of the wings is ſo ſtrong, that they immediately fold themſelves again, except they are carefully prevented.

One of the moſt curious and beautiful wings of this kind is that of the EARWIG, of which we have given a drawing, Plate XIV. Fig.

* Hooke's Micrographia, p. 203.

Fig. 1. When expanded it is a tolerably large wing, yet folds up under a caſe not one-eighth part of it's ſize. It is very difficult to unfold this wing, on account of it's curious texture. They are beſt opened immediately after the inſect is killed. Hold the earwig by the thorax, between the finger and thumb; then with a blunt pointed pin endeavour gently to open it, by ſpreading it over the fore-finger, gradually ſliding at the ſame time the thumb over it. When the wing is fully expanded, ſeparate it from the inſect by a ſharp knife, or a pair of ſciſſars. The wing ſhould be preſſed for ſome time between the thumb and finger before it be removed; it may then be placed between two pieces of paper, and again preſſed for at leaſt an hour: after which, it may be put between the tales without any danger of folding up again.

The wings of the notonecta, and other water inſects, as well as moſt ſpecies of the grylli, require equal care and delicacy with that of the earwig to diſplay them properly.

The WINGS OF BUTTERFLIES AND MOTHS are covered with very minute ſcales or feathers, that afford a beautiful object for the microſcope; near the thorax, the ſhoulder, the middle of the wing, and the fringes of the wings, they are generally intermixed with hair. The ſcales from one part, alſo, often differ in ſhape from thoſe of another; they may be firſt ſcraped off or looſened from the wing with a knife, and then bruſh them into a piece of paper with a camel's hair pencil; the ſcales may be ſeparated from the hairs with the aſſiſtance of a common magnifying glaſs.

The proboſcis of inſects, as of the gnat, the tabanus, &c. requires much attention, and conſiderable care, to be diſſected properly

properly for the microſcope; and many muſt be prepared before the obſerver decides upon the ſituation and ſhape of the parts; he will often alſo be able to unfold in one ſpecimen ſome parts that he can ſcarce diſcover in another. It is well known that the COLLECTOR OF THE BEE forms a moſt beautiful object; a figure of it is given in Plate XIII. Fig. 3. In it is diſplayed a moſt wonderful mechaniſm, admirably adapted to collect and extract the various ſweets from flowers, &c. To prepare this, it ſhould firſt be carefully waſhed with ſpirit of turpentine, by which means it will be freed from the unctuous and melliferous particles which uſually adhere to it; when dry, it muſt be again waſhed with a camel's hair pencil, to diſengage and bring forward the ſmall hairs which form one part of it's microſcopic beauty.

The caſe which encloſes THE STING OF THE BEE, the waſp, and the hornet, are ſo hard, that it is very difficult to extract them without breaking or otherwiſe injuring them. It will be found, perhaps, the beſt way to ſoak the caſe and the reſt of the apparatus for ſome time in ſpirit of wine or turpentine, then lay it on a piece of clean paper, and with a blunt knife draw out the ſting, holding the ſheath by the nail of the finger, or by any blunt inſtrument; great care is requiſite to preſerve the feelers, which when cleaned add much to the beauty of the object.

The EYES OF THE LIBELLULA and different flies, of the lobſter, &c. are firſt to be cleaned from the blood and other extraneous matter, they ſhould then be ſoaked in water for ſome days, after which you may ſeparate one or two ſkins from the eye, which, if they remain, render it too opake and confuſed;

6 ſome

fome care is, however, requifite in this feparation, otherwife the fkin may be made too thin, fo as not to enable you to form an accurate idea of it's organization.

The exuviæ of infects are in general a very pleafing object, and require but little preparation. If they are curled or bent up, keep them in a moift atmofphere for a few hours, and they will foon become fo relaxed that you may extend them with eafe to their natural pofitions. The fteam of warm water anfwers the purpofe very well.

The beard of the lepas anitifera is to be foaked in clean foft water, and frequently brufhed while wet with a camel's hair pencil; it may then be left to dry: after which it muft be again brufhed with a dry pencil, to difengage and feparate the hairs, which are apt to adhere together. A picture of this object is reprefented in Plate XIII. Fig. 1.

To view the MUSCULAR FIBRES, take a very thin piece of dried flefh, and lay it upon a flip of glafs, and moiften it with warm water; when this is evaporated, the veffels will appear plain and more vifible, and by repeated macerations the parts may be further difengaged.

To examine fat, brains, and other fimilar fubftances, we are advifed by Dr. Hooke to render the furface fmooth, by preffing it between two thin plates of flat glafs; by which the fubftance will be made much thinner and more tranfparent; otherwife the parts lying thick one upon the other, it appears confufed and indiftinct.

Some

Some fubftances are, however, fo organized, that if their peculiar form is altered, the parts we wifh to difcover are deftroyed; fuch as nerves, tendons, mufcular fibres, pith of wood, &c. many of thefe are beft to be examined while floating in fome convenient tranfparent fluid. For inftance, very few of the fibres of any of the mufcles can be difcovered when they are viewed in the open air; but if placed in water or oil, great part of their wonderful fabric may be difcovered. If the thread of a ligament is viewed in this manner, it will be feen to confift of an indefinite number of fmooth round threads lying clofe together.

Objects of an elaftic nature fhould be pulled or ftretched out while they are under the microfcope, that the texture and nature of thofe parts, whofe figure is altered by being thus pulled out, may be more fully difcovered.

To examine BONES with the microfcope. Thefe fhould firft be viewed as opake objects; afterwards, by procuring thin fections, they fhould be looked at as if tranfparent. The fections fhould be cut in all directions, and be well wafhed and cleaned; a degree of maceration will be ufeful in fome cafes. Or the bones may be put in a clear fire till they are red hot, and then taken out; by this means the bony cells will appear more confpicuous and vifible, being freed from extraneous matter.

To examine the PORES OF THE SKIN. Firft, cut or pare off with a razor as thin a flice as poffible of the upper fkin; then cut a fecond from the fame place; apply the laft to the microfcope.

THE

THE SCALES OF FISH ſhould be ſoaked in water for a few days, and then be carefully rubbed, to clean them from the ſkin and dirt which may adhere to them.

To procure the ſcales of the eel, which are a great curioſity, and the more ſo as the eel was not known to have any till they were diſcovered by the microſcope. Take a piece of the ſkin of the eel that grows on the ſide, and while it is moiſt ſpread it on a piece of glaſs, that it may dry very ſmooth; when thus dried, the ſurface will appear all over dimpled or pitted by the ſcales, which lie under a ſort of cuticle or thin ſkin; this ſkin may be raiſed with the ſharp point of a penknife, together with the ſcales which will then eaſily ſlip out, and thus you may procure as many as you pleaſe.*

On the lizard, the guana, &c. are two ſkins; one of theſe is very tranſparent, the other is thicker and more opake; by ſeparating theſe we procure two beautiful objects.

THE LEAVES of many trees, and ſome plants, when diſſected, form a very pleaſing object. To diſſect them, take a few of the moſt perfect leaves you can find, and place them in a pan with clean water; let them remain three weeks or a month without changing the water; then take them up, and try if they feel very ſoft, and appear almoſt rotten; if ſo, they are ſufficiently ſoaked. You are then to lay them on a flat board, and holding them by the ſtalk, draw the edge of a knife over the upper ſide of the leaf, which will take off moſt of the ſkin; turn the leaf, and do

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* Martin's Micrographia Nova, p. 29.

the ſame with the under ſide. When the ſkin is taken off on both ſides, waſh out the pulpy matter, and the fibres will be exhibited in a beautiful manner. By ſlitting the ſtalk you may ſeparate the anatomized leaf into two parts. The ſkins that are peeled from the fibres will alſo make a very good object. The autumn is the beſt ſeaſon for the foregoing operation, as the fibres of the leaves are much ſtronger at that ſeaſon, and leſs liable to break.

Ores and minerals ſhould all be carefully waſhed and bruſhed with a ſmall bruſh, to remove any extraneous matter that may adhere to them. Shells may be ground down on a hone, by which their internal ſtructure will be diſplayed.

TO VIEW THE CIRCULATION AND EXAMINE THE PARTICLES OF THE BLOOD. The principal point the obſerver muſt aim at, in order to view the circulation of the blood, is to procure thoſe ſmall animals or inſects that are moſt tranſparent, that by ſeeing through them he may be enabled to diſcover what paſſes within them. The particular kinds beſt adapted for the purpoſe will be enumerated in the deſcriptive catalogue at the end of this work.

If a ſmall eel is uſed for this purpoſe, it muſt be cleanſed from the ſlime which covers it; after which it may be put either in the fiſh-pan, or a glaſs tube filled with water, and then placed under the microſcope. If the eel is ſmall enough, the circulation may be viewed in the moſt ſatisfactory manner. Leeuvenhoeck has given, in his 112th epiſtle, an accurate deſcription of the blood-veſſels in part of the tail of an eel. The ſame figure may alſo be eenin my fa ther's Treatiſe on the Microſcope. The tail of any other

other ſmall fiſh may be applied in the ſame manner, or tied on a ſlip of flat glaſs, and be thus laid before the microſcope. Flounders, eels, and gudgeons, are to be had almoſt at any time in London.—N. B. By filling the tube with water, when an eel is uſed, it will in a great meaſure prevent the ſliminеſs of the eel from ſoiling the glaſs.

To view the particles of the blood, take a ſmall drop of it when warm, and ſpread it as thin as poſſible upon a flat piece of glaſs. By diluting it a little with warm water, ſome of the larger globules will divide from the ſmaller, and many of them will be ſubdivided into ſmaller ones: or a little drop of blood may be put into a capillary tube of glaſs, and be then preſented before the microſcope. Mr. Baker adviſes the mixing the blood with a little warm milk, which, he ſays, will cauſe the unbroken particles to be very diſtinctly ſeen; but the moſt accurate obſerver of theſe particles was Mr. Hewſon, and he ſays, they have been termed globules with great impropriety, being in reality flat bodies. When we conſider how many ingenious perſons have been employed in examining the blood with the beſt microſcopes, it appears ſurprizing that the figure of the particles ſhould be miſtaken; but the wonder is leſſened when we reflect how many obvious things are overlooked, till our attention is particularly directed towards them; and beſides, the blood in the human ſubject, and in quadrupeds, is ſo full of theſe particles, that it is with great difficulty they can be ſeen ſeparate until the blood is diluted. It was by diſcovering a proper method to effect this that Mr. Hewſon was indebted for his ſucceſs. He diluted the particles with ſerum, in which they would remain undiſſolved, and as he could dilute them to any degree with the ſerum, he could eaſily

 examine

examine the particles diſtinct from each other; ex. gr. take a ſmall quantity of the ſerum of the human blood, and ſhake a piece of craſſamentum in it, till it is coloured a little with the red particles; then with a ſoft hair pencil ſpread a little of it on a piece of thin glaſs, and place this glaſs under the microſcope, in ſuch a manner as not to be quite horizontal, but rather higher at one end than the other; by which means, the ſerum will flow from the higher to the lower extremity, and as it flows ſome of the particles will be found to ſwim on their flat ſides, and will appear to have a dark ſpot in the middle: others will turn over from one ſide to the other, as they roll down the glaſs.

An apparatus has been deſcribed by ſeveral authors for viewing the circulation of the blood in the meſentery of a frog; by this inſtrument curioſity may be gratified; but it is at the expence of humanity, and that without any probability of extending the bounds of ſcience, or promoting the good of mankind. No rational excuſe can be given for depriving a poor creature of it's life, the greateſt boon that nature can beſtow, or even to put it in pain, but an object of utility; he who does from hence procure benefits for the higher orders of animated beings, may be permitted to exert the power which he poſſeſſes over the inferior orders of life. But he greatly errs, if he thinks theſe powers may be uſed to gratify wanton curioſity, or the ſports of an inordinate fancy.

"——— God, when he charg'd the Jew
T' aſſiſt his foe's down-fallen beaſt to riſe;
And when the buſh-exploring boy, that ſeiz'd
The young, to let the parent bird go free,

Prov'd

Prov'd he not plainly that his meaner works
Are yet his care, and have an int'reſt all—
ALL in the univerſal Father's love?"

* * * * * * * * * *

"I would not enter on my liſt of friends
(Tho' grac'd with poliſh'd manners and fine ſenſe,
Yet wanting ſenſibility) the man
Who needleſsly ſets foot upon a worm.
An inadvertent ſtep may cruſh the ſnail
That crawls at ev'ning in the public path;
But he that has humanity, forewarn'd,
Will tread aſide, and let the reptile live."

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"A neceſſary act incurs no blame:
Not ſo when held within their proper bounds,
And guiltleſs of offence, they range the air,
Or take their paſtime in the ſpacious field:—
There they are privileg'd. And he that hunts,
Or harms them there, is guilty of a wrong."

COWPER'S POEMS, vol. 2, b. vi.

OF

OF ANIMALCULA IN INFUSIONS, &c.

Theſe require little or no preparation. The firſt object is to procure them, the ſecond to render them viſible by the microſcope. A few obſervations, however, may be of uſe. Many drops of water may be examined before any can be found; ſo that if the obſerver be too haſty, he may be eaſily diſappointed, though other parts of the ſame water may be fully peopled by them.

The ſurface of infuſed liquors is generally covered with a thin pelicule, which is eaſily broken, but acquires thickneſs by ſtanding; the greateſt number of animalcula are generally to be found in this ſuperficial film.

In ſome caſes it is neceſſary to dilute the infuſions; but this is always to be done with diſtilled water, and that water ſhould be examined in the microſcope before it is made uſe of: the neglect of this precaution has been a ſource of many errors.

Animalcula are in general better obſerved when the water is a little evaporated, as the eye is not confuſed, nor the attention diverted by a few objects. To ſeparate one or two animalcula from the reſt, place a ſmall drop of water on the glaſs near that of the infuſion; make a ſmall neck, or gutter, between the two drops with a pin, which will join them together; then the inſtant you perceive that an animalculum has traverſed the neck or gutter, and entered the drop, cut off the communication between the two drops.

To

To procure the eels in paſte, boil a little flour and water, till it comes to the conſiſtence of ſuch a paſte as is uſed by the bookbinders; expoſe it to the air in an open veſſel, and beat it together from time to time, to prevent the ſurface thereof growing hard or mouldy: after a few days it will turn ſour; then, if it be examined with attention, you will find myriads of eels on the ſurface.

To preſerve theſe eels all the year, you muſt keep the ſurface of the paſte moiſt, by putting a little water or freſh paſte from time to time to the other. Mr. Baker adviſes a drop or two of vinegar to be put into the paſte now and then. The continual motion of the eels, while the ſurface is moiſt, will prevent the paſte getting mouldy. Apply them to the microſcope upon a ſlip of flat glaſs, firſt putting on it a drop of water, taken up by the head of a pin, for them to ſwim in.

To make an infuſion of pepper. Bruiſe as much common black pepper as will cover the bottom of an open jar, and lay it thereon about half an inch thick; pour as much ſoft water in the veſſel as will riſe about an inch above the pepper. The pepper and water are then to be well ſhook together; after which they muſt not be ſtirred, but be left expoſed to the air for a few days, when a thin pelicule will be formed on the ſurface of the water, containing millions of animalcula.

The obſerver ſhould be careful not to form a judgment of the nature, the uſe, and the operations of ſmall animalcula, from ideas which he has acquired by conſidering the properties of larger animals: for, by the aſſiſtance of glaſſes, we are introduced as it were

were into a new world, and become acquainted not only with a few unknown animals, but with numerous species thereof, which are so singular in their formation and habits, that without the cleareſt proofs even their exiſtence would not be credited; and while they afford freſh inſtances of the Creator's power, they alſo give further proofs of the limits and weakneſs of the human underſtanding.

DIRECTIONS FOR FINDING, FEEDING, AND PRESERVING THE POLYPES.

Theſe little animals are to be found upon all ſorts of aquatic plants, upon branches of trees, pieces of board, rotten leaves, ſtones, and other ſubſtances that lie in the water; they are alſo to be found upon the bodies of ſeveral aquatic animals, as on the water-ſnail, on ſeveral ſpecies of the monoculus, &c. they generally fix themſelves to theſe by their tail, ſo that it is a very good method when you are in ſearch of polypes, to take up a great many of theſe ſubſtances, and put them in a glaſs full of water. If there be any polypes adhering to theſe, you will ſoon perceive them ſtretching out their arms, eſpecially if the glaſs is let ſtand ſtill for a while without moving it; for the polypes, which contract themſelves on being firſt taken out of the water, will ſoon extend themſelves again when they are at reſt.

They are to be ſought for in the corners of ditches, puddles, and ponds, being generally driven into theſe with the pieces of wood or leaves to which they have attached themſelves. They may, therefore, be ſought for in vain at one period, in a place where at another you ſhall find them in abundance. They are more eaſily perceived in a ditch when the ſun ſhines on the bottom, than at another time. They are ſeldom to be met with in winter: about the month of May they begin to appear and increaſe.

They are generally to be found in waters which move gently; for neither a rapid ſtream, nor ſtagnant waters, ever abound with them. As they are always fixed to ſome ſubſtance by their tails, and are very rarely looſe in the water, taking up water only can ſignify but little; a circumſtance which has probably been the cauſe of much diſappointment to thoſe who have ſearched for them.

The green polypes are generally about half an inch long when ſtretched out; thoſe of the ſecond and third ſort are between three quarters of an inch and an inch in length; though ſome are to be found at times which are an inch and a half long.

Heat and cold has the ſame effect upon theſe little creatures, that it has upon thoſe of a larger ſize. They are animated and enlivened by heat, whereas cold renders them faint and languid; they ſhould therefore be kept in ſuch a degree of heat, that the water may not be below temperate.

It is convenient for many experiments to ſuſpend a polype from the ſurface of the water. To effect this, take a hair pencil in one hand, and hold a pointed quill in the other; with the pencil looſen the polype from the receiver in which it is kept, and gradually raiſe it near the top of the water, ſo that the anterior end may be next the point of the pencil; then lift it out of

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the water, and keep it ſo for a minute; after which, thruſt the point of the pencil, together with the anterior end, by little and little under water, until no more than about half the tenth of an inch of the polype's tail remains above it's ſurface; at this inſtant, with the pointed quill remove that part of the polype from the pencil which is already in the water, and at the ſame time blowing againſt the polype, it will be looſened, and remain out of the water.

When the polypes were firſt diſcovered, Mr. Trembley had ſome difficulty to find out that food which was proper for them; but he ſoon diſcovered, that a ſmall ſpecies of the millepede anſwered the purpoſe very well: the pulices aquatices have alſo been recommended. The ſmall red worms, which are to be found on the mud-banks of the Thames, particularly near the ſhores, anſwer the purpoſe alſo; they are eaſily found when the tide is out, when they riſe in ſuch ſwarms on the ſurface of the mud, that it appears of a red colour. Theſe worms are an excellent food for the polype. If a ſufficient quantity is gathered in November, and put into a large glaſs full of water, with three or four inches of earth at the bottom, you will have a ſupply for the polypes all the winter. They may alſo be fed with common worms, with the larva of gnats and other inſects, and even with butchers meat, &c. if it be cut ſmall enough.

River, or any ſoft water, agrees with them; but that which is hard and ſharp prevents their thriving, and generally kills them in a few days. The worms with which they are fed ſhould be always cleanſed before you feed the polypes with them.

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The polypes are commonly infested with little lice; from these it is necessary to free them, in order to preserve your polypes in a good state of health. They may be cleansed from the lice by rubbing them with a hair pencil; this cannot be easily done, without they have affixed themselves to some substance: so that if they are suspended from the surface of the water, you must endeavour to get them to fix themselves to a piece of packthread; when they are fastened thereto, you may then rub them with a hair pencil, without loosening them from the thread.

The lice which torment the polype are not only very numerous, but they are also very large relative to it's size: they may be said to be nearly as large with respect to them, as a common beetle is to us. If they are not rubbed off, they soon cover their bodies, and in a little time totally destroy them.

To preserve the polypes in health, it is also necessary often to change the water they are kept in, and particularly after they have done eating; it is not sufficient to pour the water off, all the polypes should be taken out, and the bottom and sides of the vessel rubbed from the slimy sediment adhering thereto; this is caused by their fæces, and is fatal to them if not cleaned away. The fæces often occasion a species of mortification, which increases every day; it's progress may be stopped by cutting off the diseased part. To take them out, first loosen their tails from the sides or bottom of the glass; then take them up one by one, with a quill cut in the shape of a scoop, and place them in another glass with clean water; if they cling to the quill, let it remain a minute or two in water, and they will soon disengage themselves.

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They are preserved beſt in large glaſſes, that hold three or four quarts of water; for in a glaſs of this ſize the water need not be renewed ſo often, particularly if the fæces are taken out from time to time with the feathered end of a pen, to which it readily adheres; and further, the trouble of feeding each individual is in ſome meaſure ſaved, as you need only throw in a parcel of worms, and let the polypes divide them for themſelves.

To obſerve with accuracy the various habitudes, poſitions, &c. of this little animal, it will be neceſſary to place ſome of them in narrow cylindrical glaſſes; then, by means of the microſcope, Fig. 3, Plate VI. you may obſerve it exerting all it's actions of life with eaſe and convenience; the facility with which the lens of the fore-mentioned microſcope may be moved and placed in any direction, renders it a moſt convenient inſtrument for examining any object that requires to be viewed in water.

It is alſo very proper to dry ſome of them, and place them between talcs in a ſlider; this however requires ſome dexterity, and a little practice; tho' when executed with ſucceſs, it fully rewards the pains of the obſerver. Chuſe a proper polype, and put it in a ſmall concave lens, with a drop of water; when it is extended, and the tail fixed, pour off a little of the water, and then plunge it with the concave into ſome ſpirit of wine contained in the bowl of a large ſpoon; by this it is inſtantly killed, the arms and body contracting more or leſs; rub it gently, while in ſpirits, with a ſmall hair pencil, to cleanſe it from the lice.

The difficulty now begins; for the parts of the polype, on being taken out of the ſpirits, immediately cling together, ſo that it it is not practicable to extend the body, and separate the arms on the talc, without tearing them to pieces: so that the only method is, to adjust them upon the talc while in the spirits; this may be done by slipping the talc under the body of the polype, while it lies in the spirits, and displaying it's arms thereon by the small hair pencil and a pair of nippers; then lift the talc, with the polype upon it, out of the spirits; take hold of it with the nippers in the left hand, dip the pencil in the spirits with the right hand, and therewith dispose of the several parts, that they may lie in a convenient manner, at the same time brushing away any lice that may be seen upon the talc; now let it dry, which it does in a little time, and place the talc carefully in the hole of the slider. To prevent the upper talc and ring pressing on the polype, you must cut three pieces of cork, about the bigness of a pin's head, and the depth of the polype, and fix them by gum in a triangular position, partly on the edges of the said talc, partly to the sides of the ivory hole itself; the upper talc may then be laid on these corks, and pressed down by the ring as usual. *

OF VEGETABLES.

I wish I could give the reader a satisfactory account of all the preparations which are requisite to fit for the microscope the objects of the vegetable kingdom. Dr. Hill is the only writer who has handled this subject. I shall, therefore, extract from his "Treatise on the Construction of Timber," what he has said; this, together with the improvements I have made on the cutting

* Baker on the Polypes.

cutting engine, will enable the reader to purſue the ſubject, and extend it further, both for his own pleaſure, and the advantage of the public.

THE MANNER OF OBTAINING THE PARTS OF A SHOOT SEPARATE.

In the beginning of April, take a quantity of young branches from the ſcarlet oak, and other trees. Theſe are firſt cut into lengths, of the growth of different ſeaſons; and then part are left entire, part ſplit, and the reſt quartered. In this ſtate they are put into a wicker baſket, with large openings, or of looſe work, and a heavy ſtone is put in with them: a rope is tied to the handle of the baſket, and it is thrown into a brook of running water: at times it is taken up, and expoſed a little to the air; it is frequently ſhook about under water, to waſh off filth; and once in ten days the ſticks are examined.

By degrees the parts looſen from one another; and by gentle rubbing in a baſon of water, juſt warmed, they will be ſo far ſeparated, that a pencil bruſh will perfect the buſineſs, and afford pieces of various ſize, pure, diſtinct, and clean. One part will in this way ſeparate at one time, and another at another; but by returning the ſticks to the water, and repeating the operation, in the courſe of four or five weeks, every part may be obtained diſtinct. They are beſt examined immediately; but if any one wiſhes to preſerve them for repeated inquiries, it may be done in this manner: diſſolve half an ounce of alum in two quarts of water; drop the pieces thus ſeparated, for a few moments, into this ſolution, then dry them upon paper, and put them up in

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vials of ſpirit of wine. Nothing but ſpirit of wine can preſerve theſe tender bodies.

To prepare the Rind for Observation.

As the veſſels of the rind are of different diameters in various trees, though their conſtruction and that of the blebs is perfectly the ſame in all, it will be beſt to chuſe for this purpoſe the rind of a tree wherein they are largeſt. The rind of the aſh-leaved maple is finely ſuited. A piece of this may be obtained of two inches long, and will very ſucceſsfully anſwer the intention. Such a piece being prepared without alum or ſpirit, but dried from the water in which it had been macerated, it is to be impregnated with lead in the following manner, to ſhew the apertures by their colour.

Diſſolve one dram of ſugar of lead in an ounce and a half of water; filter this through paper, and pour it into a tea-cup. Clip off a thin ſlice of what was the lower end of the piece of rind as it grew on the tree, and plunge it near an inch deep into the liquor; keep it upright between two pieces of ſtick, ſo that one half or more may be above the water: whelm a wine and water glaſs over the tea-cup, and ſet the whole in a warm place. When it has ſtood two days, take it out, and clip off all that part which was in the liquor, and throw it away.

The circumſtances here mentioned, trivial as they ſeem, muſt be attended to: the operation will not ſucceed, even if the covering-glaſs be omitted; it keeps a moiſt atmoſphere about the rind, and makes it's veſſels ſupple.

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While this is ſtanding, put into a baſon two ounces of quick lime, and an ounce of orpiment; pour upon them a pint and a half of boiling water; ſtir the whole together, and when it has ſtood a day and night, it will be fit for uſe. This is the liquor probatorius vini of ſome of the German chemiſts: it diſcovers lead when wines are adulterated with it, and will ſhew it any where.

Put a little of this liquor in a tea-cup, and plunge the piece of rind half-way into it.

In the former part of this experiment, the veſſels of the rind have been filled with a ſolution of lead, that makes of itſelf no viſible alteration in them; but this colourleſs impregnation, when the orpiment lixivium gets to it, becomes of a deep brown; the veſſels themſelves appear ſomewhat the darker for it; but theſe dots, which are real openings, now are ſeen to be plainly ſuch, the colour being perfectly viſible in them, and much darker than in the veſſels. This object muſt be always viewed dry.

If a piece of the rind, thus impregnated, be gently rubbed between the fingers, till the parts are ſeparated, we ſhall be able in one place or other to get a view of the veſſels all round, and of the films which form the blebs between them.

Every part of the rind, and every coat of it, even the interſtitial place between it's innermoſt coat and bark, are filled with a fine fluid. The very courſe and progreſs of the fluid may be ſhewn in this part, even by an eaſy preparation: only that different rinds muſt be ſought for this purpoſe, the veſſels in ſome being

being larger than in others. Repeated trials have ſhewn me that the whole progreſs may be eaſily marked in the three following kinds, with only a tincture of cochineal.

Put half an ounce of cochineal, in powder, into half a pint of ſpirit of wine; ſet it in a warm place, and ſhake it often for four days; then filter off the clear tincture. Put an inch depth of this into a cup, and ſet upright in it pieces of the rind of aſh, white willow, and ozier, prepared as has been directed, by maceration in water; for in that way one trouble does for a hundred kinds. Let an inch of the rinds alſo ſtand up out of the tincture. After twenty-four hours take them out, clip off the part which was immerſed in the fluid, and ſave the reſt for obſervation.

TO PREPARE THE BLEA.

Cut the pieces in a fit ſeaſon, either juſt before the firſt leaves of ſpring, or in the midſummer ſhooting time. Then we ſee all the wonders of the ſtructure; the thouſands of mouths which open throughout the courſe of theſe innumerable veſſels, to pour their fluid into the interſtitial matter.

Theſe veſſels, which are in nature ciſterns of ſap for the feeding the growth of the whole tree, are ſo large, that they are capable of being filled with coloured wax, in the manner of the veſſels in anatomical injections; and this way they afford pleaſing objects for the microſcope, and give excellent opportunities of tracing their courſe and ſtructure.

A METHOD OF FILLING THE SAP VESSELS OF PLANTS.

A great many ſhoots of the ſcarlet and other oaks are to be taken off in the ſpring; they muſt be cut into pieces of about two inches in length, and immediately from the cutting they muſt drop into ſome warm rain water: in this they are to ſtand twenty-four hours, and then be boiled a little. When taken out, they are to be tied on ſtrings, and hung up in a place where the air paſſes freely, but the ſun does not ſhine. When they are perfectly dry, a large quantity of green wax, ſuch as is uſed for the ſeals of law deeds, is to be gently melted in an earthen pipkin ſet in water; the water to be heated and kept boiling. As ſoon as the wax runs, the ſticks are to be put in, and they are frequently to be ſtirred about. They muſt be kept in this ſtate about an hour, and then the pipkin is to be taken out of the water, and ſet upon a naked fire, where it is to be kept with the wax boiling for two or three hours; freſh ſupplies of the ſame wax being added from time to time.

After this it is to be removed from the fire, and the ſticks immediately taken out with a pair of nippers; when they are cold, the rough wax about them is to be broken off. Both ends of each ſtick are to be cut off half an inch long, and thrown away, and the middle pieces ſaved. Theſe are then to be cut in ſmaller lengths, ſmoothed at the ends with a fine chiſſel, and many of them ſplit in various thickneſſes.

Thus are obtained preparations, not only of great uſe, but of a wonderful beauty. Many trees this way afford handſome objects as well as the oak; and in ſome, where the ſap veſſels are few,

few, large, and diſtinct, the ſplit pieces reſemble ſtriped ſatins, in a way ſcarce to be credited. It is in ſuch that the outer coats of theſe veſſels are moſt happily of all to be examined.

THE METHOD OF PREPARING SALTS AND SALINE SUBSTANCES FOR THE VIEWING THEIR CONFIGURATIONS.

Diſſolve the ſubject to be examined in no larger a quantity of river or rain water than is ſufficient to ſaturate it; if it is a body eaſily diſſolvable, make uſe of cold water, otherwiſe make the water warm or hot, or even boiling, according as you find it neceſſary. After it is perfectly diſſolved, let it reſt for ſome hours, till, if over-charged, the redundant ſaline particles are precipitated, and ſettle at the bottom, or ſhoot into cryſtals; by which means you are moſt likely to have a ſolution of the ſame ſtrength at one time as at another; that is, a ſolution fully charged with as much as it can hold up, and no more: and by theſe precautions the configurations appear alike, how often ſoever tried: whereas, if the water be leſs ſaturated, the proportions, at different times, will be ſubject to more uncertainty; and if it be examined before ſuch ſeparation and precipitation of the redundant ſalts, little more will be ſeen than a confuſed maſs of cryſtals.

The ſolution being thus prepared, take up a drop of it with a gooſe quill, cut in faſhion of a ſcoop, and place it on a flat ſlip of glaſs, of about three quarters of an inch in width, and between three and four inches long, ſpreading it on the glaſs with the quill, in either a round or oval figure, till it appears a quarter of an inch or more in diameter, and ſo ſhallow as to riſe very little above the ſurface of the glaſs. When it is ſo diſpoſed, hold it as level as you can over the clear part of a fire that is not too fierce, or over the flame of a candle, at a diſtance proportionable to the degree of heat it requires, (which experience only can direct) and watch it very carefully till you diſcover the ſaline particles beginning to gather and look white, or of ſome other colour, at the extremities of the edges; then having adjuſted the microſcope before-hand for it's reception, armed with the fourth glaſs, which is the fitteſt for moſt of theſe experiments, place it under your eye, and bring it exactly to the focus of the magnifier; and after running over the whole drop, fix your attention on that ſide where you obſerve any increaſe or puſhing forwards of cryſtalline matter from the circumference towards the center.

This motion is extremely ſlow at the beginning, unleſs the drop has been over-heated, but quickens as the water evaporates, and in many kinds, towards the concluſion, produces configurations with a ſwiftneſs inconceivable, compoſed of an infinity of parts, which are adjuſted to each other with an elegance, regularity, and order, beyond what the exacteſt pencil in the world, guided by the ruler and compaſs, can ever equal, or the moſt luxuriant imagination fancy.

When action once begins, the eye cannot be taken off, even for a moment, without loſing ſomething worth obſervation; for the figures alter every inſtant, till the whole proceſs is over; and in many ſorts, after all ſeems at an end, new forms ariſe, different entirely from any that appeared before, and which probably are owing to ſome ſmall quantity of ſalt of another kind, which the other ſeparates from, and leaves to act, after itſelf has done; and in in ſome ſubjećts three or four different ſorts are obſervable, few or none being ſimple and homogeneous.

When the configurations are fully formed, and all the water evaporated, moſt kinds of them are ſoon deſtroyed again by the moiſture or action of the air upon them; their points and angles loſe their ſharpneſs, become uneven and defaced, and moulder as it were away; but ſome few are permanent, and by being incloſed between glaſſes, they may be preſerved months or even years.

It happens oftentimes that a drop of a ſaline ſolution can hardly be ſpread on the ſlip of glaſs, by reaſon of the glaſs's ſmoothneſs, but breaks into little globules, as it would do were the ſurface greaſy: the way to prevent this is, by rubbing the broken drop with your finger over the glaſs, ſo as to leave the glaſs ſmeared with it; on which ſmeared place, when dry, another drop of the ſolution may be ſpread very eaſily in what form one pleaſes.

It ſometimes happens, that when a heated drop is placed properly for examination, the obſerver finds he can diſtinguiſh nothing; which is owing to ſaline ſteams that riſe from the drop cover, and obſcure the object glaſs, and therefore muſt immediately be wiped away with a ſoft cloth or leather.

In all examinations by the microſcope of ſaline ſolutions, even though made in the day-time, you muſt uſe a candle; for the configurations being exceedingly tranſparent, are rendered much more diſtinguiſhable by the brown light a candle affords, than by

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the more white and tranſparent day-light; and beſides, either by moving the candle or turning the microſcope, ſuch light may be varied or directed juſt as the ſubject requires.

It may be alſo proper to take notice, that no kinds of microſcopes are fit for theſe obſervations, but ſuch as have an open ſtage, whereon the ſlips of glaſs, with the liquor upon them, may be placed readily, and in a perfect horizontal poſition; and moreover, where they can be turned about freely, and without diſordering the fluid.

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CHAP.

CHAP. V.

Of Insects in General.

NATURAL hiſtory has been more cultivated in the preſent century than in all thoſe which have preceded it. Many men, of the firſt rank in literature, have not diſdained to become labourers in the vaſt field which this ſcience offers every day to the eyes of an accurate and attentive obſerver. The animal, the vegetable, and the mineral kingdoms, have been examined with the greateſt care; and that confuſion and perplexity, which, from a view of the immenſe variety of individuals which each kingdom contained, it ſeemed natural to apprehend, has been removed, by introducing ſyſtematic order into this branch of ſcience; by which means the various individuals have been diſtributed into claſſes and genera, and we are now enabled to form diſtinct and accurate ideas of them. To the ſame ſyſtematic plan, and the nicety of diſcrimination which ariſes from it, we are indebted for the diſcovery and deſcription of many new ſpecies in each kingdom.

Amidſt the numerous objects which crowd in upon the natural hiſtorian, and engage his attention, inſects have not been neglected; and though they are the moſt numerous of the animal tribe, and for the moſt part very ſmall, yet the knowledge of their nature

nature and wonderful œconomy has been cultivated with unremitting ardour. Some authors have confined themſelves to divide and ſeparate them into various claſſes, and deſcribe their characteriſtic differences: others have been employed in tracing their habits of life, or in exploring the wonderous mechaniſm of their frame and ſtructure; ſo that the nature, habits, and many peculiarities of their ſtate of life, are now well known.

In number, ſingularity of appearance, and variety of form, inſects exceed every other part of animated nature. Earth, air, and water, are filled with hoſts thereof, a far greater part of which are inviſible to the naked eye; but amongſt all this variety, we perceive the ſame regularity, and can trace the footſteps of that love and wiſdom which ſo ſtrongly marks every work of God. In contemplating the works of the Creator, we ſhall always find his wiſdom and his love in pages written by his own eternal hand, in characters legible to every eye.

After an attentive examination of the nature and fabric of both the leaſt and largeſt animals, I cannot (ſays the truly great and moſt excellent Swammerdam) but allow the leſs an equal, perhaps a ſuperior, degree of dignity. Whoever duly conſiders the conduct and inſtinct of the one, with the manners and actions of the other, muſt acknowledge all are under the direction and controul of a ſupreme and particular intelligence; which, as in the largeſt it extends beyond the limits of our comprehenſion, eſcapes our reſearches in the ſmalleſt. If, while we diſſect with care the larger animals, we are filled with wonder at the elegant diſpoſition of their limbs, the inimitable order of their muſcles, and the regular direction of their veins, arteries, and nerves; to what

what an height is our aſtoniſhment raiſed, when we diſcover all theſe parts arranged in the leaſt, in the ſame regular manner. How is it poſſible but what we muſt ſtand amazed, when we reflect that thoſe little animals, whoſe bodies are ſmaller than the point of the diſſecting knife, have muſcles, veins, arteries, and every other part common to the larger animals? Creatures ſo very diminutive, that our hands are not delicate enough to manage, nor our eyes ſufficiently acute to ſee them.

All beings are perfect, conſidered in themſelves: they all anſwer one end. The determinations or qualities of each being are the means relative to this end. Thoſe means which are of an exalted nature anſwer a nobler or higher purpoſe. The meaſure of perfection conſiſts in the relation which every being bears to the whole.

When conſidered with reſpect to the Creator, all creatures are upon a level; and yet, as creatures, even the moſt deſpicable bear ſuch relation to their Creator, as to make them highly valuable to their fellow-creatures, who are themſelves only valuable by ſharing and partaking of the Divine influence. As the harmony and infinity of the eternal Artiſt are impreſſed on all his works, and as outwardly we can find no bounds, ſo inwardly we can find no end of art and beauty. " Let us then not ſlight or deem that little, in which immenſity is ſo conſpicuous; or that trivial, in which there is ſuch a manifeſtation of infinite wiſdom and power:" * but let us rather

X " Muſe

* Brooke's Univerſal Beauty, a poem.

——"Muſe upon his ſkill diſplayed;
(Infinite ſkill) in all that he has made!
To trace in nature's moſt minute deſign,
The ſignature and ſtamp of pow'r divine;
Contrivance intricate, expreſs'd with eaſe,
Where unaſſiſted ſight no beauty ſees;
The ſhapely limb, and lubricated joint,
Within the ſmall dimenſions of a point;
Muſcle and nerve miraculouſly ſpun,
His mighty work, who ſpeaks and it is done,
Th' inviſible in things ſcarce ſeen reveal'd,
To whom an atom is an ample field.
To wonder at a thouſand inſect forms,
Theſe hatch'd, and thoſe reſuſcitated worms,
New life ordain'd, and brighter ſcenes to ſhare,
Once prone on earth, now buoyant upon air."*

The name of inſect has been appropriated to theſe ſmall animals on account of the ſections or diviſions in the bodies of the greater number of them, from whence the parts ſeem to be joined together by a kind of neck. It is perhaps impoſſible to find any general term that ſhall embrace the whole genera of inſects, as many circumſtances muſt be deſcribed before we can attain an exact notion of theſe animals and their conſtitution.

Inſects are by moſt writers conſidered as divided into four principal parts; the caput or head, the thorax or trunk, the abdomen or belly, and artus or limbs: a perfect knowledge of theſe

* Cowper's Poems, vol. I. p. 261.

these parts, and their several subdivisions, is requisite for those who are desirous of forming accurate ideas of these little animals, or who wish to arrange them in their proper classes.

THE HEAD is affixed to the thorax by a species of articulation or joint; it is the principal seat of the senses, and contains the rudiments of the brain;* it is furnished with a mouth, eyes, antennæ, a forehead, a throat, and stemmata. In the greater part of insects the head is distinctly divided from the thorax, but in others it coalesces with it. The head of some insects is very large in proportion to their bodies; the proportion between the head of the same insect is not always the same; in the caterpillars with horny heads it is generally small before they moult or change their skin, but much larger after each moulting. The hardness of the exterior part of the head prevents it's growth before the change, it is consequently, relative to the body, very small; but when the insect is disposing itself for the change, the internal substance of the head retires inwards to the first ring of the neck, where it has room to expand itself; so that when the animal quits the skin, we are surprised with a head twice the former size: and as the insect neither eats nor grows while the head is forming, there is this further circumstance to be remarked, that the body and the head have each their particular time of growth. While the head expands and grows, the body does not grow at all; when the body increases, the head remains of the same size, without any change. The heads of all kinds of insects form very pleasing as well as most diversified objects for the opake microscope.

X 2 THE

* Fabricius Philosophia Entomologica, p. 18.

THE MOUTH is a part of the infect to which the naturalift will find it neceffary to pay a very particular attention: Fabricius goes fo far as to affert, that without a thorough knowledge of the mouth, it's form, and various appendages, it will be impoffible ever to difcriminate with accuracy one infect from another. In the ftructure of the mouth confiderable art and wifdom is difplayed: the diverfity in the figure is almoft as great as the variety of fpecies. It is ufually placed in the fore part of the head, extending fomewhat downwards; in the chermes, coccus, and fome other infects, it is placed under the breaft. Some infects have their mouths armed with ftrong jaws, with which they bruife and tear their food: however fine and delicate thefe organs may appear, they are really hard, and in fome fpecies fufficiently ftrong to pierce the hardeft wood. Others are furnifhed with a kind of tube or tongue, at one time moveable, at another fixed: with this they fuck the juices of the flowers. In fome again the tongue is fo fhort as to appear to us incapable of anfwering the purpofe for which it was formed, and the oeftri appear to have no mouth.

The roftrum, or probofcis, is the mouth drawn out to a rigid point. In many infects of the hemiptera clafs it is bent downward towards the breaft and belly.

The jaws are generally two in number, fometimes four, and at others more; they are placed in an horizontal direction: the inner edge, in fome infects, is ferrated, or furnifhed with fmall teeth.

The tongue is in general a taper and compact inftrument, ufed by the infect to extract the alimentary juices on which it feeds: fome ſome can extend or contract it; others roll up their's with dexterity; in ſome it is incloſed in a ſheath, with the pointed end of which they pierce the ſubſtances which contain their food, and then extract the juice with their tongue; in many it is placed in a groove under the belly; taper and ſpiral in the butterfly; tubular and fleſhy in the fly; in ſome it is long, and in others ſhort, but in all affording a fund of amuſement for the microſcope.

M. De Geer * has given us an account of a very curious circumſtance concerning the tongue of the papillon de ſaules. † Having cut off the tongue from the butterfly, almoſt as ſoon as it was emancipated from the chryſalis, it moved and rolled itſelf up at intervals for a conſiderable time: an hour after it had been cut off, it repeated the ſame motions, recommencing them every time it was touched. The ſame effect does not follow if the butterfly has been freed from the chryſalis a few days.

The ſtructure of THE EYE is, in all creatures, a moſt admirable piece of mechaniſm, but in none more ſo than in thoſe of inſects: there is no part of theſe ſmall creatures which exhibits more clearly the prodigious art with which they are organized, and ſhews how many wonders eſcape the natural ſight of man. The eyes are very different in different ſpecies, varying in number, ſituation, connection, figure, and ſimplicity of conſtruction. The greater part have two eyes, but in the monoculus they approach ſo near to each other as to appear like one; the gyrinus has four eyes, the ſcorpion ſix, the ſpider eight, and the ſcolopendra three.

The

* De Geer, Memoires pour ſervir à L'Hiſtoire des Inſectes, tom. I. p. 77.

† Papilio Antiopa, Lin. Syſt. Nat. p. 776, N° 165.

The eyes are generally convex; they have no eye-brows, the outer tunic is hard and tranſparent, having no external motion, the genus of canceri or crabs excepted. The eyes of the greater number appear, when examined by the microſcope, to be cut into a multitude of little planes or facets, like the facets of a diamond, having to the naked eye the appearance of net-work. Each of theſe ſmall facets is ſuppoſed to poſſeſs the powers and properties of an eye. Leeuenhoek counted 3181 of theſe facets in the cornea of a beetle, 8000 in thoſe of a fly. As the eyes of inſects are immoveable, they would have loſt ſight of many objects, if their eyes had been framed like thoſe of other animals; but by means of their multiplied eyes, they can eaſily view ſurrounding objects: nor is it at all improbable, that, as objects do not appear double to our eyes, but that they are ſtrengthened, and many falſe appearances are corrected by the uſe of both; ſo the numerous inlets to ſight in an inſect may increaſe their field of view, augment the intenſity of the light, and be productive of other advantages, of which we can form no conception. The eyes of inſects differ in colour, ſome being found of every colour, and of inexpreſſible beauty and brightneſs.

The antennæ are fine and ſlender horns, conſiſting of ſeveral articulations, moveable in various directions. They are beautiful in form, of a delicate ſtructure, and are placed in the fore part of the head: they vary in different inſects, not only in their ſhape, their length, their bulk, but alſo in the number of their articulations. The antennæ of the male inſect generally differ from thoſe of the female: they form one of the moſt diſtinguiſhing characteriſtics of inſects, and one of the means of judging to what genus they belong. The greateſt number of inſects

6

infects have only two antennæ; the oniſcus, the pagurus, and aſtacus have four; indeed Fabricius gives ſix to the latter.* Of the uſe they are to theſe little animals, or the end of the Creator in forming them, we are altogether ignorant: ſome writers have conjectured that they were the organs of ſmell and hearing; others have ſuppoſed that they were appropriated to a feeling more delicate than our own, and ſenſible to the leaſt motion or diſturbance in the ambient fluid in which they move: ſeveral inſects cover their eyes with them when they take their reſt. They are characterized by naturaliſts under the following names:

Setaceous are thoſe that, like a briſtle, grow gradually taper towards their point or extremity.

Filiform, thread ſhaped, and of an uniform thickneſs.

Moniliform; theſe are of a regular thickneſs, but conſiſt of a ſeries of knobs, like a necklace of beads.

Clavated, formed like a club, increaſing gradually from the baſe to the extremity.

Capitated; theſe are alſo formed like a club, but the laſt articulation is larger than the reſt, finiſhing with a kind of capital or head.

Fissiles; theſe are like the former, only that the head is divided into different parts or laminæ.

Perfoliatæ;

* Fabricius Philoſophia Entomologica, p. 19.

PERFOLIATÆ; in theſe the head is divided horizontally, but the laminæ are connected by a kind of thread paſſing through their center.

PECTINATÆ; theſe have ſeveral lateral appendages, and appear like a feather.

ARISTATÆ, ſuch as have a lateral hair, which is either naked, or furniſhed with ſmaller hairs.

Beſides the foregoing terms, the antennæ are called ſhort (*breviores*) when they are ſhorter than the body; *mediocres*, or middling, when they are of the ſame length; and *longiores*, when they are longer.

Near the mouth there is alſo a ſpecies of ſmall filiform articulated antennæ, called the PALPI, or feelers; they are generally four in number, ſometimes ſix; they are placed under and at the ſides of the mouth, which ſituation, together with their ſize, ſufficiently diſtinguiſh them from the antennæ; they are in continual motion, the animal thruſting them in every matter, as a hog would it's noſe, when in ſearch of food. Some have ſuppoſed them to be a kind of hand to aſſiſt in holding the food when it is near the mouth.

THE FOREHEAD occupies the upper part of the head, between the eyes, the mouth, and the thorax.

THE STEMMATA, or crown, three elevated ſhining hemiſpheric ſpots reſembling eyes, and placed upon the upper part of the head, as in moſt of the hymenoptera claſs.

THE

THE TRUNK is ſituated between the head and the abdomen; the legs and wings are inſerted into it; but in order to diſtinguiſh the parts thereof more eaſily, it is divided into the thorax, ſcutellum, and ſternum.

THE THORAX is the upper part of the trunk; it is of various ſhapes and proportions; the ſides and back of it are often armed with points.

THE SCUTELLUM, or eſcutcheon, is the poſterior part of the thorax, and is generally of a triangular form; though it adheres to the thorax, yet it is eaſily diſtinguiſhed from it, by it's figure, it's uſe, and often by an intervening ſuture; it appears deſigned to aſſiſt in expanding the wings when the inſect is going to fly.

THE STERNUM is ſituated on the inferior part of the thorax; it is pointed behind in ſome ſpecies, and bifid in others.

THE ABDOMEN contains the ſtomach, the inteſtines, the air veſſels, the ovary, &c. it is affixed to the thorax, and in moſt inſects diſtinct from it, forming the poſterior part of the body, being generally compoſed of rings or ſegments, by which the inſect can lengthen or ſhorten it, or even move it in different directions. In ſome ſpecies it ſeems to be formed but of one piece. The upper part of the abdomen is called the tergum, the under part the venter; the anus is the poſterior part of the abdomen.

THE SPIRACULA are ſmall oblong oval holes or pores, that are placed ſingly, one on each ſide of every ring of the abdomen; through these the insect is supposed to breathe: this singular circumstance in their respiration forms another peculiar character of insects.

THE LIMBS, or the organs used by the insect for moving it's body, and for defending itself, are the tail, the sting, the feet, the wings, the halteres or poisers.

THE TAIL terminates the abdomen, and is constructed in a wonderful manner for answering the purposes for which it is formed, namely, to direct the motion of the insect, to serve as an instrument of defence, or for depositing the eggs; the figure and size thereof varying in each genus and it's families. In some it is simple, *simplex*, and yet capable of being extended or drawn back at pleasure. In others, *elongata*, elongated. Setaceous, shaped like a bristle; *triseta*, with three appendages like bristles; in some it is forked, *furcata*; and in others it is furnished with a pair of forceps, *forcipata*; in the blatta and others it is *foliosa*, or like a leaf. In the scorpion and panorpa it is *telifera*, furnished with a sting. Further particulars may be obtained from the Philosophia Entomologica of Fabricius.

ACULEUS, or sting, an instrument with which insects wound and instil a poison; the sting generally proceeds from the under part of the last ring of the belly: in some it is sharp and pointed, in others formed like a saw. It is used by many insects both as an offensive and defensive weapon; by others it is only used to pierce the substances where they mean to deposit their eggs.

PEDES,

PEDES, THE FEET. These are admirably adapted for their intended service, to give the most convenient and proper motion, and from the variety in their construction, their various articulations, &c. furnish the microscopic observer with a great many curious and interesting objects: the most general number is six; some have eight, as the spider; the crab has ten; the oniscus fourteen; the julus has from seventy to one hundred and twenty on each side. The legs of those insects that have not more than ten, are affixed to the trunk; while those that exceed that number have part fixed to the trunk, the rest to the abdomen.

The legs of insects are generally divided into four parts. The first, which is usually the largest, is called the *femur*; the second, or *tibia*, is joined to the former, and is commonly of the same size throughout, and longer than the femur; this is followed by the third part, which is distinguished by the name of *tarsus*, or foot; it is composed of several joints, the one articulated to the other, the number of the rings varying in different insects: the tarsus is terminated by the *unguis*, or claw.

The writers on natural history, in order to render their descriptions clear and accurate, have given several names to the legs of insects, from the nature of the motions produced by them.

Thus *cursorii*, from that of running; these are the most numerous.

The *saltatorii*, those that are used for leaping.

 The

The *natatorii*, thoſe that ſerve as oars for ſwimming. The thighs of the *ſaltatorii* are remarkably large, by which means they have conſiderably more ſtrength and power for leaping. The feet of the *natatorii* are flat, and edged with hairs; thus have a proper ſurface to ſtrike againſt the water, as in the dytiſcus, notonecta, &c.

Such feet as have no claws are termed MUTICI. The chelæ, or claws, are an enlargement of the extremity of the fore feet, each of which is furniſhed with two leſſer claws, which act like a thumb and finger, as in the crab.

The under part of the feet, in ſome inſects, is covered with a kind of bruſh or ſponge, by which they are enabled to walk with eaſe on the moſt poliſhed ſubſtances, and in ſituations from which it would ſeem that they muſt neceſſarily fall.

> " They tread the ceiling, an inverted floor,
> And from it's precipice depend ſecure."

Many inſects can only move the thigh in a vertical direction; while others can move it in various directions. The progreſſive motion of inſects, and the various methods employed to effect it, will be found a very curious and important ſubject, and well worthy the attention of the natural hiſtorian. The mechanic will not find it loſt labour if he beſtows ſome time on the ſame ſubject. Very little has been done on this head, and that principally by Mr. de Reaumur, in his excellent Memoires; and by M. Weiſs, in a memoir publiſhed in the Journal de Phyſique for 1771. The reader may alſo conſult Borelli de Motu Animalium.

Motion

Motion is one of the principal phænomena of nature, and as it were the ſoul of our ſyſtem; and is as admirable in the ſmalleſt animal as in the univerſe at large. It may not be amiſs juſt to notice here, that there are ſome inſects of the beetle kind, which contradict an aſſertion of Borelli's, that an animal puts in action each foot on one ſide before it moves thoſe on the oppoſite ſide; whereas theſe employ in walking the two moſt diſtant feet on the ſame ſide, and the middle foot on the oppoſite; a method which is firm and natural.

THE WINGS, thoſe organs by which the inſect is enabled to fly; ſome have only two, others are furniſhed with four, two on each ſide; theſe are in ſome of the ſame ſize, in others the ſuperior ones are much larger than the inferior. The variety in the form and ſtructure of the wings is almoſt infinite; the beauty of their colouring, the art with which they are connected to the body, the curious manner in which ſome are folded up, the fine articulations provided for this purpoſe, by which they are laid up in their caſes when out of uſe, and yet ready to be extended in a moment for flight: together with the various ramifications, by which the nouriſhing juices are circulated, and the wing ſtrengthened, afford a fund of rational inveſtigation highly entertaining, exhibiting, particularly when examined by the microſcope, a moſt wonderful diſplay of divine wiſdom and power. The more delicate and tranſparent wings are covered and protected by ELYTRA, or caſes, which are generally hard and opake, often highly poliſhed, adorned with ornamental flutings, and ſtudded with brilliants. The wings of moths and butterflies are moſtly farinaceous, covered with a fine duſt, that occaſions thoſe beautiful colours with which they are ſo elegantly painted; for

ſtripped

ſtripped of theſe, the wing is tranſparent and colourleſs. By the aſſiſtance of the microſcope, we diſcover that this duſt is a regular aſſemblage of organized ſcales, which will be more particularly deſcribed hereafter. A few of theſe, as ſeen in the microſcope, are exhibited in Plate 16, Fig. F E H I.

The following names are made uſe of to deſcribe the different kinds of wings. They are firſt diſtinguiſhed, with reſpect to their ſurfaces, into SUPERIOR and INFERIOR. The part next the head is called the ANTERIOR part, that neareſt the tail the POSTERIOR part. THE INTERIOR part is that next the abdomen; THE EXTERIOR part is the outermoſt edge.

Thoſe wings are termed PLICATILES, which are folded when the inſect is at reſt, as in the waſp.

PLANÆ, thoſe which are incapable of being folded.

ERECTÆ, whoſe ſuperior ſurfaces are brought in contact when the inſect is at reſt, as in the ephemera, papiliones, &c.

PATENTES, if they are extended horizontally when the inſect is at reſt, as in the phalænæ geometræ.

INCUMBENTES, thoſe inſects which, when they are not in motion, cover horizontally with their wings the ſuperior part of the abdomen.

DEFLEXÆ; theſe are alſo incumbentes, but not horizontally, the outer edges declining towards the ſides.

REVERSÆ, are alſo deflexæ, with this addition, that the edges of the inferior wing project from under the anterior part of the ſuperior one.

DENTATÆ, with ſcolloped edges.

CAUDATÆ; in theſe ſome of the fibres of the wing are extended beyond the margin into a kind of tail.

RETICULATÆ, when the veins or membranes of the wings put on the appearance of net-work.

The wings are further diſtinguiſhed by their ornaments being painted with ſpots (*maculæ*), bands (*faſciæ*), ſtreaks (*ſtrigæ*): when theſe are extended lengthways, they are called lines (*linæ*); and if with dots, *punctæ*; one or more rings are termed eyes, *ocellus*; if the ſpots are ſhaped like a kidney, they are termed *ſtigmata*.

The elytra, or cruſtaceous caſes of the wings, are extended when the inſect flies, and ſhut when it reſts, forming a longitudinal ſuture down the middle of the back; they are of various ſhapes, and are diſtinguiſhed by the following names:

ABREVIATA, when they are ſhorter than the abdomen.

TRUNCATA, when the extremity terminates in a tranſverſe direct line.

SERRATA,

SERRATA, having the external margin edged with teeth or notches.

SPINOSA, when the exterior ſurface is covered with ſmall ſharp points.

SCABRA, when it is very rough.

STRIATA, marked with ſlender longitudinal furrows.

PORCATI, having ſharp longitudinal ridges.

SULCATI, with deep furrows.

HEMELYTRA, when the caſes are neither ſo hard as the elytra, nor ſo delicate as the tranſparent wing.

Under the wings of moſt inſects, which have only two, there is a ſmall head placed on a ſtalk, frequently under a little arched ſcale; theſe are called HALTERES, poiſers; they appear to be rudiments of the hinder wings: it has been ſuppoſed that they ſerve to keep the body in equilibrio when the inſect is flying.

The bodies of inſects are covered with a hard ſkin, which anſwers the purpoſe of an internal ſkeleton, and is one of the diſtinguiſhing characters of an inſect. All quadrupedes, birds, and fiſhes, have an internal ſkeleton of bones to which the muſcles are fixed; but the whole interior body of an inſect is compoſed of ſoft fleſh, and the muſcles are affixed to the exterior ſkeleton or or ſkin, which in theſe anſwer the purpoſe of bones. The ſkin ſerves as a continent to the whole inſect, covering the body, connecting the parts, and maintaining them in their proper places. This external covering is very ſtrong in thoſe inſects, which, by the nature of their life, are expoſed to ſtrong friction, or violent compreſſion; but is more tender and delicate in thoſe which are not ſo expoſed. The ſkin of inſects, like that of larger animals, is porous; the pores in ſome ſpecies are very large. Many inſects often change or caſt off their ſkin; this exuvia forms an excellent object for the microſcope.

Another diſtinguiſhing criterion of inſects is the colour of their blood, which is never red; this, at firſt ſight, ſeems liable to ſome objections, on account of the drop of red liquor which is often procured from ſmall inſects when ſqueezed or preſſed to pieces. It does not appear, however, that this is the blood of the little animal; when it exiſted as a worm there was no ſuch appearance, and when they exiſt as a fly it is only found in the eye, and not in the body, which would be the caſe if it circulated in the veins of the inſects. It is probable there is a circulation of ſome fluid analagous to the blood in moſt inſects: with the aſſiſtance of the microſcope this circulation may be perceived in many; but the circulating liquor is not red.

To theſe diſcriminating characteriſtics we may alſo add the following particulars: 1. That the body of inſects is divided by inciſuræ, or tranſverſal diviſions, from whence they take their name.

 2. That

2. That they are furnifhed with antennæ, which are placed upon the fore part of the head; thefe are jointed, and moveable in various directions.

3. That no infect in it's perfect ftate, or after it has gone through all it's transformation, has lefs than fix legs, though many have more. There are fome moths, whofe two fore feet are fo fmall as fcarcely to deferve that name. A proper attention to the nature and number of the feet of infects would tend to fix their real rank in that fcale of animated nature, which is handed down to us in the facred fcriptures; a fcale which, from the lively reprefentations it holds forth, as well as their moral applications to the purpofes of life, and the fource from whence it is derived, fhews that it is replete with the moft important information.

4. That infects have neither the organs of fmell nor hearing; at leaft they have not as yet been difcovered, though it is reported that Fabricius has lately found and defcribed the organs of hearing in the lobfter.

5. That they do not refpire air by the mouth, but that they infpire and exhale it, by means of organs which are placed on the body.

6. That they move the jaws from right to left, not up and down.

7. That they have neither eye-lid nor pupil.

To

To these we may also add, that the mechanism resulting from the LIFE of insects is not of so compound a nature as in animals of a larger size. They have less variety of organs, though some of the organs are more multiplied; and it is by the number and situation of these that their rank in the great scale of beings is to be determined.

These characters are often united in the same insect; there are, however, some species in which one or two of them are wanting.

Every microscopic observer, who wishes to avail himself of the discoveries of other writers, or to communicate intelligibly his own, will find it necessary to make himself master of the various classes, genera, &c. into which insects have been divided by LINNÆUS. All systems have their defects, and it is highly probable that this may be the case with that of the celebrated Linnæus: but the purpose of science is answered by using those discriminations which are generally adopted.

The following general idea of the Linnæan classes may serve as a foundation for this knowledge: a fuller account may be obtained by consulting the under-mentioned works.

Institutions of Entomology, a translation of Linnæus's Ordines et Genera Insectorum, or Systematic Arrangement of Insects, &c. by Thomas Pattison Yeats.

Fundamenta Entomologica, or an Introduction to the Knowledge of Insects, translated from Linnæus by W. Curtis, author of the Flora Londinensis, Botanical Magazine, &c.

The Genera Insectorum of Linnæus, exemplified by various Specimens of English Insects, drawn from Nature, by James Barbut.

Class the first. COLEOPTRA. The insects of this class have four wings; the upper ones, called the elytra, are crustaceous, formed of a hard bony substance, which, when shut, form a longitudinal suture down the back, as in the scarabæus, melolontha, or cockchaffer, &c. &c.

2. HEMIPTERA. These have also four wings; but the elytra are different, being half crustaceous, half membranaceous: the wings do not form a longitudinal suture, but extend the one over the other, as in the gryllus, grasshopper, &c.

3. LEPIDOPTERA. Those which have four membranaceous wings covered with fine scales, as the butterflies and moths.

4. NEUROPTERA. These have four membranaceous transparent wings, which are generally reticulated, as in the libellula, or dragon flies.

5. HYMENOPTERA. These, like the preceding class, have four membranaceous wings; but the abdomen is furnished with a sting, as in the bees, wasps, &c.

6. DIPTERA. These have only two wings, as common house flies, gnats, &c.

7. AP-

7. APTERA. Theſe have no wings, as ſpiders, lice, acari, &c.

OF THE TRANSFORMATION OF INSECTS.

Inſects are further diſtinguiſhed from other animals by the wonderful changes that all, except thoſe of the aptera claſs, paſs through. Moſt animals retain, during their whole life, the ſame form which they receive at their birth; but inſects go through wonderful exterior and interior changes, inſomuch that the ſame individual, at it's birth and middle ſtate, differs eſſentially from that under which it appears when arrived at a ſtate of maturity; and this difference is not confined to marks, colour, or texture, but is extended to their form, proportion, motion, organs, and habits of life.

The ancient writers on natural hiſtory were not unacquainted with theſe transformations, but the ideas they entertained of them were very imperfect, and often erroneous. It was not till towards the latter end of the laſt century that any juſt conception of this ſubject was formed, and the myſtery was then unveiled by thoſe two great anatomiſts Malphigi and Swammerdam, who obſerved theſe inſects under every appearance, and by diſſecting them at the time juſt preceding their changes, were enabled to prove that the moth and butterfly grow and ſtrengthen themſelves, and that their members are formed and unfolded, under the figure of the inſect we call a caterpillar; and they alſo ſhewed, that it is not difficult to exhibit in theſe all the parts of the future moth, as it's wings, legs, antennæ, &c. and conſequently that the changes which are apparently ſudden to our eyes, are gradually formed under the ſkin of the animal, and only appear ſudden to us, becauſe the inſect then gets rid of a caſe which had before concealed his real members. Theſe transformations clearly prove, that without repeated experience every thing in nature would appear a myſtery: for who, on conſidering by the mere light of nature or reaſon a gnat or butterfly in their fly or perfect ſtate, could have diſcovered the relation which in this ſtate and form it bears to the ſeveral changes of ſtate, and their correſponding forms, through which it has paſſed,* and which are to appearance as diſtinct as difference can make them.

The life of thoſe inſects which paſs through theſe various changes, may be divided into four principal parts, each of which will be found truly worthy of all the attention of the microſcopic obſerver.

The firſt change is from the EGG into the LARVA; or, as it is more generally called, into the worm or caterpillar.

From the LARVA it paſſes into the PUPA, or chryſalis ſtate.

From the PUPA into the imago or fly ſtate.

Few ſubjects can be found that are more expreſſive of the extenſive goodneſs of Divine Providence, than theſe transformations, in which we find the occaſional and temporary parts and organs of

* All is phænomenon, and type on earth,
Replete with ſacred and myſterious birth.

Brooke's Univerſal Beauty, b. v.

of theſe little animals ſuited and adapted with the moſt minute exactneſs to the immediate manner and convenience of their exiſtence; which again are ſhifted and changed, upon the inſects commencing a new ſcene and ſtate of action.

In it's larva ſtate the inſect appears groveling, heavy, and voracious, in the form of a worm, with a long body, compoſed of ſucceſſive rings; crawling along by the aſſiſtance of theſe, or ſmall little hooks, which are placed on the ſide of the body. It's head is armed with ſtrong jaws, it's eyes ſmooth, entirely deprived of ſex, the blood circulating from the hind part towards the head. It breathes through ſmall apertures, which are ſituated on each ſide of the body, or through one or more tubes placed in the hinder part thereof. While it is in the larva ſtate, the inſect is as it were maſked, and it's true appearance concealed; for under this maſk the more perfect form is hidden from the human eye.

In the pupa ſtate the inſect may be compared to a child in ſwaddling clothes; it's members are all folded together under the breaſt, and incloſed within one or more coverings, remaining there without motion. While in this ſtate, no inſect but thoſe of the hemiptera claſs take any nouriſhment. This change is effected various ways; in ſome inſects the ſkin of the larva opens, and leaves a paſſage, with all it's integuments; in others, the ſkin hardens and becomes a ſpecies of cone, which entirely conceals the inſects; others form or ſpin cones for themſelves, and in this ſtate they remain till the parts have acquired ſufficient firmneſs, and are ready to perform their ſeveral offices.

The

The insect then casts off the spoils of it's former state, and appears in it's imago or perfect form; for it has now attained the state of organical perfection, which answers to the rank it is to hold in the corporeal world. They are now furnished with wings, magnificently adorned; soar above and despise their former pursuits, wing the soft air, chuse their mates, and transmit their nature to a succeeding race. Their members, which in the preceding state were wrapped up, soft, and motionless, now display themselves, grow strong, and are put in exercise. The interior changes are as considerable as those of the exterior form, and that in proportion as the first state differs from the last; some organs acquire greater strength and firmness, others are rendered more delicate, some are suppressed, and some unfolded, which did not seem to exist in the former stages of it's life.

"Who that beholds the summer's glist'ning swarms,
Ten thousand thousand gaily gilded forms,
In volant dance of mix'd rotation play,
Bask in the beam, and beautify the day;
Who'd think these airy wantons so adorn,
Were late his vile antipathy and scorn;
Prone to the dust, or reptile thro' the mire,
And ever thence unlikely to aspire?
Or who, with transient view beholding, loaths
Those crawling sects, whom vilest semblance cloahs:
Who with corruption hold their kindred state,
As by contempt, or negligence of fate;
Could think that such, revers'd by wond'rous doom,
Sublimer pow'rs and brighter forms assume;

From

From death their future happier life derive,
And, tho' apparently entomb'd, revive;
Chang'd, thro' amazing transmigration, rise,
And wing the regions of unwonted skies."*

OF THE LARVA STATE.

As the larvæ (caterpillars) of the moth and butterfly † form the most numerous family among the tribe of insects, and have been more particularly observed than any other kind, perhaps on account of the usefulness of one of their number, and are therefore best known, we shall first describe them, and their various changes from this state to their last and perfect form, and then proceed to those insects which differ most from the caterpillar in one or all of their various changes.

The greater part of those insects which come forth in spring or summer perish or disappear at the approach of winter; there are very few, the period of whose life exceeds that of a year; some survive the rigours of winter, being concealed and buried under ground; many are hid in the bark of trees, and others in the chinks of old walls; some, like

A a the

* Brooke's Universal Beauty.

† The butterflies are distinguished from the moth by the time of their flying abroad, and by their antennæ; the butterflies appear by day, their antennæ are generally terminated by a little knob; the moths fly mostly in the evening, and their antennæ are either setaceous or pectinated.

the caterpillar of the brown-tailed moth,* which was ſo uncommonly numerous and deſtructive near London, in the year 1782, at the approach of winter not only ſecure and ſtrengthen the web in which the ſociety inhabit, and thus protect themſelves from impertinent intruders, but each individual alſo ſpins a caſe for itſelf, where it reſts in torpid ſecurity, notwithſtanding the inclemency of the ſeaſon, till the ſpring animates it afreſh, and informs them that the all-bountiful Author of nature has provided food convenient for them. Many that are hatched in the autumn retire and live under the earth during the winter months, but in the ſpring come out, feed, and proceed onward to their ſeveral changes; while no ſmall part paſs the colder months in their chryſalis, or pupa ſtate: but the greater number of the caterpillar race remain in the egg, being carefully depoſited by the parent fly in thoſe places where they will be hatched with the greateſt ſafety and ſucceſs; in this ſtate the latent principle of life is preſerved till the genial influences of the ſpring call it into action, and bring forth the young inſect to ſhare the banquet that nature has provided; then wherever we turn, or wherever we move, we find this inſect in one ſhape or another.

"When firſt breaks forth the bright enliv'ning ray;
* * * * * * * * * * *
——— The gay, the quick'ning inſects riſe,
And gilded ſquadrons ſtrike our wond'ring eyes;
Muſic flies wanton from ten thouſand wings,
And life and joy through ev'ry region rings."—†

All

* Curtis's ſhort hiſtory of the brown-tailed moth.

† Brooke's Univerſal Beauty.

All caterpillars are hatched from the egg, and when they firſt proceed from it are generally ſmall and feeble, but grow in ſtrength as they increaſe in ſize. The body of the caterpillar is divided into twelve rings; the head is connected with the firſt, and is hard and cruſtaceous. No caterpillar of the moth or butterfly has leſs than eight, or more than ſixteen feet; thoſe which have more than ſixteen are not the larva of the moth or butterfly; the ſix firſt feet are cruſtaceous, pointed, and fixed to the three firſt rings of the body; theſe feet are the covering to the ſix future feet of the moth; the other ſix feet are ſoft and flexible, or membranaceous; they vary both in figure and number, and are proper only to the larva ſtate: with reſpect to their external figure, they are either ſmooth or hairy, ſoft to the touch, or hard like ſhagreen, beautifully adorned with a great variety of the moſt lively tints; on each ſide of the body nine little oval holes are placed, which are generally conſidered as the organs of reſpiration. There are on each ſide of the head of the caterpillar five or ſix little black ſpots, which are ſuppoſed to be it's eyes. Theſe creatures vary in ſize, from half an inch long to four and five inches.

The caterpillar, whoſe life is one continued ſucceſſion of changes, often moults it's ſkin before it attains it's full growth. Theſe changes are the more ſingular, becauſe when the caterpillar moults, it is not ſimply the ſkin that is changed; for we find in the exuvia the ſkull, the jaws, and all the exterior parts, both ſcaly and membranaceous, which compoſe it's upper and under lip, it's antennæ, palpi, and even thoſe cruſtaceous pieces within the head, which ſerve as a fixed baſis to a number of muſcles; we further find in the exuvia, the ſpiracula, the claws, and

and ſheaths of the anterior limbs, and in general all that is viſible of the caterpillar.

The new organs were under the old ones as in a ſheath, ſo that the caterpillar effects the changes by withdrawing itſelf from the old ſkin, when it finds itſelf lodged in too narrow a compaſs. But to effect this change, to puſh off the old covering, and bring forwards the new, is a work of labour and time. Thoſe caterpillars who live in ſociety, and have a kind of neſt or habitation, retire there to change their ſkin, fixing the hooks of the feet, during the operation, firmly in the web of their neſt. Some of the ſolitary ſpecies ſpin at this time a ſlender web, to which they affix themſelves. A day or two before the critical moment approaches, the inſect ceaſes to eat, and loſes it's uſual activity; in proportion as the time of change approaches, the colour of the caterpillar becomes more feeble, the ſkin hardens and withers, and is ſoon incapable of receiving thoſe juices by which it was heretofore nouriſhed and ſupported. The inſect may now be ſeen, at diſtant intervals, to elevate it's back, and ſtretch itſelf to it's utmoſt extent; ſometimes to lift up the head, move it a little from ſide to ſide, and then let it fall again; near the change, the ſecond and third rings are ſeen to ſwell conſiderably; by theſe internal efforts the old parts are ſtretched and diſtended as much as poſſible, an operation which is attended with much difficulty, as the new parts are all weak and tender. However, by repeated exertions, all the veſſels which conveyed the nouriſhment to the exterior ſkin are diſengaged, and ceaſe to act, and a ſlit is made on the back, generally beginning at the ſecond or third ring; the new ſkin may now be juſt perceived, being diſtinguiſhed by the freſhneſs and brightneſs of it's colour; the caterpillar then preſſes the

the body like a wedge into this ſlit, by which means it is ſoon opened from the firſt down to the fourth ring; this renders it large enough for the inſect to paſs through, which it ſoon effects in a very curious manner. The caterpillar generally faſts a whole day after each moulting, for it is neceſſary that the parts ſhould acquire a certain degree of conſiſtency, before it can live and act in it's uſual manner; many alſo periſh under the operation.

The inſect always appears much larger after it has quitted the exuvia; the body had grown under the old ſkin, till it was become too large for it: now as the growth was gradual, and the parts ſoft, the ſkin preſſed them together, ſo that they lay in a ſmall ſpace; but as ſoon as the ſkin is caſt off, they are as it were liberated from their bonds, and diſtend themſelves conſiderably. Some caterpillars, in changing their ſkin, from ſmooth become covered with fine hair; while others, that were covered with this fine hair, have the laſt ſkin ſmooth.*

OF THE PUPA.

Before we deſcribe the change of the larva into the pupa ſtate, it will be neceſſary to give the reader an account of thoſe names by which naturaliſts diſtinguiſh the different appearances of inſects in the pupa ſtate.

It is called COARCTATA, when it is ſtraitened or confined to a caſe of a globular form, which has no reſemblance to the inſect it contains.

It

* Valmont de Bomare Dictionnaire Univerſel d'Hiſtoire Naturelle, vol. ii. 2d edit. 12mo. p. 394.

It is called OBTECTA, difguifed or fhrowded, when the infect is enveloped in a cruftaceous covering, confifting of two parts, one of which furrounds the head and thorax, the other the abdomen.

It is termed INCOMPLETA, when the pupa has perceptible wings and feet, but cannot move them.

SEMICOMPLETA; thefe can walk or run, but have only the rudiments of wings. The difference between the pupa and the larva of this clafs is very inconfiderable, as they eat, walk, and act, juft as they did in their primitive ftate; the only remarkable difference is a kind of cafe, which contains the wings that are to be developed in their fly ftate.

COMPLETA; thofe defigned by this name take their perfect form at their birth, and do not pafs, like other infects, through a variety of ftates, though they often change their fkin.

It is a general rule, that all winged infects pafs through the larva and pupa ftate before they affume their perfect form: there are alfo infects which have no wings, and yet undergo fimilar transformation, as the bed bug, the flea, &c. Other infects, which have no wings, and which always remain without them, never pafs through the pupa ftate, but are fubject to confiderable changes, as well with refpect to the number as the figure of their parts; thus mites have four pair of feet, and two fmaller ones at the fore part of the body, near the head; yet fome of thefe are born with only three pair of feet, the fourth is not perceived till fome time after their birth.* The figure of the monoculus quadri-

* De Geer Memoires pour fervir à l'Hiftoire des Infectes, tom. 1. p. 154.

quadricornis of Linnæus (Fauna Suecica, edit. Stockholm, 1761, No. 2049) changes confiderably after it's birth.* The julus is an infect with a great number of feet, fome fpecies having an hundred pair and upwards. M. De Geer has given a defcription of one with more than two hundred pair,† and yet thefe at their birth have only three pair, the reft are not perceived till fome time after.

We fhall now return to the caterpillar, and take notice of the care and provifion it makes to pafs from the larva ftate into that of the pupa, or chryfalis; which is, in general, a ftate of imperfection, inactivity, and weaknefs, through which the infect, when it has obtained a proper fize, muft pafs; and in which it remains often for months, fometimes for a whole year, expofed, without any means of efcaping, to every event; and in which it receives the neceffary preparations for it's perfect ftate, and is enabled once more to appear upon the tranfitory fcene of time. During it's paffage from one ftate to the other, as well as when it is in the pupa form, the microfcopical obferver will find many opportunities of exercifing his inftrument.

The tranfitions of the caterpillar from one ftate to another, are to it a fubject of the moft interefting nature; for in paffing through them, it often runs the rifk of lofing it's life, and life is the greateft boon the Creator can beftow; it is ever accompanied with a degree of delight proportioned to the ftate in which the creature exifts, and the ufe it makes of the gift it has received. If the caterpillar could therefore forefee the efforts and exertions it muft

* De Geer Memoires pour fervir à l'Hiftoire des Infectes, tom. 1, p. 155.

† Memoires des Sçavans etrangers, tom. 3, p. 61.

muſt make to put off it's preſent form, and the ſtate of weakneſs and impotence under which it muſt exiſt while in the pupa ſtate, it would undoubtedly chuſe the moſt convenient place, the moſt advantageous ſituation, for the performance of this arduous operation; one where it would be the leaſt expoſed to danger, when it had neither ſtrength to reſiſt, nor ſwiftneſs to avoid the attack of an enemy.

All theſe neceſſary inſtructions the caterpillar receives from the influence of an all-regulating Providence, which conveys the proper information to it by it's own ſenſations: hence, when the critical period approaches, it proceeds as if it knew what would be the reſult of it's operations. Different ſpecies prepare themſelves for this ſtate in different ways, ſuited to their nature and the length of time they are to remain in this ſtate.

When the caterpillar has attained to it's full growth, and the parts of the future butterfly are ſufficiently formed beneath it's ſkin, it prepares for it's change into the pupa ſtate; it ſeeks for a proper place in which to perform the important buſineſs: the different methods employed by theſe little animals to ſecure this ſtate of reſt, may be reduced to four: 1. Some ſpin webs, or cones, in which they incloſe themſelves; 2. Others conceal themſelves in little cells, which they form under ground; 3. Some ſuſpend themſelves by their poſterior extremity; 4. While others are ſuſpended by a girdle that goes round their body. We ſhall deſcribe the variety in theſe, as well as the induſtry uſed in conſtructing them, after we have gone through the manner in which the caterpillar prepares itſelf for and paſſes through the pupa ſtate.

4 Preparatory

Preparatory to the change, it ceafes to take any food, empties itfelf of all the excrementitious matter that is contained in the inteftines, voiding at the fame time the membrane which ferved as a lining to thefe and the ftomach. It generally perfeveres in a ftate of reft and inactivity for feveral days, which affords the external and internal organs that are under the fkin an opportunity of gradually unfolding themfelves. In proportion as the change into the pupa form approaches, the body is obferved often to extend and contract itfelf; the hinder part is that which is firft difengaged from the caterpillar fkin; when this part of the body is free, the animal contracts and draws it up towards the head; it then liberates itfelf in the fame manner from the two fucceeding rings, confequently the infect is now lodged in the fore part of it's caterpillar covering; the half which is abandoned remains flaccid and empty, while the fore part is fwoln and diftended. The animal, by ftrong efforts, ftill forcing itfelf againft the fore part of the fkin, burfts the fkull into three pieces, and forms a longitudinal opening in the three firft rings of the body; through this it proceeds, drawing one part after the other, by alternately lengthening and fhortening, fwelling and contracting the body and different rings; or elfe, by pufhing back the exuvia, gets rid of it's odious reptile form.

The caterpillar, thus ftripped from it's fkin, is what we call the pupa, chryfalis, and aurelia, in which the parts of the future moth are inclofed in a cruftaceous covering, but are fo foft, that the flighteft touch will difcompofe them. The exterior part of the chryfalis is at firft exceedingly tender, foft, and partly tranfparent, being covered with a vifcous fluid; this foon dries up, thickens, and forms a new covering for the animal, capable of resisting external injuries; a case, which is at the same time the sepulchre of the caterpillar, and the cradle of the moth; where, as under a veil, this wonderful transformation is carried on.

The pupa has been called a chrysalis, or creature made of gold, from the resplendent yellow colour with which some kinds are adorned. M. de Reaumur has shewn us whence they derive this rich colour; that it proceeds from two skins, the upper one a beautiful brown, which lays upon or covers a highly-polished and smooth white skin: the light reflected from the last, in passing through, gives it the golden yellow, in the same manner as this colour is often given to leather; so that the whole appears gilded, although no gold enters into the tincture. The chrysalis of the common white butterfly furnishes a most beautiful object for the lucernal opake microscope.

Those who are desirous to discover distinctly the various members of the moth in the pupa, should examine it before the forementioned fluid is dried up, when it will be found to be only the moth, with the members glued together; these, by degrees, acquire sufficient force to break their covering, and disengage themselves from the bands which confine them.

To examine the moth concealed under the skin of a caterpillar, one of them should be taken at the last change; when the skin begins to open, it should be drowned in spirits of wine, or some strong liquor, and be left therein for some days, that it may take more consistency and harden itself; the skin of the caterpillar may then be easily removed: the chrysalis, or feeble moth, will be first discovered, after which the tender moth may be

traced

traced out, and it's wings, legs, antennæ, &c. may be opened and difplayed by an accurate obferver.

The parts of the moth, or butterfly, are not difpofed exactly in the fame manner in the body of the caterpillar, as when left naked in the chryfalis. The wings are longer and narrower, being wound up into the form of a cord, and the antennæ are rolled up on the head; the tongue is alfo twifted up and laid upon the head, but in a very different manner from what it is in the perfect animal, and different from that which it lies in within the chryfalis; fo that it is by a progreffive and gradual change, that the interior parts are prepared for the moth and pupa ftate. The eggs, hereafter to be depofited by the moth, are alfo to be found not only in the chryfalis, but in the caterpillar itfelf, arranged in their natural and regular order.

The time which the moth, or butterfly, remains in the pupa ftate is not always the fame, varying in different fpecies, and depending alfo upon the warmth of the weather, and other adventitious circumftances; fome remain in that fituation for a few weeks; others do not attain their perfect form for eight, nine, or eleven months: this often depends on the feafon in which they affume the pupa form, or rather on the time of their birth. Some irregularities are alfo occafioned by the different temperature of the air, by which they are retarded or accelerated, fo as to be brought forward in the feafon beft fuited to their nature and the ends of their exiftence. I have heard of an inftance, where the pupa produced from caterpillars of the fame eggs, nourifhed in the fame manner, and which all fpun up within a few days of each other in the autumn, came into the fly ftate at three different and diftant periods, viz. one-third of them the fpring following their change, one-third more the fucceeding fpring, and the remainder the fpring after; making three years from their firft hatching; a further and manifeft proof of the beauty and wifdom of the laws of Divine order, which are continually operating for the beft interefts of all created beings. As the transformation of infects is retarded by cold, and accelerated by heat, the ordinary period of thefe changes may fometimes be altered, by placing them in different degrees of heat or cold; by thefe they may be awakened fooner to a new ftate of exiftence, or kept in one of profound fleep.*

There are fome caterpillars who remain in their cone eight or nine months, before they become complete chryfalifes; fo that their duration in the pupa ftate is much fhorter than it naturally appears to be.

As foon as the moth acquires fufficient ftrength to break the bonds which furround it, and of which it is informed by it's internal fenfations, it makes a powerful effort to efcape from it's prifon, and view the world with new-formed eyes. The moth frees itfelf from the pupa with much greater eafe than the pupa from the caterpillar; for the cafe of the pupa becomes fo dry, when the moth is near the time of throwing off it's covering, that it will break to pieces if it be only gently preffed between the fingers; and very few of the parts will be found, on examination, to adhere to the body. Hence when the infect has acquired a proper degree of folidity, it does not require any great exertion to fplit the membrane which covers it. A fmall degree of motion,

* Reaumur Memoires fur les Infectes, tom. 2, mem. 1.

motion, or a little inflation of the body, is ſufficient for this purpoſe; theſe motions reiterated a few times, enlarge the hole, and afford the moth room to eſcape from it's confinement. The opening through which they paſs is always at the ſame part of the ſkin, a little above the trunk, between the wings and a ſmall piece which covers the head; the different fiſſures are generally made in the ſame direction. If the outer caſe is opened, it is eaſy to diſcover the efforts the inſect makes to emancipate itſelf from it's ſhell; when the operation begins, there ſeems to be a violent agitation in the humours contained in the little animal; the fluids ſeem to be driven with rapidity through all the veſſels, and it is ſeen to agitate it's legs, &c. as it were ſtruggling to get free; theſe efforts, as we have already ſaid, ſoon break it's brittle ſkin.

The looſening the exterior bands of the pupa is not the only difficulty many moths have to encounter with; it has often alſo to pierce the cone, or caſe, in which it has been incloſed, and that at a time when it's members are very feeble, when it is no longer furniſhed with ſtrong jaws to pierce and cut it's way through; but, by the regular laws of Divine order, means are furniſhed to every creature of attaining the end for which it was produced: thus, in the preſent caſe, ſome of theſe inſects are provided with a liquor with which they ſoften and weaken the end of the cone; ſome leave one end feeble, and cloſe it only with a few threads, ſo that a ſlight effort of the head enables the moth to burſt the priſon doors, and immerge into day.

When the moth firſt ſees the day, it is humid and moiſt; but this humidity ſoon evaporates, the interior parts dry and harden as well as the exterior; the wings, which are crumpled, or thick and

and ſmall, extend themſelves, are ſtrengthened and hardened inſenſibly, and the fibres which were at firſt flexible become hard and ſtiff; even ſo ſtiff, that Malphigi conſidered them as bones: in proportion as theſe fibres harden, the fluid which circulates within them, and extends the wings, loſes it's force; ſo that if any extraneous circumſtance prevents the motion of this fluid, at the firſt inſtant of the moth's eſcape from it's former ſtate, the wing will then become ill-ſhaped; often expanding with ſuch rapidity, that the naked eye cannot trace it's unfolding. The wing, which was ſcarce half the length of the body, acquires in a few minutes it's full ſize, ſo as to be nearly five times as large as they were before: nor is it the wings only which are thus increaſed; all their ſpots and colours, heretofore ſo minute as to be ſcarce diſcernible, are proportionally extended, ſo that what before appeared as only ſo many unmeaning and confuſed points, become diſtinct and beautiful ornaments; and thoſe that are furniſhed with a tongue, or trunk, curl and coil it up.

When the wings are unfolded, the tongue rolled up, the moth ſufficiently dried, and the different members ſtrengthened, it takes it's flight. Moſt of them, ſoon after they have attained their perfect ſtate, void an excrementitious ſubſtance, which M. de Reaumur thinks is the laſt time of their doing it; that they reject very little, if any, during the reſt of their lives.

If the moth is opened down the belly, and the fatty parts which fill it are removed, the groſs artery, which has been called the heart, will be viſible, and the contractions and dilations, by which it puſhes forwards the liquor it contains, may be eaſily obſerved. One of the moſt remarkable circumſtances is, that the

6 circula-

circulation of this fluid in the moth is directly contrary to that which took place in the caterpillar; in this the liquor moved from the tail to the head, whereas in the moth it moves from the head to the tail; so that the fluid which answers the purposes of the blood in the moth, goes from the superior towards the inferior parts; but in the voracious sensual caterpillar the order is inverted, it proceeds from the inferior towards the superior parts.

The food of the caterpillar is gross and solid, and even this it is obliged to earn with much labour and danger; but when freed as it were from the jaws of death, and arrived at it's perfect form, the purest nectar is it's portion, and the air it's element. It was supplied with coarse food, in the first state, by the painful operation of it's teeth, which was afterwards digested by a violent trituration of the stomach. The intestines are now formed in a more delicate manner, and suited to a more pure and elegant aliment, which nature has prepared for it's use, from the most fragrant and beautiful flowers. Many internal parts of the caterpillar disappear in the chrysalis, and many that could not be perceived before are now rendered visible: the interior changes are not less surprizing than those of the exterior form, and are, properly speaking, creative of them; for it is from these the exterior form originates, and to these it always corresponds. In a word, the creature that heretofore crept upon the earth, now flies freely through the air; and far from creating our aversion by it's frightful prickles and foul appearance, it attracts our notice by the most elegant shape and cloathing.*

Yon

* Swammerdam's Book of Nature, p. 10.

Yon maggot, vileſt offspring of the earth,
Anſwers the genial baſeneſs of his birth:
Lo! where he rolls and battens with delight
In filth, to ſmell offenſive, foul to ſight!
Well pleas'd he drinks the ſtench, the dirt devours,
And prides him in the puddle of his pow'rs;
Careleſs, unconſcious of the beauteous gueſt,
Th' internal ſpeck committed to his breaſt;
Yet in his breaſt th' internal ſpeck grows warm,
And quickens into motion, life, and form:
Far other form than that it's foſterer bore,
High o'er it's parent worm ordain'd to ſoar.
The ſon ſtill growing as the ſire decays,
In radiant plume his infant form arrays;
Matures as in a ſoft and ſilent womb,
Then op'ning, peeps from his paternal tomb;
Now ſtruggling, breaks at once into the day,
Tries his young limbs, and bids his wings diſplay;
Expands his lineaments, erects his face,
Riſes ſublime o'er all the reptile race;
From dew-dropt bloſſoms ſips the nectar'd ſtream,
And baſks within the glory of the beam. *

The induſtry of the caterpillar, in ſecuring itſelf for it's change into the chryſalis, muſt not be paſſed by; not only becauſe they naturally lead the reader to conſider and admire that Divine agency by which they are informed, but becauſe the different modes they make uſe of cannot be properly inveſtigated, without the

* Brooke's Redemption.

the aſſiſtance of glaſſes, and are conſequently a proper ſubject for the microſcope; we ſhall ſelect from a great variety, a few inſtances, to animate the reader in theſe reſearches.

Some caterpillars, towards the time of their change, ſuſpend themſelves from the branch of a tree, with the head downwards; in this poſition they aſſume the pupa form, and from thence immerge a butterfly or moth. In order to ſuſpend itſelf in this poſition, the inſect covers with threads that part of the branch from which it means to ſuſpend itſelf; it places theſe in different directions, and then covers them with other threads, laying on ſeveral ſucceſſive thickneſſes, each new layer being ſmaller in ſize than that which preceded it; forming, when finiſhed, a little cone or hillock of ſilk, as will be found when examined by the microſcope. The caterpillar hooks itſelf by the hinder feet to this hillock; and when it has found, by ſeveral trials, that it is ſtrongly fixed thereto, throws itſelf forward, letting the body fall with the head downwards. Soon after it is thus ſuſpended, it bends the fore part of the body, keeping this bent poſture for ſome time; then ſtraitening the body, again in a little time bending it, and ſo on, repeating this operation till it has formed a ſlit in the ſkin upon the back; part of the pupa ſoon forces itſelf through this, and extends the ſlit as far as the laſt cruſtaceous feet; the pupa then forces upwards the ſkin, as we would puſh down a ſtocking, by means of it's little hooks and the motion of the body, till it has ſlipped it off to that part from which the caterpillar had ſuſpended itſelf. But the pupa has ſtill to diſengage itſelf from this ſmall packet, to which the exuvia is now reduced: here the obſerver will find himſelf intereſted for the little animal, anxious to learn how the pupa will quit this

Cc ſkin,

ſkin, and how it will be enabled to fix itſelf to the hillock, as it has neither arms nor legs. A little attention ſoon explains the operation, and extricates the obſerver from his embarraſſment. It ſeizes the exuvia by the rings of the body, and thus holds itſelf as it were by a pair of pincers; then, by bending the tail, it frees itſelf from the old ſkin, and by the ſame method ſoon ſuſpends itſelf to the ſilken mount; it lengthens out the hinder part of the body, and claſps, by means of it's rings, the various foldings of the exuvia one after another; thus creeping backward on the ſpoils, till it can reach the hillock with the tail; which, when examined by the microſcope, will be found to be furniſhed with hooks to fix itſelf by.

It is ſurprizing to ſee with what exactneſs and eaſe theſe inſects perform an operation ſo delicate and dangerous, which is only executed once in their life; and nought elſe can account for it, but the conſideration that he, who deſigned that the caterpillar ſhould paſs through theſe changes, had provided means for that end, regularly connecting the greater ſteps by intermediate ones, the deſire of extending their ſpecies, forming and acting upon the organization, till the purpoſes of their life are completed.

Different kinds of theſe inſects require variety in the mode of ſuſpenſion; ſome fix themſelves in an horizontal poſition, by a girdle which they tie round their body; this girdle appears to the naked eye as a ſingle thread; when examined with the microſcope, it will be found to be an aſſemblage of fine threads, lying cloſe to each other, ſo fixed as to ſupport the caterpillar, and yet leave it in full freedom to effect the changes. Like the preceding kind, it fixes the girdle to the branch of a tree; in this ſituation

6 it

it remains for ſome time motionleſs, and then begins to bend, move, and agitate it's body in a very ſingular manner, till it has opened the exterior covering, which it puſhes off and removes much in the ſame manner as we have deſcribed in the preceding article, and yet with ſuch dexterity, that the pupa remains ſuſpended by the ſame girdle.

The induſtry of thoſe that ſpin cones, or caſes, in which they incloſe themſelves, in order to prepare for their transformation in ſecurity, is more generally known, as it is from one ſpecies of theſe that we derive ſo many benefits, namely, from the ſilk-worm. All caterpillars undergo ſimilar changes with it, and many in the butterfly ſtate greatly exceed it in beauty: but the golden tiſſue, in which the ſilk-worm wraps itſelf, far ſurpaſſes the ſilky threads of all the other kinds; they may indeed come forth with a variety of colours, and wings bedecked with gold and ſcarlet, yet they are but the beings of a ſummer's day; both their life and beauty quickly vaniſh, and leave no remembrance after them; but the ſilk-worm leaves behind it ſuch beneficial monuments, as at once record the wiſdom of their Creator, and his bounty to man. *

The ſubſtance of which the ſilk is formed, is a fine yellow tranſparent gum, contained in two reſervoirs that wind about the inteſtines, and which, when they are unfolded, are about ten inches long; they terminate in two exceeding ſmall orifices near the mouth, through which the ſilk is drawn, or ſpun, to the degree of fineneſs which it's occaſions may require. This apparatus has been compared to the inſtrument uſed by the wire-drawers,

* Pullein on the Culture of Silk.

and by which gold and filver is drawn to any degree of minuteneſs. Every thread proceeds from theſe two reſervoirs, but are united afterwards; ſo that if it is examined by the microſcope, it will be found to conſiſt of two cylinders, or threads, glued together, with a groove in the middle; a ſeparation may ſometimes be perceived.

When the ſilk-worm has found a convenient ſituation, it ſets to work, firſt ſpinning ſome looſe thread, which ſerves to ſupport the future ſuperſtructure; upon theſe it forms an oval of a looſe texture, conſiſting of what is called the floſs ſilk; within this it forms a firm and more conſiſtent ball of ſilk, remaining during the whole buſineſs within the circumference of the ſpheroid that it is forming, reſting on it's hinder parts, and with it's mouth and fore legs directing and faſtening the threads. Theſe threads are not directed in a regular circular form, but are ſpun in different ſpots, in an infinite number of zig-zag lines: ſo that when it is wound off, it proceeds in a very irregular manner, ſometimes from one ſide of the cone, then from the other. This thread, when meaſured, has been found to be about three hundred yards long, and ſo fine, that eight or ten are generally rolled off into one by the manufacturers. The ſilk-worm uſually employs about three days in finiſhing this cone; the inſide is generally ſmeared with a kind of gum, that is deſigned to keep out the rain; in this cone it aſſumes the pupa form, and remains therein from fifteen to thirty days, according to the warmth of the climate. When the moth is formed, it moiſtens the end of this cone, and by frequent motions of the head looſens the texture of the ſilk, ſo as to form a hole without breaking it.

When

When the ſilk-worm has attained it's perfect growth, the reſervoirs of ſilk are full, and it is preſſed by it's ſenſations to get rid of this incumbrance, and accordingly ſpins a cone, the altitude and ſize of which are proportioned to it's wants: by traverſing backwards and forwards, it is relieved, and thus attains, by an innate deſire, the end for which it was formed.

The ſize of the cone is not always proportioned to the ſize of the caterpillar; ſome that are ſmall conſtruct larger cones than other caterpillars which are greater in ſize.

There is a caterpillar which forms it's ſilken cone in the ſhape of a boat turned bottom upwards, whence it is called by M. de Reaumur the "coque en batteau;" the conſtruction is complicated, and ſeems to require more art than is uſually attributed to this inſect. It conſiſts of two principal parts, ſhaped like ſhells, which are put together with conſiderable ſkill and propriety; each ſhell, or ſide, is framed by itſelf, and formed of an innumerable quantity of minute ſilk rings; in the fore part there is a projection, in which a ſmall crevice may be perceived, which ſerves, when opened, for the eſcape of the moth; the ſides are connected with ſo much art, that they open and ſhut as if framed with ſprings; ſo that the cone, from which the butterfly has eſcaped, appears as cloſe as that which is ſtill inhabited.

Thoſe which are not furniſhed with a ſilky cone, ſupply their want with various materials, which they are ſufficiently ſkilful to form into a proper habitation, to ſecure them while preparing for the perfect ſtate; ſome conſtruct their's with leaves and branches, tying them faſt together, and then ſtrengthening the connection; others

others connect these leaves with great regularity; many strip themselves of their hairs, and form a mixture of hair and silk; others construct a cone of sand, or earth, cementing the particles with a kind of glue; some gnaw the wood into a kind of saw-dust, and glue it together; with an innumerable variety of modes suited to their present and future state.

OF THE BEETLE.

To make the reader more fully acquainted with a subject which affords such abundant matter for the exercise of his microscope, I shall proceed to describe, in as concise a manner as I am able, the changes of a few insects of different classes, beginning with the beetle.

The beetle is of the first (or coleoptrous) class, having four wings. The two upper ones are crustaceous, and form a case to the lower ones; when they are shut, there is a longitudinal suture down the back: this formation of the wings is necessary, as the beetle often lives under the surface of the earth, in holes which they dig by their own industry and strength. These cases save their real wings from the damage which they might otherwise sustain, by rubbing or crushing against the sides of their abode; they serve also to keep the wings clean, and produce a buzzing noise when the animal rises in the air. The strength of the beetle is astonishing; it has been estimated that, bulk for bulk, their muscles are a thousand times stronger than those of a man.

The beetle is only an insect disengaged from the pupa form; the pupa is a transformation in like manner from the worm, or larva,

larva, and this proceeds from the egg; ſo that here, as in the foregoing inſtances, one inſect is exhibited in four different ſtates of life, after paſſing through three of which, and the various miſeries attendant on them, it is advanced to a more perfect ſtate. When a larva, it trains a miſerable exiſtence under the earth: in the pupa form it is deprived of motion, and as it were dead. But the beetle itſelf lives at pleaſure above and under ground, and alſo in the air, enjoying a higher degree of life, which it has attained by ſlow progreſſion, and paſſing through difficulties, affliction, and death.

If we judge of the rank which the beetle holds in the ſcale of animation, from the places where they are generally found, from the food which nouriſhes them, from the diſguſting and odious forms of many, from their antipathy to light, and their delight in darkneſs, we ſhall not form great ideas of the dignity of their ſituation. But as all things are rendered ſubſervient to the laws of Divine order, it is ſufficient for us to contemplate the wonders that are diſplayed in this and every other organ of life, for the reception of which, from the FOUNTAIN AND SOURCE OF ALL LIFE, each individual is adapted, and that in a manner correſponding to the ſtate of exiſtence it is to enjoy, and the energies it is called forth to repreſent; indeed the manner of it's exiſtence entirely depends on the degree of life which it is enabled to receive, and the ſtate in which that degree is communicated in it's deſcent through different orders of being.

"One is the flood which univerſal flows;
And hence the reptile, hence the ſeraph glows."

BROOKE.

The

The egg of the rhinoceros * beetle is of an oblong round figure, of a white colour; the ſhell thin, tender, and flexible; the teeth of the worm that is within the ſhell come to perfection before the other parts; ſo that as ſoon as it is hatched, it is capable of devouring, and nouriſhing itſelf with the wood among which it is placed. The larva, or worm, is curiouſly folded in the egg, the tail reſting between the teeth, which are diſpoſed on each ſide the belly; the worm, in proper time, breaks the ſhell, in the ſame manner as a chicken, and crawls from thence to the next ſuitable ſubſtance.

The worm, when it is hatched, is very white, has ſix legs, a wrinkled naked body, but the other parts all covered with hair: the head is then alſo bigger than the whole body, a circumſtance which may be obſerved in larger animals, and which is founded on wiſe reaſons.† If the egg is obſerved from time to time while the inſect is within it, the beating of the heart may be perceived.

The eggs of the earth-worm, the ſnail, and the beetle, will afford many ſubjects for the microſcope, and will be found to deſerve a very attentive examination. Swammerdam was accuſtomed to hatch them in a diſh, covered with white paper, which he always kept in a moiſt ſtate. To preſerve theſe and ſuch like eggs, they muſt be pierced with a fine needle; the contained liquors muſt be preſſed out, after which they ſhould be blown up by means of a ſmall glaſs tube, and then filled with a little roſin diſſolved in oil of ſpike.

The

* Scarabæus Actæon, Lin. Syſt. Nat. p. 541-3.

† Swammerdam's Book of Nature, pt. 1, p. 33.

The worm of the rhinoceros beetle, like other insects in the larva state, changes it's skin; in order to effect which, it discharges all it's excrement, and forms a convenient hole in the earth, in which it may perform the wonderful operation; for it does not, like the serpent, cast off merely an external covering, but the throat, a part of the stomach, and the inward surface of the great gut, change at the same time their skin: as if it were to increase the wonder, and to call forth our attention to these representative changes, some hundreds of pulmonary pipes cast also each it's delicate skin, a transparent membrane is taken from the eyes, and the skull remains fixed to the exuvia.

After the operation, the head and teeth are white and tender, though at other times as hard as a bone; so that the larva, when provoked, will attempt to gnaw iron. For an accurate anatomical description of this worm, I must refer the reader to M. Swammerdam; he will find it, like the rest of this author's works, well worthy of his attentive perusal. To dissect it, he first killed it in spirits of wine, or suffocated it in rain water rather more than lukewarm, not taking it out from thence for some hours. This preparation prevents an improper contraction of the muscular fibres.

When the time approaches for the worm to take upon it the pupa form, it generally penetrates deeper into the ground,* or those places where it inhabits, to find a situation that it can more easily suit to it's subsequent process. Having found a proper

 place,

* The larva of those beetles which live under ground are in general heavy, idle, and voracious; on the contrary, the larva which inhabit the waters are exceedingly active.

place, they form with their hinder feet a poliſhed cavity, in this they lie for ſome time immoveable; after which, by voiding excrementitious ſubſtances, and by the evaporation of humidity, it becomes thinner and ſhorter, the ſkin more furrowed and wrinkled, ſo that it ſoon appears as if it was ſtarved by degrees. If it be diſſected about this period, the head, the belly, and the thorax, may be clearly diſtinguiſhed. While ſome external and internal parts are changing by a ſlow accretion, others are gently diſtended by the force of the blood and impelled humours. The body contracting itſelf, while the blood is propelled towards the fore-parts, forces the ſkull open in three parts, and the ſkin in the middle of the back is ſeparated, by means of an undulating motion of the inciſions of the back; at the ſame time the eyes, the horns, the lips, &c. caſt their exuvia. During this operation, a thin watery humour is diffuſed between the old and new ſkin, which renders the ſeparation eaſier. The proceſs going on gradually, the worm is at laſt diſengaged from it's ſkin, and the limbs and parts are, by a continual unfolding, transformed into the pupa ſtate; after which, it twiſts and compreſſes the exuvia by the fundament, and throws it towards the hinder part under the belly. The pupa is at this time very delicate, tender, and flexible; and affords a moſt aſtoniſhing appearance to an attentive obſerver. Swammerdam thinks it is ſcarce to be equalled among the wonders which are diſplayed in the inſect part of the creation; in it the future parts of the beetle are finely exhibited, ſo diſpoſed and formed, as ſoon to be able to ſerve the creature in a more perfect ſtate of life, and to put on a more elegant form.

The

The pupa * of this insect weighs, a little after it's change, much heavier than it does in it's beetle state; this is also the case with the pupa of the bee and hornet. The latter has been found to weigh ten times as much as the hornet itself; this is probably occasioned by a superabundant degree of moisture, by which these insects are kept in a state of inactivity (a kind of preternatural dropsy) till it is in some measure dissipated; in proportion as this moisture is evaporated, the skin hardens and dries; some days are required to sweat off this superfluous moisture. If the skin is taken off at this time, many curious circumstances may be noted; but what claims our attention most is, that the horn, which is so hard in the male beetle when in a state of maturity, that it will bear to be sharpened against a grindstone, † in the pupa state is quite soft, and more like a fluid than a solid substance.

How long the scene of mutation continues is not known; some remain during the whole winter, more particularly those who quit the larva state in autumn, when a sudden cold checks their further operations, and consequently they remain without any food for several months. Some species of the beetle tribe go through all the stages of their existence in a season, while others employ near four years in the process, and live as winged insects a year.

When the proper time for the final change arrives, all the muscular parts grow strong, and are thus more able to shake off

* Swammerdam's Book of Nature, p. 144.

† Mouffet, p. 152.

their laſt integuments, which is performed exactly in the ſame manner as in the paſſage of the inſect from the larva to the pupa ſtate, ſo that in this laſt ſkin, which is extremely delicate, the traces of the pulmonary tubes, that have been pulled off and turned out, again become viſible.

All parts of the inſect, and more particularly the wings and their caſes, are at this time ſwelled and extended, by the air and fluids which are driven into them through the arteries and pulmonary tubes; the wings are at this period ſoft as wet paper, and the blood iſſues from them on the leaſt wound; but when they have acquired their proper conſiſtency, which in the elytra is very conſiderable, they will not give the leaſt ſign of any fluid within them, though cut or torn almoſt aſunder.

The pupa being diſengaged from it's ſkin, aſſumes a different form, in which it is dignified with the name of a beetle, with a difference of ſex, being either male or female.

The inſect now begins to enjoy a life far preferable to it's former ſtate of exiſtence; from living in dirt and filth, under briars and thorns, it now raiſes itſelf towards the ſkies, and ſuſtains itſelf with the oozing liquors of flowers.

OF THE MUSCA CHAMELEON.

We proceed to illuſtrate the nature of the different transformations in inſects, by giving an account of the muſca chameleon: in the worm or larva condition it lives in the water, breathes by the tail, and carries it's legs within a little ſnout near it's mouth. When

When it is arrived at the time for it's pupa ſtate, it goes through the change without caſting off the ſkin of the larva. Laſtly, in the imago, or fly ſtate, it would infallibly periſh in the water: the element, which had hitherto ſupplied it with life and motion, would now be it's immediate deſtruction.

This inſect is characterized by Linnæus as muſca chamæleon. Habitat larva in aquis dulcibus; muſca ſupra aquam obambulare ſolet. In a former edition of the Fauna Suecica he called it oeſtrus aquæ; but on a more minute examination, he found it was a muſca; beſides, the larvæ of all known oeſtri are nouriſhed in the bodies of animals.

The larva of this inſect, when viewed by the naked eye, appears to conſiſt of twelve annular diviſions, ſee Plate XI. Fig. 1; by theſe it is ſeparated into a head, thorax, and abdomen; but as the ſtomach and inteſtines lie equally in the thorax and abdomen, it is not eaſy to diſtinguiſh their limits until the inſect approaches the pupa ſtate.

The parts moſt worthy of notice, when this inſect is viewed by the naked eye, are the tail and ſnout. The tail is furniſhed with an elegant crown or circle of hair b, diſpoſed quite round it in an annular form; by means of this the tail is ſupported on the ſurface of the water while the worm or larva is moving therein, the body in the mean while hanging towards the bottom; it will ſometimes remain in this ſituation for a conſiderable time, without the leaſt ſenſible motion. When it has a mind to ſink to the bottom by means of it's tail, it generally bends the hairs of that part towards each other in the middle, but much cloſer towards the

6 extremity;

extremity; by this means a hollow ſpace is formed, and the bladder of air pent up in it looks like a pearl, Fig. 2, Plate XI. It is by the aſſiſtance of this bubble, or little balloon, that the inſect raiſes itſelf again to the ſurface of the water. If this bubble eſcapes, it can replace it from the pulmonary tubes; ſometimes large quantities of air may be ſeen to ariſe in bubbles from the tail of the worm to the ſurface of the water, and there mix with the incumbent atmoſphere. This operation may be eaſily ſeen by placing the worm in a glaſs full of water, where it will afford a very entertaining ſpectacle.

The ſnout is divided into three parts, of which that in the middle is immoveable; the two other parts grow from the ſides of the former; theſe are moveable, vibrating in a very ſingular manner, like the tongues of lizards and ſerpents. The greateſt ſtrength of the creature is fixed in theſe lateral parts of the ſnout; it is on theſe that it walks when it is out of the water, appearing as it were to walk on it's mouth, uſing it, as the parrot does it's beak, to move (climb) with greater advantage.

We ſhall now conſider the external figure of this worm, as it appears with the microſcope. It is ſmall towards the head, larger about thoſe parts which may be conſidered as the thorax, it then grows ſmaller, converging at the abdomen, terminating in a ſharp tail, ſurrounded with hairs in the form of the rays of a ſtar.

This worm, the head and tail included, has twelve annular diviſions, 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, Fig. 3, Plate XI. It's ſkin reſembles the covering of thoſe animals that are provided with

with a cruſtaceous habit, more than it does that of naked worms or caterpillars; it is moderately hard, and like the rough ſkin called ſhagreen, being thick ſet with a number of grains, evenly diſtributed. The ſubſtance of the ſkin is firm and hard, and yet very flexible.

On each ſide of the body are nine ſpiracula, or holes, for the purpoſe of reſpiration; there are no ſuch holes viſible on the tail ring *a*, nor on the third ring counting from the head; for at the extremity of the tail there is an opening for the admiſſion and expulſion of air: in the third ring the ſpiracula are very ſmall, and appear only under the ſkin, near the place where the embryo wings of the future fly are concealed. It is remarkable that caterpillars, in general, have two rings without theſe ſpiracula; perhaps, becauſe they change into flies with four wings; whereas this worm produces a fly that has only two.

The ſkin has three different ſhades of colour; it is adorned with oblong black furrows, with ſpots of a light colour, and orbicular rings, from which there generally ſprings a hair, as in the figure before us, only the hair that grows on the inſect's ſide is repreſented; beſides this there are here and there ſome other larger hairs c c. The difference of colour in this worm ariſes from the quantity of grains in the ſame ſpace; for in proportion as there is a greater or leſſer quantity of theſe, the furrows and rings are of a deeper or paler colour.

The head *d* is divided into three parts, and covered with a ſkin, the grains on which are hardly diſcernible. The eyes are rather protuberant, and lie forwards near the ſnout. It has alſo two

two ſmall horns i i on the fore-part of the head. The ſnout is crooked, and ends in a ſharp point as at f; but what is altogether ſingular and ſurprizing, though no doubt wiſely contrived by the great and Almighty Architect, is, that this inſect's legs are placed near the ſnout, between the ſinuſſes, in which the eyes are fixed. Each of theſe legs conſiſts of three joints, the outermoſt of which is covered with hard and ſtiff hairs like briſtles. From the next joint there ſprings a horny bone h h, which the inſect uſes as a kind of thumb; the joint is alſo of a black ſubſtance, between bone and horn in hardneſs; the third joint is of the ſame nature. To diſtinguiſh theſe particulars, the parts that form the upper ſides of the mouth and the eyes muſt be ſeparated by means of a ſmall fine knife; you may then, by the aſſiſtance of the microſcope, perceive that the leg is articulated by means of ſome particular ligaments, with that portion of the inſect's mouth which anſwers to the lower jaw in the human frame. We may then alſo diſcern the muſcles which ſerve to move the legs, and draw them up into a cavity that lies between the ſnout and thoſe parts of the mouth which are near the horns i i.

This inſect not only walks with theſe legs at the bottom of the water, but even moves itſelf on land by means of them; it likewiſe makes uſe of them to ſwim, while it keeps it's tail on the ſurface contiguous to the air, and hangs downward with the reſt of the body in the water; in this ſituation no motion is perceived in it but what ariſes from it's legs, which it moves in a moſt elegant manner. It is reaſonable to conclude from what has been ſaid, that the principal part of the creature's ſtrength lies in theſe legs: nor will it be difficult for thoſe who are acquainted with the nature of the ancient hieroglyphics (which are now opening ſo clearly)

clearly) to fix the rank of this infect in animated life, and point out thofe orders of being, and the moral ftate through which it receives it's form and habits of life.

The fnout is black and hard, the back part is quite folid, and fomewhat of a globular form, whereas the front, f, is fharp and hollow; on the back part three membranaceous divifions may be obferved, by means of which, and the mufcles contained in the fnout, the infect can at pleafure expand or contract it.

The tail is conftructed and planned with great fkill and wifdom. The extreme verge, or border, is furrounded by thirty hairs, and the fides adorned with others that are fmaller; here and there the large hairs branch out into fmaller ones, which may be reckoned as fingle hairs. Thefe hairs are all rooted in the outer fkin, which in this place is covered with rough grains, as may be feen by cutting it off, and holding it up, when dry, againft the light, upon a thin plate of glafs. By the fame mode you will find, that at the extremities of the hairs there are alfo grains like thofe of the fkin; in the middle of the tail there is a fmall opening; within it are minute holes, by which the infect takes in and lets out the air it breathes. The hairs are very feldom difpofed in fo regular a manner as they are reprefented in Fig. 3, Plate XI. except when the infect floats with the body in the water, and the tail with it's hairs a little lower than the furface, for they are then difplayed exactly as delineated in the plate. The leaft motion downward of the tail produces a concavity in the water, and it then affumes the figure of a wine glafs, wide at the top, narrow at the bottom.

The tail ſerves the larva both for the purpoſes of ſwimming and breathing, and it receives through the tail that which is the univerſal principle of life and motion in animals. By means of theſe hairs it can ſtop itſelf at pleaſure when ſwimming, or remain ſuſpended quietly in the water for any length of time.

The motion of this inſect in ſwimming is very beautiful, eſpecially when it advances with it's whole body floating on the ſurface of the water, after filling itſelf with air by the tail. To ſet out, it firſt bends the body to the right or left, and then contracts it in the form of the letter S, and again ſtretches it out in a ſtrait line: by thus alternately contracting and then extending the body, it moves along on the ſurface of the water. It is of a very quiet diſpoſition, and not diſturbed by handling.

Theſe larva are generally to be found in ſhallow ſtanding waters, about the beginning of June, ſooner or later as the ſummer is more or leſs favorable; in ſome ſeaſons they are to be found in great numbers, while in others it is no eaſy matter to meet with them. They love to crawl on the plants and graſs which grows in the water, and are often to be met with in ditches, floating on the ſurface of the water by means of their tail, the head and thorax at the ſame time hanging down; and in this ſituation they will turn over the clay and dirt with their ſnout and feet in ſearch of food, which is generally a viſcous matter that is common in ſmall ponds and about the ſides of ditches. This worm is very harmleſs, contrary to the opinion one might form at firſt ſight, from the ſurprizing vibratory motion of the legs, which reſembles the brandiſhings of an envenomed tongue or ſting They are moſt eaſily killed for diſſection in ſpirit of turpentine.

After

After a certain period they paſs into the pupa form; when they are about to change, they betake themſelves to the hérbs that float on the ſurface of the water, and creep gently thereon, till at length they lie partly on the dry ſurface, and partly on the water; when in the larva or pupa ſtate, they can live in water, but can by no means inhabit there when changed into flies: indeed, man alſo, whilſt in the uterus, lives in water, which he cannot do afterwards. When theſe worms have found a proper ſituation, they by degrees contract themſelves, and, in a manner ſcarce perceivable, loſe all power of moving. The inward parts of the worm's tail now ſeparate from the outmoſt ſkin, and become greatly contracted; this probably gives the inſect a great deal of pain: by this contraction, an empty ſpace is left in the exterior ſkin, into which the air ſoon penetrates.

Thus this inſect paſſes into the pupa ſtate under it's own ſkin, entirely different from that of the caterpillar, which caſts off the exterior ſkin at this time; this change may often be obſerved to take place in the ſpace of ten or twelve hours, but in what manner it is performed we are ignorant, as it is effected in a hidden unknown way, inwardly within the ſkin, which conceals it from our view.

Whilſt the larva is changing under the ſkin, the body, head, and tail, ſeparate inſenſibly from their outward veſture. The legs at this time, and their cartilaginous bones, are, on account of the parts which are withdrawn from them, left empty; the worm loſes alſo now the former ſkull, the beak, together with the horny bones belonging thereto, which remain in the ſkin of the exuvia. It is worthy of notice, that the optic nerves ſeparate

 alſo

alſo from the eyes, and no more perform their office. The muſcles of the rings alſo in like manner, and a great part of the pulmonary points of reſpiration, are ſeparated from the external ſkin. Thus the whole body contracts itſelf by degrees into a ſmall compact maſs. At this time the gullet and the pulmonary tubes caſt a coat within the ſkin. To make this evident, it is neceſſary to open the abdomen, when the pupa, it's parts, together with the caſt off pulmonary pipes, may be clearly ſeen.

An exact account of all the changes of the interior parts is to be found in Swammerdam's Book of Nature. Theſe changes are beſt examined by taking the pupa out of the ſkin, or outſide caſe, when it begins to harden; for as it has not then quite attained the pupa form, and the members are ſomewhat different from what they will be when in that ſtate, it is more eaſy to obſerve their reſpective ſituation, than when the pupa is ſome days older, and has loſt the greateſt part of the ſuperfluous humours. The pupa is incloſed in a double garment; the interior one is a thin membrane, which inveſts it very cloſely; the other, or exterior one, is formed of the outermoſt hard ſkin of the larva, within which it performs it's changes in an inviſible manner: it is this ſkin which gives it the appearance of the larva while in the pupa ſtate.

When the time approaches that the hidden inſect, now in the pupa form within it's old covering, is to attain the imago, fly, or perfect ſtate, which generally happens in about eleven days after the preceding change, the ſuperfluous humours are evaporated by inſenſible perſpiration. The little pupa is contracted unto the fifth ring of the ſkin, and the four laſt rings of the abdomen are filled with air, through the aperture in the reſpiratory orifice of the

the tail. This may be ſeen by expoſing the pupa a little while to the rays of the ſun, and then putting it's tail in water, when you will find it breathe ſtronger than it did before, and, by expreſſing an air-bubble out of it's tail, and then ſucking it in again, will manifeſtly perform the action of inſpiration and exſpiration. The anterior part of the pupa is drawn back from the ſkin, and having partly deſerted it, the beak, head, and firſt ring of the breaſt, the little creature lies ſtill, until it's exhaling members have acquired ſtrength to burſt the two membranes which ſurround it.

If the exterior caſe is opened near this period, a wonderful variety of colour may be perceived through the thin ſkin which inveſts the pupa. The colours of many of the different parts are now changed; ſome parts from aqueous become membranaceous, ſome fleſhy, and others cruſtaceous. The whole body becomes inſenſibly ſhaggy, the feet and claws begin to move: the variations may be accurately obſerved by opening a pupa every day until the time of change. For this purpoſe they ſhould be laid on white paper, in an earthen diſh; they ſhould alſo be made ſomewhat moiſt, and be kept under a glaſs: the paper ſerves the pupa to fix it's claw to, when they come forth in the form of a fly. A little water ſhould be poured into the diſh, to keep the pupa from drying and ſuffocation.

When the fly begins to appear, the exterior ſkin is ſeen to move about the third and fourth anterior ring; the inſect then uſes all it's efforts to promote it's eſcape, and to quit the interior and exterior ſkin at one and the ſame time. The exterior ſkin is divided into four parts; the inſect immediately afterwards breaks open

open it's inner coat, and casting it off, escapes from the prison in which it was entombed, in the form of a beautiful fly. It is to be observed here, that there is nothing accidental in the breaking of the outermost skin; but it is perfectly ordained by a constant order, always happening in the same manner in all these changes: the skin also is, in those places where it is broke open, so circumstanced by the Author of nature, as if joined together by sutures.

When the wings are expanded, the little creature immediately enters into another state of life: for the insect that lived before in water and mud, now visits the fields and meadows, being transported through the air on it's elegant wings.*

The larva à queue de rat † (musca pendula, Lin.) is also transformed under the skin, which hardens, and forms a case or general covering to the pupa: two horns are pushed out, while it is in this state, from the interior parts; they serve the purpose of respiration: this larva will be more particularly described in a subsequent part of this chapter.

The insects in this class, that is, those that pass into the pupa state under the skin of the larva, go through a change more (according to M. de Reaumur) than the caterpillar, undergoing a change while under their skin, before they assume the pupa form.

The aquatic larva of the musca chameleon retains it's form to the last; but there are many insects that are transformed under their

* Swammerdam's Book of Nature, pt. 2, p. 58.

† Reaum. 8vo. edit. tom. 4, pt. 2, 11 mem. p. 199, plate 30 and 31.

their ſkin, which form a cone or caſe for the pupa. In theſe the larva loſes firſt it's length; the body becoming ſhorter, aſſumes the figure of an egg; and the ſkin forms a hard and cruſtaceous caſe, or ſolid lodging, for the embryo inſect.

OF THE LIBELLULA.

In the libellula, or dragon fly, we have an inſtance of thoſe inſects who are termed in the pupa ſtate ſemicompleta, that is, who proceed from the egg in the figure which they preſerve, till the time comes of aſſuming their wings, and who walk, act, and eat, as well till that period as afterwards.

Of all the flies which adorn or diverſify the face of nature, there are few, if any, more beautiful than the libellula: "they are almoſt of all colours, green, blue, crimſon, ſcarlet, and white; ſome unite a variety of the moſt vivid tints, and exhibit, in one animal, more different ſhades than are to be found in the rainbow." The larva of the libellula is an inhabitant of the water, the fly itſelf is generally found hovering on the borders thereof.

Theſe inſects are produced from an egg which is depoſited in the water by the parent; the egg ſinks to the bottom, and remains there till the young inſect finds ſtrength to break the ſhell. The larva is hexapode, and is not quite ſo long as the fly; on the trunk are four prominencies, or little bunches, which become more apparent, in proportion as the larva increaſes in ſize and changes it's ſkin. Theſe bunches contain the rudiments of the wings, which adorn the inſect when in it's perfect ſtate.

 The .

The head of the larva of this insect is exceedingly singular, being covered with a mask which goes over the whole fore part of the head, having proper cavities within to suit the different prominencies of the face, and fits it more exactly than the common mask does the human face; it is of a triangular form, growing smaller towards the bottom: at the bottom there is a knuckle which fits a cavity near the neck; on this part it turns as on a pivot. The upper part of this mask is divided into two pieces, or shutters, which the insect can open or close at pleasure; it can also let down the whole mask whenever it pleases. The edges of the shutters are toothed like a saw. It makes use of the mask to seize and hold it's prey.

There is a considerable difference in the shape of these masks in different species of the libellula, some having two claws near the top of it, which they can throw in or out at pleasure, and which make it a very formidable instrument to the insects on which it feeds.

These animals generally live and feed at the bottom of the water, swimming only occasionally; their manner of swimming, or rather moving in the water, is curious, being by sudden jerks given at intervals; but this motion is not occasioned by their legs, which at this time are kept immoveable and close to the body: it is by forcing out a stream of water from the tail, that the body is carried forwards; this may be easily perceived by placing them in a flat vessel, in which there is only just water enough to cover the bottom. Here the action of the water squirted from their tail will be very visible; it will occasion a small current, and give a sensible motion to any light bodies that are lying on the

the ſurface thereof. This action can only be effected at intervals, becauſe after each ejaculation the inſect is obliged to take a freſh ſupply of water. The larva will ſometimes turn it's tail above the ſurface of the water, and force out a ſmall ſtream from it, as from a little fountain, and with conſiderable force.

The pupa differs but very little from the larva; the bunches, containing the wings, grow large, and begin to appear like four ſhort thick wings. It is full as lively as the larva, ſeeking and enjoying it's food in the ſame manner: when it is arrived at it's full growth, and is nearly ready to go through it's laſt change, it approaches the edge of the water, or comes entirely out of it, fixing itſelf firmly to ſome piece of wood or other ſubſtance by it's acute claws. It remains for ſome time immoveable; the ſkin then opens down the back, and on the head; through this opening they exhibit the real head and eyes, and at length the legs; it then creeps forward by degrees, drawing it's wings, and then the body, out of the ſkin. The wings, which are moiſt and folded, now expand themſelves to their real ſize; the body is alſo extended till it has gained it's proper dimenſions, which extenſion is accompliſhed by the propelling force of the circulating fluids. When the wings and limbs are dry, it enters on a more noble ſtate of life, it now wings the air and ſeeks it's mate.

——— What terms expreſſive may relate
The change, the ſplendor of their new-form'd ſtate!
In ev'ry eye ten thouſand brilliants blaze,
And living pearls the vaſt horizon gaze;

 Gemm'd

Gemm'd o'er their heads, the mines of India gleam,
And heaven's own wardrobe has array'd their frame;
Where colours blend an ever-varying dye,
And wanton in their gay exchanges vie.

The females of the gall inſect, which have no wings, paſs through no transformation; while the male, which has two wings, paſſes through the pupa ſtate before it becomes a fly. The only change which takes place in the female gall inſect (and which is, however, a very conſiderable one) is this, that after a certain time it fixes itſelf to the branch of the tree, without being able to detach itſelf; it afterwards increaſes much in ſize, and becomes like a true gall; the female, by remaining thus fixed, for the greater part of her life, to the place where ſhe was firſt ſeen, has very little the appearance of an animal; it is in this period of their life that they grow moſt, and produce their young, while they appear a portion of the branch they adhere to; and what is more ſingular, the larger they grow the leſs they look like animals, and while they are employed in laying thouſands of eggs, one would take them for nothing but mere galls. The genera of gall inſects is very extenſive; they are to be found on almoſt every ſhrub and tree.

The pucerons, to arrive at their perfect ſtate, paſs through that of the ſemicomplete pupa, and their wings do not appear till they have quitted their pupa ſtate; but as in all the families of pucerons there are many who never become winged, we muſt not forget to obſerve, that theſe undergo no transformation, remaining always the ſame, without changing their figure, though they increaſe in ſize, and change their ſkin. It is remarkable, that

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that amongſt inſects of the ſame kind ſome individuals ſhould be transformed, while others are not at all changed: theſe inſects will be conſidered more fully in another part of this chapter.

Mr. Reaumur * has ſhewn that the ſpider fly (hyppoboſca equina, Lin.) lays ſo large an egg, that the fly which proceeds from it is as big as the mother, though the egg does not increaſe the leaſt in ſize from the time it is firſt laid. The inſect proceeds alſo from the egg in the imago, or fly ſtate; it is probably transformed in the egg, for Mr. Reaumur has found it in the pupa ſtate therein, and having boiled ſome of their eggs which had been laid for ſome days, he found the inſect in the form of an oval ball, ſimilar to that the pupa of flies with two wings are generally found in. De Geer thinks that the egg itſelf is a true larva, which, when it is born, has nothing elſe to do but to diſengage it's limbs, &c. from the ſhell which covers it; and he thinks this the more probable, becauſe there is no embryo ſeen in this egg, but it is entirely filled with the inſect; he has alſo perceived a contracting and dilating motion in the egg, while it was in the belly of the mother, and immediately after it was lain; circumſtances which do not agree with a ſimple egg.

As Mr. Bonnet † has attempted to give a theory of theſe various changes, the following extract from it will, I hope, prove agreeable to the reader; it will at leaſt tend to render his ideas of this wonderful ſubject clearer, and will probably open to his mind many new ſources of contemplation.

Ff2 An

* Reaumur, tom. 6, mem. 14.

† Bonnet Conſiderations ſur les corps organiſes. Contemplation of Nature, &c.

An inſect that muſt caſt off it's exuvia, or moult five times before it attains the pupa ſtate, may be conſidered as compoſed of five organized bodies, incloſed within each other, and nouriſhed by common viſcera, placed in the center: what the bud of the tree is to the inviſible buds it contains, ſuch is the exterior part of the caterpillar to the interior bodies it conceals in it's boſom.

Four of theſe bodies have the ſame eſſential ſtructure, namely, that which is peculiar to the inſect in it's larva or caterpillar ſtate: the fifth body is that of the pupa. The reſpective ſtate of theſe bodies is in proportion to their diſtance from the center of the animal; thoſe that are fartheſt off have moſt conſiſtence, or unfold themſelves ſooneſt.

When the exterior body has attained it's full growth, that interior one which is next in order is conſiderably unfolded; it is then lodged in too narrow a compaſs, therefore it ſtretches on all ſides the ſheath which covers it; the veſſels which nouriſh the external covering, being broken by this violent diſtenſion, ceaſe to act, the ſkin wrinkles and dries up; at length it opens, and the inſect is cloathed with a new ſkin, and new organs.

The inſect generally faſts for a day or two preceding each change; this is probably occaſioned by the violent ſtate in which it then is, or it may be neceſſary to prevent obſtructions, &c. let this be as it may, the inſect is always very weak after it has changed it's ſkin, the parts being as yet affected by the exertions they have gone through. The ſcaly parts, as the head and legs, are almoſt entirely membranaceous, and imbrued with a fluid that inſinuates itſelf between the two ſkins, and thus facilitates their

their ſeparation; this moiſture evaporates by degrees, all the parts acquire a conſiſtence, and the inſect is then in a condition to act.

The firſt uſe that ſome caterpillars, who live on leaves, make of their new form, is to devour greedily their exuvia; ſometimes they do not wait till their jaws have acquired their full ſtrength; ſome have been ſeen to gnaw the ſhell from which they proceeded, and even the eggs of ſuch caterpillars as have not been hatched.

When we have once formed the idea that all the exterior parts are inlaid, or included one within the other, the production of new organs does not appear ſo embarraſſing, being nothing more than a ſimple developement; but it is more difficult to form any conception of the changes that happen in the viſcera before and after the transformation, the various modifications they undergo eluding our reſearches. We have already obſerved, that a little before the change the caterpillar rejects the membrane that lines the inteſtinal bag: this bowel has hitherto digeſted only groſs food, whereas it muſt hereafter digeſt that which is very delicate: a fluid that circulates in the caterpillar, from the hind part towards the head, circulates a contrary way after transformation. Now if this inverſion is as real as obſervation ſeems to indicate, how amazing the change the interior parts of the animal muſt have undergone! When the caterpillar moults, ſmall cluſters of the tracheal veſſels are caſt off with the exuvia, and new ones are ſubſtituted in their room; but how is this effected, how are the lungs replaced by other lungs? The more we endeavour

endeavour to inveſtigate this ſubject, the more we find it is enveloped in darkneſs.

Whilſt the powers of life are employed conformable to the laws of Divine Providence, to change the viſcera, and give them a new form, they are alſo unfolding divers other organs, which were uſeleſs to the inſect while in the larva ſtate, but which are neceſſary to that which ſucceeds. That theſe interior operations of life may be carried on with greater energy, the animal is thrown into a kind of ſleep; during this period, the corpus craſſum is diſtributed into all the parts, in order to bring them to perfection, while the evaporation of the ſuperfluous humours makes way for the elements of the fibres to approach each other, and unite more cloſely. The little wounds in the inſide, which have been occaſioned by the rupture of the veſſels, are gradually conſolidated; thoſe parts which had been violently exerciſed, recover their tone, and the circulating fluids inſenſibly find their new channel. Laſtly, many veſſels are effaced, and turned into a liquid ſediment, which is rejected by the perfect inſect.

When theſe various changes are conſidered, we are ſurprized at the ſingularity of the means the AUTHOR of NATURE has made choice of, in order to bring the different ſpecies of animals to perfection; and are apt to aſk, why the caterpillar was not born a moth? why it paſſes through the larva and pupa ſtate? why all inſects that are transformed do not undergo the ſame change? Theſe, and a variety of queſtions that may be ſtarted concerning the eſſe and eſſence of thoſe exiſtences which appear before us, derive their ſolution from the general ſyſtem which is unknown to us. If all were to arrive at perfection at once, the chain

chain would be broken, the creature unhappy, and man moſt of all.

Amongſt inſects, ſome are produced ſuch as they will be during their whole lives; others come forth incloſed in an egg, and are hatched from this in a form that admits of no variation; many come into the world under a form which differs but little from that which they have when arrived at an age of maturity; ſome again aſſume various forms, that are more or leſs remote from that which conſtitutes their perfect ſtate; laſtly, ſome go through part of theſe transformations in the belly of the mother, and are born of an equal ſize with their parent.

By theſe various changes, a ſingle individual unites within itſelf two or three different ſpecies, and becomes ſucceſſively the inhabitant of two or three worlds: and how great is the diverſity of it's operation in theſe various abodes! Let us alſo conſider what riches we ſhould have been deprived of, if the ſilk-worm had been born in it's perfect ſtate.

Since it has been ſhewn that the larva or caterpillar is really the moth, crawling, eating, and ſpinning, under the form of the worm, and that the pupa is only the moth ſwathed up, it is clear that they are not three ſelfs, or three perſons, but that the ſame individual feels, taſtes, ſees, and acts by different organs, at different periods of it's life, having ſenſations and wants at one time, which it has not at another; theſe wants and ſenſations always bearing a relation to the organs which excite them.

ON

ON THE RESPIRATION OF INSECTS.

As reſpiration is one of the moſt important actions in the life of every animal, great pains have been taken by many naturaliſts to inveſtigate the nature of this action in inſects; to prove it's exiſtence, and explain in what manner it is carried on. Malphigi, Swammerdam, Reaumur, and Lyonet, have diſcovered in the caterpillar two air-veſſels placed the whole length of the inſect, theſe they have called the tracheæ; they have alſo ſhewn that an infinite number of ramifications proceed from theſe, and are diſperſed through the whole body; that the tracheal veſſels communicate with particular openings on the ſkin of the caterpillar, termed ſpiracula; there are nine of theſe on each ſide of the body. Theſe veſſels ſeem calculated for the reception of air; they contain no fluids, are of a cartilaginous nature, and when cut preſerve their figure, and exhibit a well-terminated opening. Notwithſtanding this diſcovery, the exiſtence of reſpiration has not been proved in many ſpecies of inſects, and the mechaniſm thereof is very obſcure in all; and it is no more ſurprizing, that reſpiration does not exiſt in the embryo ſtate of inſects, than in that of other animals, where we find that reſpiration, which after their birth is abſolutely neceſſary for their exiſtence, to be by no means ſo before it.

M. de Reaumur thought that the air entered by the ſpiracula into the trachea, but did not come out by the ſame orifice, and conſequently that the reſpiration of inſects was carried on in a manner totally different from that of other animals, that the air was exſpired through a number of ſmall holes, or pores, which are to be found in the ſkin of the caterpillar, after having been conducted

conducted to them through the extremities of the finer ramifications of the tracheal veſſels: whereas M. Bonnet, in conſequence of a great variety of experiments, ſuppoſed that the inſpiration and exſpiration of the air was through the ſpiracula, and that there was no exſpiration of air through the pores of the ſkin. Theſe experiments were made either by plunging the caterpillars into water, or anointing them with fat and greaſy ſubſtances, ſome all over, others only partially. The number of ſmall bubbles which are obſerved to cover the ſurface of their bodies, when they are immerged in water, does not ariſe from the air which is included within, and then proceeding from them, but they are formed by the air which is lodged near the ſurface of their bodies, in the ſame manner that it is about all other ſubſtances. To render the experiments more accurate, and prevent the air from adhering to the ſkin, before he plunged the caterpillars in water he always bruſhed them over with an hair pencil; after this, very few air bubbles will be found on their bodies when they are immerged in water.

A caterpillar will remain a conſiderable time under water, without deſtroying the principle of life; and they alſo recover, in general, ſoon after they are taken out. To know whether a few only of the ſpiracula might not be ſufficient for the purpoſes of reſpiration, he plunged ſome partially in water, ſo that only two or more ſpiracula remained in the open air: in theſe caſes the caterpillar did not become torpid as it did when they were all immerged in water.

One caterpillar, upon which M. Bonnet made his experiments, lived eight days ſuſpended in water, with only two of it's anterior

 ſpiracula

ſpiracula in the air; during this time he obſerved, that when the inſect moved itſelf, little ſtreams of bubbles iſſued from the anterior ſpiracula on the left ſide; from this and many other experiments it appeared to him, that amongſt all the eighteen ſpiracula, the two anterior and the two poſterior are of the greateſt uſe in reſpiration.* Sometimes, when the mouths of theſe have been ſtopped with oil, the caterpillar has fell into convulſions. If the poſterior part has been oiled, that part will become paralytic. Notwithſtanding theſe experiments, and many more which have been made, the ſubject is far from being decided, and many ſtill doubt whether there is any reſpiration in inſects ſimilar to our's, at leaſt at certain periods of their life.

This opinion ſeems to be further confirmed by the experiments of M. Lyonet. He placed ſeveral of the large muſk beetle, probably the cerambyx moſchatus, under a glaſs, where he had been burning ſulphur, and which he kept burning while they were there; and though the vapour was ſo thick that he could not ſee them, and that he kept them therein more than half an hour, they did not ſeem in the leaſt incommoded.†

When we conſider the great ſolidity of the caſes, or cones, of the pupas of different inſects, it is not eaſy to conceive how they can live ſeveral months under the earth, in ſpaces ſo confined, and almoſt impervious to the air. If reſpiration was abſolutely neceſſary to their exiſtence, and indeed if they did reſpire, the ſame ſituation ſeems to preclude a continuance of the operation, as the air would ſoon be corrupted, and unfit for the offices of life.

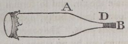
* Philoſ. Tranſ. vol. xlv. p. 300.

† Leſſer Theologie des Inſectes, tom. 1, p. 124. Ibid, p. 126.

life. As the trachea are divided and ſubdivided to a prodigious degree of minuteneſs, it has been conjectured by ſome writers, that they may act as ſo many ſieves, which, by ſeparations properly contrived, filtrate the air, and ſo furniſh it to the body of different degrees of purity and ſubtilty, agreeable to the purpoſes and nature of the various parts. The experiments that have been made with the air-pump are by no means concluſive; the injury the inſect ſuſtains when the atmoſpheric preſſure is taken from the body, does not prove that it inſpired and exſpired the air that we have removed; it only ſhews that an incumbent preſſure is neceſſary to their comfortable exiſtence, as it prevents the fluids from diſengaging themſelves in an aerial form, and as it counterballances and re-acts on the principle of life, and by keeping the action thereof in proper tone and order, confines and regulates it's energies.

Though it is difficult to aſcertain whether ſome inſects reſpire, at leaſt at certain periods of their exiſtence, yet there are others to whom the inſpiration and exſpiration of air ſeems abſolutely neceſſary: there are many aquatic inſects who are obliged to keep their tails ſuſpended on the ſurface of the water for this purpoſe. To prove this, keep the tail under water, and you will perceive the inſect to be agitated and uneaſy, and to ſeek for ſome opening to expoſe this part to the air; if it finds none, it ſoon goes to the bottom and dies. Some aquatic beetles reſiſt the trial for a conſiderable time, while their larva can only ſupport it for a few minutes. There is a circumſtance which renders all experiments on this ſubject with inſects doubtful and difficult, namely, the vaſt tenaciouſneſs of the life principle in the lower orders of animated nature, and it's diſſemination through their whole frame.

M. Mufchenbrock inclofed the pupa of a moth in a glafs tube, nearly of the fame fize with the moth itfelf.



The end A of the tube was drawn out into a capillary form, the other end was covered with a piece of wet bladder, to exclude the air; the capillary end was then plunged in water, which rofe to D. He placed the capillary part of the tube before a microfcope, on a fmall micrometer, in order to obferve any motion or change in the fituation of the water; as it is evident the exfpiration or infpiration of air by the infect would make it rife or fall alternately.

In the firft experiment he obferved a fmall degree of motion at diftant intervals, not above two or three times in an hour; in a fecond experiment on another fubject, he could obferve no motion at all. He then placed fome pupas under the receiver of an air-pump, in water which he had previoufly purged of it's air; on exhaufting the air from the receiver, he obferved one bubble to arife in a part near the tail, and a few near the wings. The pupa did not fwell under the operation; on the contrary, on letting in the air, it was found to be diminifhed in a fmall degree, but in lefs than a quarter of an hour it recovered it's former figure. Mr. Martinet publifhed at Leyden, in 1753, a differtation, in which, it is faid, he has clearly proved, by a number of experiments, that the pupa of the caterpillar and fome other infects do not refpire: I have not feen the work.

Among

Among the insects in which the respiration seems to be most clearly proved, is the larva à queue de rat (musca pendula, Lin.); these live under water in the mud, to which they affix themselves; though they live under water, the respiration of fresh air is necessary to their existence; for this purpose they are furnished with a tail, which often appears of an excessive length relative to their body; the body is seldom more than three quarters of an inch in length, while the tail is frequently more than four inches; it is composed of two tubes, which run one into the other, something similar to the tubes of a refracting telescope. Besides this, the materials of which the tubes are composed are capable of a great degree of extension. When the tail is at it's full length, it is exceeding small, not being larger near the extremity than a horse-hair; there is a little knob at the end, which is furnished with small hairs, to extend on the water, something similar to those at the tail of the musca chameleon.

In the body of the larva are two large tracheal vessels; these air-vessels extend from the head to the tail, and terminate in the respiring tubes, and receive the air from them. The larva quits the water when the time of it's transformation approaches, and enters in the earth, where the skin hardens and forms a case, in which the pupa is formed; soon after the change, four tubes, or horns, are seen projecting from the case: these M. de Reaumur supposes to be organs for communicating air to the interior parts of the insect; they are connected with little bladders which are found filled with air, and by which it is conveyed to the spiracula of the pupa. The larva of gnats, and other small aquatic insects of the same kind, are furnished with small tubes, that play on the surface of the water, and convey the air from thence to the insect.

insect. Many other singularities are to be found among the aquatic larva.

The reader will not, I hope, be displeased with another account of the musca pendula, drawn up by a naturalist who knew how to render every subject interesting, but more particularly those of this science. "Being out, says he, on an excursion with some friends, we were struck with the appearance of a little puddle of reddish water, the surface of which was in continual motion; on taking up some of this water, we found a number of dirty shapeless animals, which had much the appearance of a common maggot, but much uglier; they were brown, thick, and short, and furnished with tails. I ordered them to be laid down on the grass, and dispatched a servant for some clear water, and then began to explain their nature, origin, and properties.

"I had often informed my companions that none of the winged insects were hatched in their perfect state from the egg, but that they all are first produced in the form of worms, maggots, or caterpillars; or, in other words, covered with skins, under which they live, move, and eat, and have the appearance of very different animals from their parents; they were not, therefore, surprized, when I informed them that the creatures before us were not in their ultimate state, but were the produce of the bee fly, an insect resembling the common humble bee in form, size, and colour, but having only two wings; whereas the bee has four, and a sting, which is wanting to the fly.

"This fly is instructed by the Universal Guide and Guardian of nature, to lay it's eggs about the edges of the water. It's young, while

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while in the worm ſtate, are to live and feed in water; but the female parent cannot depoſit her eggs in that element without periſhing in the attempt. She lays them on dry land, near the proper place of reſidence of her young, and they are inſtructed by the ſame Guide to place them in ſuch a ſituation, that as ſoon as they are hatched they make their way to the water; and finally, when they have acquired their full growth, and the animal within is ready to burſt forth into a new life, and enjoy the regions of the air, it again quits the water, that this great event may be finiſhed at land.

"As the ſervant was now returned with a little water, I juſt obſerved, that though reſpiration is neceſſary to all animal life, yet it is variouſly performed in the ſeveral ſpecies; and that thus, while man and the generality of other animals reſpired by the mouth, this creature does it by the tail. The inſects we were examining were about half an inch long, and their tails near an inch: I proportioned the water in the glaſs to this meaſure in depth, and on our throwing ſome of them into it, their bodies naturally ſunk with the head downwards, and while they ſeemed ſearching after food about the bottom, the extremities of their tails were ſeen juſt above the water, and in continual motion.

"My companions, who have long ſince learnt to make every obſervation of this kind a ſource of adoration to the ſupreme creator, diſpoſer, and preſerver of all things, were admiring the care of his providence in contriving thus amazingly that a poor reptile ſhould not be ſuffocated while it fed. When I ordered a pint more water to be thrown into the glaſs, they all cried out, at firſt, againſt my deſtroying theſe unhappy animals; but their admiration

miration was raiſed much higher than before, when I obſerved that they would receive no harm, for they had a power of lengthening their tail about an inch, but that they were not left without means of life in a much more increaſed depth of water; on adding a quart more water, it was ſoon found that the apparent tail of the inſect was a mere tube, containing within it another much ſmaller, yet ſufficiently large for the paſſage of all the air that was neceſſary to this animal, a fine ſlender pipe being immediately darted up out of this, and extended to the new ſurface; on raiſing the water two inches higher the pipe was immediately lengthened again as far as was neceſſary, and ſo on till the limits of the glaſs ſuffered us to carry the experiment no further."

OF THE GENERATION OF INSECTS.

One of the greateſt myſteries in nature is generation, or that power by which the various ſpecies of animals, &c. are propagated; by which one ſingle individual gives birth to thouſands, or even millions of individuals like itſelf; all formed agreeable to proportions which are only known to that ADORABLE WISDOM which has eſtabliſhed them. We ſhall never be able to form any adequate conception of this power, till we are acquainted with the principles of life, and can trace their various gradations in different orders of beings. Many ancient philoſophers, from a miſconception and perverſion of the ſentiments of the more ancient ſages, imagined that inſects were produced from corrupt and putrefied ſubſtances; that organized bodies, animated with life, and framed in a moſt wonderful manner, owed their origin to mere chance! Not ſo the moſt ancient ſages; they taught that every degree of life muſt proceed from the fountain and ſource of all

all life, and that therefore, when manifested, it must be replete with infinite wonders; but then they also shewed, that if in it's descent through the higher orders of being it was perverted, it would be manifested in loathsome forms, and with filthy propensities; and that according to the degree of reception of the Divine goodness and truth, or the perversion thereof, new forms of life would be occasionally manifested. The gloom of night still wraps this subject in obscurity; will the dawn of day ere long gild the horizon of the scientific world? or is the time of it's breaking forth yet far from us? Be this as it may, insects will be found to conform to that general law of order which runs through the whole of animated nature, namely, that the conjunction of the male and female is necessary for the production of their offspring. Where we cannot ascertain causes, we must be content with facts.

Though insects are, like larger animals, distinguished into male and female, yet in some classes there is a kind of mules, partaking of neither sex, though originating themselves from the conjunction of both: many other particularities relative to the sexes can only be touched upon here.

In many insects the male and female are with difficulty distinguished, and in some they differ so widely, that an unskilful person might easily take the male and female of the same insect for different species; as for instance, in the phalæna humuli, piniaria, russula. The dissimilarity is still greater in those insects in which the male has wings and the female none, as in the coccus lampyris, phalæna antiqua, &c.

In general the male is ſmaller than the female. The antennæ of the male are, for the moſt part, larger than thoſe of the female. In ſome moths, and other inſects which are furniſhed with feathered antennæ, the feathers of the male fly are large and beautiful, while thoſe of the female are ſmall, and ſcarce to be perceived. Some male beetles are furniſhed with a horn, which is wanting in the female.

"Pleraque inſectorum genitalia ſua intra anum habent abſcondita, et penes ſolitarios, ſed nonnulla penem habent bifidum: cancri autem et aranei geminos, quemadmodum nonnulla amphibia, et quod mirandum in loco alieno, ut cancer, ſub baſi caudæ. Araneus mas palpos habet clavatos, qui penes ſunt, juxta os utrinque unicum, quæ clavæ ſexum nec ſpeciem diſtinguunt; et fœmina vulvas ſuas habet in abdomine juxta pectus; heic vero ſi unquam vere dixeris: res plena timoris amor, ſi enim procus inauſpicato acceſſerit, fœmina ipſum devorat, quod etiam fit, ſi non ſtatim ſe retraxerit. Libellula fœmina genitale ſuum ſub apice gerit caudæ, et mas ſub pectore, adeo ut cum mas collum fœmina forcipe caudæ arripit, illa caudam ſuam pectori ejus adplicet, ſicque peculiari ratione connexæ volitent."

Inſects are either oviparous or viviparous; or, in other words, the ſpecies is perpetuated, either by their laying of eggs, or bringing forth their young alive. The former is the more general caſe; there are but few inſtances of the latter. Thoſe inſects which paſs through the different transformations already deſcribed, cannot propagate till they arrive at their imago or perfect ſtate; and we believe there is ſeldom any conjunction of the fexes in other claffes till they have moulted, or put off their laft fkin, the cancri and monoculi excepted.

Mr. de Reaumur mentions fix or feven fpecies of two-winged flies that are viviparous, bringing forth worms, which are afterwards transformed into flies. The womb of one of thefe is fingularly curious: it is formed of a band rolled up in a fpiral form, and about two inches and a half in length; fo that it is feven or eight times longer than the body of the fly, and compofed of worms placed one on the fide of the other with wonderous art: they are many thoufands in number.*

The habits of the pucerons are fo very fingular, that I cannot pafs them over in filence; the more fo, as they are a very curious object for the microfcope. They are called by various names, the proper one is aphis; that which they are moft known by is puceron, though they are fometimes called vine fretters and plant lice. They belong to the hemiptera order. The roftrum is inflected, the antennæ are longer than the thorax, fome have four erect wings, others have none at all: towards the end of the belly there are two tubes, from which is ejected that moft delicate juice called honey-dew.

The aphides are a very numerous genus; Linnæus has enumerated thirty-three different fpecies, whofe trivial names are taken from the plant which they inhabit, though it is probable the number is much larger, as the fame plant is often found to fupport two or three different forts of aphides.

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* Reaumur Mem. des Infectes, tom. 4, p. 415.

An aphis, or puceron, brought up in the moſt perfect ſolitude from the very moment of it's birth, in a few days will be found in the midſt of a numerous family; repeat the experiment on one of the individuals of this family, and you will find this ſecond generation will multiply like it's parent, and this you may purſue through many generations.

Mr. Bonnet had repeated experiments of this kind, as far as the ſixth generation, which all uniformly preſented the obſerver with fruitful virgins, when he was engaged in a ſeries of new and tedious experiments, from a ſuſpicion imparted by Mr. Trembley in a letter to him, who thus expreſſes himſelf: "I have formed "the deſign of rearing ſeveral generations of ſolitary pucerons, in "order to ſee if they would all equally bring forth young. In "caſes ſo remote from uſual circumſtances, it is allowed to try all "ſorts of means; and I argued with myſelf, who knows but that "one copulation might ſerve for ſeveral generations?" This "WHO KNOWS." perſuaded Mr. Bonnet that he had not ſufficiently purſued his inveſtigations. He therefore now reared o the tenth generation his ſolitary aphides, having the patience to keep an exact account of the days and hours of the birth of each generation. He then diſcovered both males and females among them, whoſe amours were not in the leaſt equivocal; the males are produced only in the tenth generation, and are but few in number; that theſe ſoon arriving at their full growth, copulate with the females, and that the virtue of this copulation ſerves for ten ſucceſſive generations; that all theſe generations, except the firſt, from fecundated eggs are produced viviparous, and all the individuals are females, except thoſe of the laſt generation, among whom ſome males appear to lay the foundation of a freſh ſeries.

In

In order to give a further inſight into the nature of theſe inſects, I ſhall inſert an extract of a deſcription of the different generations of them by Dr. Richardſon, as publiſhed in the Philoſophical Tranſactions, vol. lxi.

The great variety of ſpecies which occur in the inſects now under conſideration, may make an inquiry into their particular natures ſeem not a little perplexing, but by reducing them under their proper genus, the difficulty is conſiderably diminiſhed. We may reaſonably ſuppoſe all the inſects, comprehended under any diſtinct genus, to partake of one general nature; and by diligently examining any particular ſpecies, may thence gain ſome inſight into the nature of all the reſt. With this view Dr. Richardſon choſe out of the various ſorts of aphides the largeſt of thoſe found on the roſe tree, not only as it's ſize makes it the more conſpicuous, but as there are few others of ſo long a duration. This ſort appears early in the ſpring, and continues late in the autumn; while ſeveral are limited to a much ſhorter term, in conformity to the different trees and plants from whence they draw their nouriſhment.

1. If at the beginning of February the weather happens to be ſo warm as to make the buds of the roſe tree ſwell and appear green, ſmall aphides are frequently to be found on them, though not larger than the young ones in ſummer, when firſt produced. It will be found, that thoſe aphides which appear only in ſpring, proceed from ſmall black oval eggs, which were depoſited on the laſt year's ſhoot; though when it happens that the inſects make too early an appearance, the greater part ſuffer from the ſharp weather that uſually ſucceeds; by which means, the roſe trees are

are ſome years in a manner freed from them. The ſame kind of animal is then at one time of the year viviparous, and at another oviparous.

Thoſe aphides which withſtand the ſeverity of the weather ſeldom come to their full growth before the month of April, at which time they uſually begin to breed, after twice caſting off their exuvia, or outward covering. It appears that they are all females, which produce each of them a numerous progeny, and that without having intercourſe with any male inſect; they are viviparous, and what is equally ſingular, the young ones all come into the world backwards. When they firſt come from the parent, they are enveloped by a thin membrane, having in this ſituation the appearance of an oval egg; theſe egg-like appearances adhere by one extremity to the mother, while the young ones contained in them extend the other, by that means gradually drawing the ruptured membrane over the head and body to the hind feet. During this operation, and for ſome time after, the fore part of the head adheres, by means of ſomething glutinous, to the vent of the parent. Being thus ſuſpended in the air, it ſoon frees itſelf from the membrane in which it was confined; and after it's limbs are a little ſtrengthened, is ſet down on ſome tender ſhoots, and left to provide for itſelf.

In the ſpring months there appear on the roſe trees but two generations of aphides, including thoſe which proceed immediately from the laſt year's eggs; the warmth of the ſummer adds ſo much to their fertility, that no leſs than five generations ſucceed one another in the interval. One is produced in May, which caſts off it's covering; while the months of June and July each

each ſupply two more, which caſt off their coverings three or four times, according to the different warmth of the ſeaſon. This frequent change of their outward coat is the more extraordinary, becauſe it is repeated more often when the inſects come the ſooneſt to their growth, which ſometimes happens in ten days, where warmth and plenty of nouriſhment conſpired.

Early in the month of June, ſome of the third generation which were produced about the middle of May, after caſting off their laſt covering, diſcover four erect wings, much longer than their bodies; and the ſame is obſervable in all the ſucceeding generations which are produced during the ſummer months, but ſtill without any diverſity of ſex; for ſome time before the aphides come to their full growth, it is eaſy to diſtinguiſh which will have wings, by a remarkable fullneſs of the breaſt, which in the others is hardly to be diſtinguiſhed from the body. When the laſt covering is rejected, the wings, which were before folded up in a very narrow compaſs, are gradually extended in a very ſurprizing manner, till their dimenſions are at laſt very conſiderable.

The increaſe of theſe inſects in the ſummer time is ſo very great, that by wounding and exhauſting the tender ſhoots they would frequently ſuppreſs all vegetation, had they not many enemies to reſtrain them. Notwithſtanding theſe inſects have a numerous tribe of enemies, they are not without friends, if thoſe may be conſidered as ſuch, who are officious in their attendance for the good things they expect to reap thereby. The ant and the bee are of this kind, collecting the honey in which the aphides abound, but with this difference, that the ants are conſtant viſitors, the bee only when flowers are ſcarce; the ants will ſuck in in the honey while the aphides are in the act of discharging it; the bees only collect it from the leaves on which it has fallen.

In the autumn three more generations of aphides are produced, two of which generally make their appearance in the month of August, and the third before the middle of September. The two first differ in no respect from those which are found in summer; but the third differs greatly from all the rest. Though all the aphides which have hitherto appeared were females, in this tenth generation several male insects are found, but not by any means so numerous as the females.

The females have at first the same appearance with those of the former generations, but in a few days their colour changes from a green to a yellow, which is gradually converted into an orange before they come to their full growth; they differ also in another respect from those which occur in summer, for all these yellow females are without wings. The male insects are, however, still more remarkable, their outward appearance readily distinguishing them from this and all other generations. When first produced, they are not of a green colour like the rest, but of a reddish brown, and have afterwards a dark line along the back; they come to their full growth in about three weeks, and then cast off their last covering, the whole insect being after this of a bright yellow colour, the wings only excepted; but after this change to a deeper yellow, and in a very few hours to a dark brown, if we except the body, which is something lighter coloured, and has a reddish cast. The males no sooner come to maturity than they copulate with the females, who in a day or two after their intercourse with the males lay their eggs, generally near the buds.

Where

Where there are a number crowded together, they of courfe interfere with each other, in which cafe they will frequently depofit their eggs on other parts of the branches.

It is highly probable that the aphides derive confiderable advantages by living in fociety; the reiterated punctures of a great number of them may attract a larger quantity of nutritious juices to that part of the tree, or plant, where they have taken up their abode.

In the natural hiftory of infects, new objects of furprize are continually rifing before the obferver: fingular as we have already fhewn is the production of the puceron, that of the bee will not be found to be lefs fo; and though this little republic has at all times gained univerfal efteem and admiration, though they have attracted the attention of the moft ingenious and laborious inquirers into nature, yet the mode of propagating their fpecies feems to have baffled the ingenuity of ages, and rendered their attempts to difcover it abortive; even the labours and fcrupulous attention of Swammerdam were unfuccefsful; though, while he was writing his treatife on bees, his daily labour began at fix in the morning, and from that hour till twelve he continued watching their operations, his head in a manner diffolving into fweat, under the irrefiftible ardour of the fun; and if he defifted at noon, it was only becaufe his eyes then became too weak, as well from the extraordinary afflux of light and the ufe of glaffes, to continue longer exercifed by fuch minute objects. He fpent one month entirely in examining, defcribing, and reprefenting their inteftines; and many months on other parts: employing whole days in making obfervations, and whole nights in regiftering

 them,

them, till at laſt he brought his treatiſe of bees to the wiſhed-for perfection, a work which all the ages, from the commencement of natural hiſtory to our own times, have produced nothing to equal, nothing to compare with it.* "Read it, ſays the great Boerhaave, conſider it, and then judge for yourſelf." Reaumur, however, thought he had in ſome meaſure removed the veil, and explained their manner of generating: he ſuppoſes the queen bee to be the only female in the hive, and the mother of the next generation; that the drones are the males, by which ſhe is fecundated; and that the working bees, or thoſe that collect wax on the flowers, that knead it, and form from it the combs and cells, which they afterwards fill with honey, are of neither ſex. The queen bee is known by it's ſize, being generally much larger than the working bee or the drone.

"High on her throne, the bright imperial queen
Gives the prime movement to the ſtate machine:
She in the ſubject ſees the duteous child;
She the true parent, as the regent mild;
With princely grace inveſted ſits elate,
Informs their conduct, and directs the ſtate.
* * * * * * * *
* * * * * * * *
The cluſtering populace obſequious wait,
Or ſpread the different orders of the ſtate;
Here greet the labourer on the toilſome way,
And to the load their friendly ſhoulders lay;
Or frequent at the buſy gate arrive,
And fill with amber ſweets their fragrant hive;

Or

* Boerhaave's Life of Swammerdam.

Or ſeek repairs to cloſe the fractur'd cell;
Or ſhut the waxen womb where embryos dwell.
The caterers prompt a frugal portion deal,
And give to diligence a haſty meal;
In each appointed province all proceed,
And neateſt order weds the ſwifteſt ſpeed;
Diſpatch flies various on ten thouſand wings,
And joy throughout the gladſome region rings."

Mr. Schirach, a German naturaliſt, affirms that all the common bees are females in diſguiſe, in which the organs that diſtinguiſh the ſex, and particularly the ovaria, are obliterated, or at leaſt from their extreme minuteneſs have eſcaped the obſerver's eye; that every one of thoſe bees, in the earlier period of it's exiſtence, is capable of becoming a queen bee, if the whole community ſhould think it proper to nurſe it in a particular manner, and raiſe it to that rank: in ſhort, that the queen bee lays only two kinds of eggs, thoſe that are to produce the drones, and thoſe from which the working bees are to proceed.

Mr. Schirach made his experiments not only in the early ſpring months, but even as late as November. He cut off from an old hive a piece of the brood comb, taking care that it contained worms which had been hatched about three days. He fixed this in an empty hive, together with a piece of honey-comb, for food to his bees, and then introduced a number of common bees into the hive. As ſoon as theſe found themſelves deprived of their queen and their liberty, a dreadful uproar took place, which laſted for the ſpace of twenty-four hours. On the ceſſation of this tumult, they betook themſelves to work, firſt proceeding to the conſtruction of a royal cell, and then taking the proper methods for feeding and hatching the brood incloſed with them; ſometimes even on the ſecond day the foundation of one or more royal cells were to be perceived; the view of which furniſhed certain indications that they had elected one of the incloſed worms to the ſovereignty. The bees may now be left at liberty.

The final reſult of theſe experiments is, that the colony of working bees being thus ſhut up with a morſel of brood comb, not only hatch, but at the end of eighteen or twenty days produce from thence one or two queens, which have to all appearance proceeded from worms of the common ſort, which appears to have been converted by them into a queen, merely becauſe they wanted one. *

From experiments of the ſame kind, varied and often repeated, Mr. Shirach concludes that all the common working bees were originally of the female ſex; but that if they are not fed, lodged, and brought up in a particular manner while they are in a larva ſtate, their organs are not developed; and that it is to this circumſtance attending the bringing up of the queen, that the extenſion of the female organs is effected, and the difference in her form and ſize produced.

Mr. Debraw has carried the ſubject further, by diſcovering the impregnation of the eggs by the males, and the difference of the ſize among the drones or males; though indeed this laſt circumſtance was not unknown to Meſſ. Maraldi and Reaumur. Mr. Debraw watched the glaſs hives with indeſatigable attention, from

* Shirach Hiſtoire Naturelle des Abeilles.

from the moment the bees, among which he took care there ſhould be a large number of drones, were put into them; to the time of the queen's laying her eggs, which generally happens the fourth or fifth day, he obſerved, that on the firſt or ſecond day (always before the third) from the time the eggs are placed in the cells, a great number of bees faſtening themſelves to one another hung down in the form of a curtain, from the top to the bottom of the hive; they had done the ſame at the time the queen depoſited her eggs, an operation which ſeems contrived on purpoſe to conceal what is tranſacting: however, through ſome parts of this veil he was enabled to ſee ſome of the bees inſerting the poſterior part of their bodies each into a cell, and ſinking into, but continuing there only a little while. When they had retired, it was eaſy to diſcover a whitiſh liquor left in the angle of the baſis of each cell, which contained an egg. In a day or two this liquor was abſorbed into the embryo, which on the fourth day aſſumes it's worm or larva ſtate, to which the working bees bring a little honey for nouriſhment, during the firſt eight or ten days after it's birth. When the bees find the worm has attained it's full growth, they leave off bringing it food, they know it has no more need of it; they have ſtill, however, another ſervice to pay it, in which they never fail, it is that of ſhutting it up in it's cell, where the larva is incloſed for eight or ten days: here a further change takes place; the larva, which was heretofore idle, now begins to work, and lines it's cell with fine ſilk, while the working bee incloſes it exteriorly with a wax covering. The concealed larva then voids it's excrement, quits it's ſkin, and aſſumes the pupa; at the end of ſome days the young bee acquires ſufficient ſtrength to quit the ſlender covering of the pupa, tear the wax covering of it's cell, and proceeds a perfect inſect.

To

To prove further that the eggs are fecundated by the males, and that their presence is necessary at the time of breeding, Mr. Debraw made the following experiments. They consist in leaving in a hive the queen, with only the common or working bees, without any drones, to see whether the eggs she laid would be prolific. To this end, he took a swarm, and shook all the bees into a tub of water, leaving them there till they were quite senseless; by which means he could distinguish the drones, without any danger of being stung: he then restored the queen and working bees to their former state, by spreading them on a brown paper in the sun; after this he replaced them in a glass hive, where they soon began to work as usual. The queen laid eggs, which, to his great surprize, were impregnated; for he imagined he had separated all the drones, or males, and therefore omitted watching them; at the end of twenty days he found several of his eggs had, in the usual course of changes, produced bees, while some had withered away, and others were covered with honey. Hence he inferred, that some of the males had escaped his notice, and impregnated part of the eggs. To convince himself of this, he took away all the brood comb that was in the hive, in order to oblige the bees to provide a fresh quantity, being determined to watch narrowly their motions after new eggs should be laid in the cells. On the second day after the eggs were placed in the cells, he perceived the same operation that was mentioned before, namely, that of the bees hanging down in the form of a curtain, while others thrust the posterior part of the body into the cells. He then introduced his hand into the hive, broke off a piece of the comb, in which there were two of these insects; he found in neither of them any sting (a circumstance peculiar to the drones); upon dissection, with the assistance of a microscope, he discovered the

the four cylindrical bodies which contain the glutinous liquor, of a whitish colour, as observed by Maraldi in the large drones. He was therefore now under a necessity of repeating his experiments, in destroying the males, and even those which might be suspected to be such.

He once more immersed the same bees in water, and when they appeared in a senseless state, he gently pressed every one, in order to distinguish those armed with stings from those which had none, and which of course he supposed to be males: of these last he found fifty-seven, and replaced the swarm in a glass hive, where they immediately applied again to the work of making cells, and on the fourth or fifth day, very early in the morning, he had the pleasure to see the queen bee deposit her eggs in those cells: he continued watching most part of the ensuing days, but could discover nothing of what he had seen before.

The eggs, after the fourth day, instead of changing in the manner of caterpillars, were found in the same state they were the first day, except that some were covered with honey. A singular event happened the next day, about noon; all the bees left their own hive, and were seen attempting to get into a neighbouring hive, on the stool of which the queen was found dead, being no doubt slain in the engagement. This event seems to have arisen from the great desire of perpetuating their species, and to which end the concurrence of the males seems so absolutely necessary; it made them desert their habitation, where no males were left, in order to fix a residence in a new one, in which there was a good stock of them.

To

To be further ſatisfied, Mr. Debraw took the brood comb, which had not been impregnated, and divided it into two parts; one he placed under a glaſs bell, No. 1, with honey-comb for the bees food, taking care to leave a queen, but no drones, among the bees confined in it: the other piece of brood-comb he placed under another glaſs bell, No. 2, with a few drones, a queen, and a proportionable number of common bees. The reſult was, that in the glaſs, No. 1, there was no impregnation, the eggs remained in the ſame ſtate they were in when put into the glaſs; and on giving the bees their liberty on the ſeventh day, they all flew away, as was found to be the caſe in the former experiment; whereas in the glaſs, No. 2, the very day after the bees had been put into it, the eggs were impregnated by the drones, and the bees did not leave their hives on receiving their liberty.

The editor of the Cyclopædia ſays, that the ſmall drones are all dead before the end of May, when the larger ſpecies appear, and ſuperſede their uſe; and that it is not without reaſon, that a modern author ſuggeſts that a ſmall number of drones are reſerved, to ſupply the neceſſities of the enſuing year; but that they are very little, if any, larger than the common bee.

It does not enter into our plan to notice further in this place the wonders of this little ſociety. A bee-hive is certainly one of the fineſt objects that can offer itſelf to the eyes of the beholder. It is not eaſy to be weary of contemplating thoſe workſhops, where thouſands of labourers are conſtantly employed in different works. While one party is employed in collecting the matter of the wax, and filling their magazines with it, others work this wax, and build with it their cells; this is again poliſhed and perfected by others: ſome wander abroad to extract the honey from the flower, which they afterwards depoſit in cells, as well for the neceſſities of the day as thoſe of the inclement ſeaſon: ſome cover with wax the cells that contain the honey, which is to be preſerved for the enſuing winter: others feed the young, &c. with various other employments, too numerous to be inſerted here.

The eggs of inſects are contained and arranged in the body of the inſect, in veſſels which vary in number and figure in different ſpecies; the ſame variety is found in the eggs; ſome are round, others oval, ſome cylindrical, and others nearly ſquare; the ſhells of ſome are hard and ſmooth, while others are ſoft and flexible. It is a general rule, that eggs do not increaſe in ſize after they are laid; among inſects we find, however, an exception to this; the eggs of the mouches a ſcie (tenthredo, Linn.) increaſe after they are laid, but their ſhell is ſoft and membranaceous.

The eggs of inſects differ in their colours; ſome may be found of almoſt every ſhade, of yellow, green, brown, and even black. The eggs of the lion puceron * (hemerobius, Linn.) are a very ſingular object, and cannot have eſcaped the eye of any perſon who is converſant among the inſects which live on trees; though of the many who have ſeen them, few, if any, have found what they really were. It is common to ſee on the leaves and pedicles of the leaves of the plumb-tree, and ſeveral other trees, as alſo on their young branches, a number of long and ſlender filaments, running out to about an inch in length; ten or twelve of theſe

* Reaumur Hiſt. de Inſectes, vol. xi. p. 142.

are uſually ſeen placed near one another, and a vaſt number of theſe cluſters are found on the ſame tree; the end of each of theſe filaments is terminated by a ſort of ſwelling, or tubercle, of the ſhape of an egg. They have generally been ſuppoſed to be of vegetable origin, and that they were a ſort of paraſitical plant, growing out of others. There is a time when theſe egg-like balls, which terminate every one of theſe filaments, are found open at the ends; in this ſtate they very much reſemble flowers, and have been figured as ſuch by ſome authors, though they are only the eggs out of which the young animals had been hatched and made their eſcape. If theſe eggs are examined by a microſcope, a worm may be diſcovered in them; or they may be put in a box, in which, in a proper time, they will produce an inſect, which, when viewed with a microſcope, will be found to be the true lion puceron.

Divine Providence inſtructs the inſects, by a lower ſpecies of perception, to depoſit their eggs in ſituations where their young ones will find the nouriſhment that is moſt convenient for them. Some depoſit their eggs in the oak leaf, producing there the red gall; others chuſe the leaf of the poplar, which ſwells into a red node or bladder; to a ſimilar cauſe we are indebted for the red knob which is often ſeen on the willow-leaf, and the three pointed protuberances upon the termination of the juniper branches. The leaves of the veronica and ceraſtium are drawn into a globular head by the eggs of an inſect lodged therein. The phalæna neuſtria glues it's eggs with great ſymmetry and propriety round the ſmaller branches of trees. Fig. 1, Plate X. repreſents a magnified view of the neſt of the eggs taken off the tree after the caterpillar had eat it's way through them; the ſtrong ground-work of of gum, by which they are connected and bound together, is very visible in many places; they strengthen this connection further, by filling up all the intervening space between the eggs with a very tenacious substance. The eggs are crustaceous, and similar to those of the hen. Fig. 3, Plate X. is a vertical section of the eggs, shewing their oval shape. Fig. 5 is an horizontal section through the middle of the egg. It is not easy to describe the beauty of these objects, when viewed in the lucernal microscope; the regularity with which they are placed, the delicacy of their texture, the beautiful and ever-varying colours which they present to the eye, give the spectator a high degree of rational delight.

Some deposit their eggs in the back of other insects; these, after having passed through their various transformations, become what is termed an ichneumon fly. In the Lapland Alps there is a fly covered with a downy hair, called the rhen-deer gad-fly, oestrus tarandi, Linn. It hovers all day over these animals, whose legs tremble under them; they prick up their ears, and flee to the mountains covered with ice and snow, to escape from a little hovering fly, but generally in vain, for the insect but too soon finds an opportunity to lodge it's egg in the back of the deer; the worm hatched from this egg perforates the skin, and remains under it during the whole winter; in the following year it becomes a fly. The oestrus bovis is an equal terror to oxen; the hippobosca equina to horses; oestrus ovis * to the sheep, &c.

 The

* Oestrus ovis in naso sive sinu frontis animalium rumenantium. Linn.

The gnat, the ephemera, the phryganea, the libellula, hover over the water all day to drop their eggs, which are hatched in the water, and continue there all the time they are in the larva form. The mafs formed by the gnat refembles a little veffel fet afloat by the infect; each egg is in the form of a keel; thefe are curioufly connected together. The gnat lays but one egg at a time, which fhe lays upon the water in a very ingenious and fimple manner; fhe ftretches her legs out, and croffes them, thus forming an angle to receive and hold the firft egg; a fecond egg is foon placed next the firft; then a third, and fo on, till the bafe is capable of fupporting itfelf. The fpawn of this infect is fometimes above an inch long, and one-eighth of an inch in diameter, and tied by a little ftem, or ftalk, to fome ftick or ftone. Sometimes they are laid in a fingle, fometimes in a double fpiral line; fometimes tranfverfely. Many moths cover their offspring with a thick bed of hair, which they gather from their own body; while others cover them with a glutinous compofition, which, when hard, protects them from moifture, rain, and cold. The gall flies, it has been already obferved, know how to open the nerves of the leaves, to depofit thus their eggs in a place which afterwards ferves them for a lodging, and a magazine of food. The folitary bees and wafps prepare an habitation for their little ones in the earth, placing there a proper quantity of food for them, when they proceed from the egg. The voracious and cruel fpider is attentive and careful of it's eggs; the wolf fpider carries them on it's back in a little bag formed of it's filk; it cannot be feparated from them but by violence, and exhibits the moft marked figns of uneafinefs when deprived of them: a circumftance the more remarkable, as they love to deftroy each other, and even carry on their courtfhips with a diffidence and

4 caution

caution unknown in any other ſpecies of animals. The hiſtory of bees and waſps, and their care and attention to their offspring, is ſo well known, that I may with propriety paſs it over here, and proceed juſt to notice the induſtrious ant, whoſe paternal affection and care is not ſo well known. They are not ſatisfied with placing their eggs in ſituations made on purpoſe, and to raiſe or rear them till they come to their nymph or pupa ſtate ; but they even extend their care to the pupa, removing them from their neſt to the ſurface of the earth, whenever the weather is fine, that they may receive the benignant influence of the ſun, carrying them back again as ſoon as the air begins to grow cold. If any accident diſturbs their neſt, and diſperſes the pupas, they manifeſt the greateſt ſigns of diſtreſs, ſeeking the loſt and ſcattered pupas, placing them in ſome ſheltered place while they repair the neſt, when they again tranſport them to it. * Many other curious particulars might be related relative to this induſtrious inſect, as their uniting together in ſcooping out earth, and tranſporting the materials for the conſtruction of their neſts, and the curious ſtructure of the neſt itſelf, which, though it appears piled up at random, will be found, on ſtricter examination, to be a work of art and deſign, with other circumſtances which are too long to be enumerated here.

The perception by which inſects are actuated, ſo as to ſecure in the moſt wonderful manner their offspring, merits the moſt attentive conſideration, and ſtrongly marks the regular proceedings of Divine Providence : they do not depoſit them at random, but place them in ſituations agreeable to their nature, and in places where they will meet with ſuch ſupplies of nouriſhment, as will

* Leſſers Theologie des Inſectes, tom. 1, p. 143.

will contribute to their perfection, and be acceptable to the several appetites of their young ones. This is beautifully illustrated by Mr. Brooke, in his philosophical poem on Universal Beauty, where, speaking on this subject, he says,

Each as reflecting on their primal state,
Or fraught with scientific craft innate,
With conscious skill their oval embryo shed,
Where native first their infancy was fed:
Or on some vegetating foliage glued;
Or o'er the flood they spread their future brood;
A slender cord the floating jelly binds,
Eludes the wave, and mocks the warring winds.
O'er this their sperm in spiral order lies,
And pearls in living ranges greet our eyes.
In firmest oak they scoop a spacious tomb,
And lay their embryo in the spurious womb:
Some flowers, some fruit, some gums, or blossoms chuse,
And confident their darling hopes infuse;
While some their eggs in ranker carnage lay,
And to their young adapt the future prey.
* * * * * * * *
* * * * * * * *
All by their dam's prophetic care receive
Whate'er peculiar indigence can crave:
Profuse at hand the plenteous tables spread,
And various appetites are aptly fed.
No less each organ suits each place of birth,
Finn'd in the flood, or reptile o'er the earth.

Each

Each organ apt to each precarious ſtate,
As for eternity deſign'd complete.

Of all the productions of nature, inſects are the moſt numerous, and multiply moſt; their fecundity is prodigious, their multiplication aſtoniſhing; the vegetables which cover the ſurface of the earth bear no proportion to their multitudes, every plant ſupporting a number often of ſcarce perceptible creatures; of the fatal effects of their prodigious multiplication, our fruit trees, &c. are too often a deplorable teſtimony. On the continent whole provinces often languiſh in conſequence of the dreadful havock made by the minute, but innumerable, hoſts of inſects.

The following is an experiment of M. Lyonet on the generation of a moth which comes from the chenille a broſſe: out of a brood of 350 eggs, that he had from a ſingle moth of this kind, he took 80, from which he got, when they were arrived at their perfect ſtate, 15 females; from whence he deduces the following conſequence: if 80 eggs give 15 females, the whole brood of 350 would have produced 65; theſe 65, in ſuppoſing them as fertile as their mother, would have produced 22,750 caterpillars, among which there would have been at leaſt 4265 females, who would have produced for the third generation 1,492,750 caterpillars. This number would have been much larger if the number of females among thoſe which were ſelected by M. Lyonet had been greater. M. de Geer counted in the belly of a moth 480 eggs, reducing theſe to 400, if ſuppoſing one-fourth only of theſe to be females, and as fruitful as their mother, they will give birth to 40,000 caterpillars for the ſecond generation; and for the third, ſuppoſing all things equal, four millions of caterpillars. It is not ſurprizing, furprizing, therefore, that they are found fo numerous in years which are favorable to their propagation. But the Creator of all things has for our fakes limited this abundant multiplication, by raifing up hofts of enemies, who, befides ficknefs, &c. deftroy the fuperfluous quantity.

The following is a calculation of the fecundity of the queen bee, by M. de Reaumur: he found that fhe laid in the two months of March and April 12,000 eggs, fo that the fwarm which left the hive in May confifted of near 12,000 bees, all produced from one mother; but thefe calculations all fall fhort of thofe which were made by Leeuwenhoek on a fly, whofe larva feeds on flefh, putrid carcafes, &c. which multiply prodigioufly, and that in a fhort fpace of time. One of thefe laid 144 eggs, from which he got as many flies in the firft month; fo that fuppofing one-half of thefe to be females, in the third month we fhall have 746,496, all produced in three months from one fly.

OF THE FOOD OF INSECTS.

Infects feed upon all kinds of vegetable and animal fubftances; there is fcarce any production of thefe two kingdoms which does not ferve for food to fome kind of infect. They may, therefore, be confidered under two heads, thofe which live on vegetables, and thofe which are fupported by animal food; each infect knows the food which is proper to fuftain it's life, it knows where to feek it, and how to procure it. It has been already obferved, that feveral infects, when arrived at a ftate of perfection, feed after their transformation upon food totally different from that which nourifhed them in their larva ftate; yet thefe are informed by by the laws of Divine order, to place their eggs on fubjects proper for the larva which are to proceed from them.

Among thofe which feed on vegetables, fome fink themfelves in the earth, deftroy the roots of the plants, and do confiderable injuries to our gardens, &c. The food of others is dry and hard; they pierce the wood, reduce it to powder, and then feed on it; fome, as the coffus, deftroy and attack the trees, while the food of others more delicate is the leaves. The leaf is eat in a different manner by different infects; fome eat the whole fubftance, whileothers feed only on the parenchemous parts, which are contained between it's fuperficial membranes, forming within fide the leaf paths and galleries. Thefe infects are not always content with the leaf, but attack the flower alfo: even this food is too grofs for many; the bee, the butterfly, the moth, as well as feveral fpecies of flies, feed only on the honey, or finer juices, which they collect from flowers. Fruits, grains, and corn, are not free from them; they divide them with us, and often deprive us of large quantities. We are continually finding the larva of fome infect in pears, plumbs, peaches, and other fruit; there is, indeed, no part of a plant which does not ferve as food to different infects; fome have one kind of plant marked out for them to inhabit and feed on, others have another affigned to them, on which, and no other, they will feed; each has it's appropriate food, and though the parent animal eats not at all, or lives upon food entirely different, yet fhe is guided, as we have already obferved, to depofit her eggs on that peculiar fhrub or plant that will be food for her young; while fome, more voracious than the reft, feed upon all with equal avidity. The grylus migratorius, a few years fince, poured out of Tartary in fuch quantities, as to lay waſte great part of Europe, producing almoſt unequalled calamities, ſwarming in ſuch multitudes as to cloud the air, deſtroying all the vegetables; in Sweden the cattle periſhed with hunger, and the men were forced to abandon their country, and fly to the neighbouring regions.* The far greater part feed only, however, on one ſpecies of plant, or at moſt on thoſe which are ſimilar to it; and the ſame ſpecies may always be found on the ſame plant.

Mr. de Reaumur ſays, that the caterpillar, which infeſts and feeds upon the cabbage, deſtroys in twenty-four hours more than twice it's weight. If larger animals required a proportionable quantity, the earth would not be able to nouriſh it's inhabitants.

A great number of inſects reject vegetable, and live on animal food; ſome ſeeking that which is beginning to putrefy, while others delight in that which is entirely putrid; others again are nouriſhed by the moſt filthy puddles, and diſguſting excrements; ſome attack and feed on man himſelf, while others are nouriſhed by his victuals, his cloaths, his furniture: ſome prey upon inſects of another ſpecies, othersatt ack their own, and harraſs each other with perpetual carnage.

Every animal has it's appropriate lice, which feed on and infeſt it. M. Rhedi has given an accurate account of a great number of theſe little noxious creatures, accompanied with figures; but, as if it were not ſufficient that theſe creatures ſhould dwell and live on the external part of the body, and ſuck the blood of the animal

* Select Diſſertations from the Amœnitates Academicæ, vol. 1, p. 398.

animal that they infeft, we find another fpecies of infects feeking their food in the more vital parts, and feeding on the flefh of the animal, while full of life and health. M. de Reaumur has given an hiftory of a fly (oeftrus bovis) which lives upon the backs, and feeds on the flefh of young oxen and cows, where it produces a kind of tumor. The fly lodges it's eggs in the flefh, by making a number of little wounds, in each of which it depofits eggs, fo that every wound becomes a neft, the eggs of which are hatched by the heat of the animal. Here the larva finds abundant food at the fame time that it is protected from the changes of the weather; and here they ftay till they are fit for transformation. The parts they inhabit are often eafy to be difcovered by a kind of lump, or tumor, which they form by their ravages; this tumor fuppurates, and is filled with matter; on this difgufting fubftance the larva feeds, and his head is always found plunged in it. When the time of their metamorphofis is ready, the larva falls upon the ground, and feeks a convenient place for the operations of the enfuing change.

There is a fpecies (oeftrus hæmorrhoidalis) which depofit their eggs in the rectum of horfes, it being in the inteftines of thefe only that they can be nourifhed. M. Vallifinieri has given an account of the introduction of thefe eggs into the horfe, as obferved by a friend of his who was looking at fome that were feeding quietly in a meadow: on a fudden they began to leap and jump, roll themfelves on the ground, then run, beat about their tails, and were otherwife violently agitated; perfuaded that thefe extraordinary motions were produced by a fly that was buzzing about them, he obferved them narrowly. The fly not being able to fucceed in it's attacks on thefe, quitted them, and flew towards

 a mare,

a mare, who was ſeparated from the reſt, making leſs noiſe than before, and here it was more ſucceſsful; it paſſed under the tail, and by cauſing an itching near the anus, forced the mare to puſh out the edge of the inteſtine, to open it, and then to enlarge the opening; the fly profited by this opportunity, and depoſited it's eggs in the fold of the inteſtine; in a little time the mare became almoſt furious, and was agitated in the moſt violent manner for a quarter of an hour, when ſhe began to grow more eaſy.

Nearly allied to the preceding are the following curious obſervations of an ingenious naturaliſt on the ichneumon fly. "As I was obſerving, ſays he, one day ſome caterpillars which were feeding voluptuouſly on a cabbage-leaf, my attention was attracted towards a part of the plant, about which a little fly was buzzing on it's wing, as if deliberating where to ſettle: I was ſurprized to ſee the herd of caterpillars, creatures of twenty times it's ſize, endeavouring in an uncouth manner, by various contortions of the body, to get out of it's way, and more ſo, whenever the fly poiſed on the wing as if going to drop; at length the creature made it's choice, and ſeated itſelf on the back of one of the largeſt and faireſt of the cluſter; it was in vain the unhappy reptile endeavoured to diſlodge the enemy. If the caterpillar had ſhewn terror on the approach of the fly, it's anguiſh at intervals now ſeemed intolerable, and I ſoon found that it was in conſequence of the ſtrokes, or wounds, given by the fly. At every wound the poor caterpillar wreathed and twiſted it's whole frame, endeavouring to diſengage itſelf, by ſhaking off the enemy, ſometimes aiming it's mouth towards the place; but it was all in vain, it's little but cruel tormentor kept it's place. When it had inflicted thirty or forty of theſe wounds, it took it's flight with a viſible triumph; in each of theſe wounds the little fly had depoſited an egg. I took the caterpillar home with me, to obſerve the progreſs of the eggs which were thus placed in it's body, taking care to give it a freſh ſupply of leaves from time to time; it recovered to all appearance in a few hours from the wounds it had received, and from that time, for the ſpace of four or five days, ſeemed to live comfortably, feeding voraciouſly. The eggs were all hatched into ſmall oblong voracious worms, which fed from the moment of it's appearance on the fleſh of the caterpillar, in whoſe body they were incloſed, and ſeemingly without wounding the organs of reſpiration or digeſtion; and when they had arrived at their full growth, they eat their way out of the ſides of the animal, at the ſame time deſtroying it. The caterpillar thus attacked by the larva of the ichneumon never eſcapes, it's deſtruction is infallible; but then it's life is not taken away at once; the larva, while it is feeding thereon, knows how to ſpare the parts which are eſſential to it's life, becauſe it's own is at that time tied up in that of the caterpillar. No butterfly is produced from it; the worms that feed on the wretched creature are no ſooner out of it's body, than every one ſpins it's own web, and under this they paſs the ſtate of reſt neceſſary to introduce them to their winged form." *

Of this ſtrange ſcene it is difficult for us to form a proper judgment; we are unacquainted with the organs of the caterpillar, ignorant of the nature of it's ſenſations, and therefore we cannot be aſſured what may be the effects of that which we ſee it ſuffer. "It is wiſdom to ſuppoſe we are ignorant, while we know the Creator cannot be cruel." From revelation we learn, that man is

* Inſpector, No. 64.

is the mean through which life is conveyed to the creatures of this lower world; that by finking into error, and fostering evil, he perverts his own life, and corrupts all that which proceeds from him: fo that the effects are the fame on the orders beneath him, as would arife to the world if a continual cloud was placed between us and the fun, depriving us at once of the falutary effects of it's invigorating heat and cheering light.

Laftly, many infects feed upon others; nay, fome even upon their own fpecies. The numbers of thefe two kinds are very numerous; and it is amongft thefe that we find the traces of the greateft art and cunning, as well in attack as in defence. Some, indeed, ufe main force alone, others employ addrefs and cunning. Every body is acquainted with the dexterous arts of the fpider, the curious web he fpins, it's regular conftruction, and the central pofition of the fpider, in order to watch more effectually the leaft motion that may be communicated to it's tender net. The art and hiftory of the formica leo are alfo well known, and a defcription of them would lead us too great lengths. Thofe who would wifh to purfue this fubject further, will find much fatisfaction in confulting the works of Reaumur and De Geer.

OF THE HABITATION OF INSECTS.

Infects may be divided, with refpect to their habitations, into two claffes, aquatic and terreftrial.

Standing waters are generally filled with infects, who live therein in different manners. There are, 1. Aquatic infects which remain always on the fuperficies of the water, or which at leaft plunge

plunge themſelves therein but rarely. 2. Others that live only in the water, and cannot ſubſiſt out of it. 3. Many, after having lived in the water while in the larva and pupa ſtate, come out afterwards with wings, and become entirely terreſtrial. 4. Some undergo all their transformations in the water, and then become amphibious. 5. Others again are born and grow in the water, but undergo their pupa ſtate on dry land, and after they are arrived at their perfect ſtate live equally in air and water. 6. Laſtly, there are ſome who live at the ſame time part in the water, and part on land, and which after their transformation ceaſe to be aquatic.

Among the inſects which remain on the ſuperficies of the water, are ſome ſpiders, which run with great addreſs and agility, without moiſtening their feet or their body; when they repoſe themſelves, they extend their feet as much as poſſible. There are alſo aquatic bugs, which ſwim, or rather run, on the water with great velocity, and by troops; another bug walks very ſlowly on the water; the gyrinus moves very ſwiftly, and in circles. There is a ſpecies of podura * which live in ſociety, and are often accumulated together in little black lumps. Thoſe inſects which always live in the water are generally born with the figure which they preſerve during their whole lives, as the monoculi, crabs, ſeveral kinds of water-mites, &c.

The number of thoſe which, after having lived in the water, leave it when in a winged ſtate, is very great: among theſe we may reckon the libellula, the ephemera, the phryganea, culices, tipulæ, and ſome ſpecies of muſcæ. All theſe, when in the larva and

* De Geer Diſcours ſur les Inſectes, tom. 2, p. 103.

and pupa ſtate, live in the water; but when they have aſſumed their perfect form, they are entirely terreſtrial, and would be drowned therein.

The notonecta, the nepa or aquatic ſcorpion, &c. never quit the water till they have paſſed through all their transformations, when they become amphibious, generally quitting it in the evening.

The water-beetles, of which there are many ſpecies, remain in the water all day, but towards evening come upon the ground and fly about, but plunge themſelves again in the water at the approach of the riſing ſun. The larvæ of theſe inſects are entirely aquatic; but when the time of their pupa ſtate arrives, they take to the earth, where they make a ſpherical caſe: ſo that theſe inſects are aquatic as larva, terreſtrial as pupa, and amphibious in the imago ſtate.

We find an inſtance of an inſect that lives at the ſame time in the water and the air, in the ſingular larva deſcribed by M. de Reaumur, Memoires de l'Acad. in 1714, p. 203. It has the head and tail in the water, while the reſt of the body is continually kept above the ſurface. In order to ſupport itſelf in this ſingular poſition, it bends the body, bringing the head near the tail, raiſing the reſt above the water, and ſupporting itſelf againſt ſome fixed object, as a plant, or againſt the borders of the pond; or, if it is placed in a glaſs veſſel, againſt the ſides of the veſſel; and if the glaſs be inclined gently, ſo that the water may nearly cover the larva, it immediately changes it's poſition, in order that part of the body may be kept dry.

At

At the baths of Abano, a ſmall town in the Venetian ſtate, there is a multitude of ſprings, ſtrongly impregnated with ſulphur, and of a boiling heat. In the midſt of theſe boiling ſprings, within three feet, of four or five of them, there is a tepid one about blood-warm. In theſe waters, not only the common potamogeitous and conſervas, or pond-weeds and water-moſſes, are found growing in an healthy ſtate; but numbers of ſmall black water-beetles are ſeen ſwimming about, which die on being taken out and plunged ſuddenly into cold water.*

Many inſects that live under the ſurface of the earth crawl out on certain occaſions, as the julus, ſcolopendra, and the oniſcus; they are alſo often to be found under ſtones, or pieces of rotten wood. Some inſects remain under ground part of their life, but quit that ſituation after their change; as do ſome caterpillars, many of the coleoptrous claſs, &c. We have already taken notice that numbers delight to dwell in filth and naſtineſs. The formica leo forms it's habitation in the ſand, as well as many ſpiders; one of theſe forms a hole in the ſand, and then lines it with a kind of ſilk, to prevent it's crumbling away; it generally keeps on the watch near the mouth of the hole, and if it perceives a fly, runs at it with ſuch velocity, as ſeldom to fail in it's attempt of ſeizing it, and then carries it to it's little den.

Another ſpider, diſcovered by Mr. l'Abbé Sauvage,† burrows in the earth like a rabbit, making a hole one or two feet deep, of a regular diameter, and ſufficiently large to move itſelf with eaſe. It lines the whole of it, either to keep the ground from tumbling

Mm in,

* Jones's Phyſiological Diſquiſitions, p. 171.

† Hiſtoire de l'Acad. 1758, p. 26.

in, or in order to perceive more regularly at the bottom what happens at the mouth, at which it forms a kind of door, made of different layers of earth, connected together by threads, and covered with a strong web of a close texture; the threads are prolonged on one side, and fixed to the ground, so as to form a strong joint; the door is hung in such a manner, as always to fall by it's own gravity. One of these cases, or nests, is in her Majesty's cabinet at Kew.

Insects are found no where so numerous as in trees and plants, where they find abundant food. They dwell 1. in the roots; 2. in the wood; 3. in the leaves, and in the galls which grow upon the leaves and branches; 4. in the flowers; 5. in the fruits and grains. It would be too tedious to enumerate the various species of these inhabitants; many particular observations have been already noticed; it has also been mentioned, that some inhabit the most fœtid substances they can find, while others dwell with and live on the larger animals; so that it only remains just to mention some of those in whom industry and art is more strongly marked to our eyes than in others.

Among the solitary bees there are so many curious circumstances to be described, that a single volume would not suffice to contain the particulars; we shall here only relate such as concern their habitations. One of these forms it's nest under ground, which is composed of several cells artfully let into each other, but not covered with a common inclosure; each cell consists of two or three membranes, inexpressibly fine, and placed over each other. The cavity, in which the nest is placed, is smeared over with a layer of matter, like that of which the cells are formed, and

and apparently ſimilar to that viſcous humour which ſnails ſpread in their paſſage from one place to another, and it is probable that they are formed of the ſame materials; this ſubſtance, though of ſo delicate a nature, gives them ſuch a degree of conſiſtency, that they may be handled without altering their form. An egg is depoſited at the bottom of each cell, where, after it is hatched, the worm finds itſelf in the midſt of a plentiful ſtock of proviſion: for in each cell there is placed a quantity of paſte, or a kind of wax, which is to ſerve as food for the worm, and ſupport the wall of the cell. The worm is alſo inſtructed ſo to conduct itſelf, and eat this food, as to leave ſufficient props for ſupporting the walls of it's apartment.

Many ſpecies of theſe bees content themſelves with penetrating into the earth, ſcooping out hollow cavities therein, poliſhing the walls, then depoſiting an egg and a ſufficient quantity of proviſions.

There is another ſpecies, that forms it's neſt under ground with remarkable induſtry; this bee generally makes a perpendicular hole in the earth about three inches deep, and cylindrical till it comes within about three-fourths of an inch of the bottom, when it begins to open it wider; as ſoon as the bee has given it the ſuitable proportions, it proceeds to line with tapeſtry not only the whole inſide of it's dwelling, but round the entrance: the ſubſtance with which it is lined is of a crimſon colour, and looks like ſattin. From this circumſtance Mr. de Reaumur * terms it the tapeſtry bee. This tapeſtry, or lining, is formed of fragments of

 the

* Reaumur Memoires pour l'Hiſtoire des Inſectes, edit. 8vo. tom. 6, partie 1, p. 170.

the flowers of the wild poppy, which ſhe cuts out curiouſly, and then ſeizing them with her legs, conveys them to her neſt. If the pieces are rumpled ſhe ſtraitens them, and then affixes them to her walls with wonderous art; ſhe generally applies two layers of theſe fragments on each other. If the piece ſhe has cut and tranſported is too large for the place ſhe intends it for, ſhe clips off the ſuperfluous parts, and conveys the ſhreds out of the apartment.

After the bee has lined her cell, ſhe fills it nearly half an inch deep with a paſte proper to nouriſh the larva when hatched from the egg; when the bee has amaſſed a ſufficient quantity of paſte, ſhe then takes her tapeſtry, and folds it over the paſte and egg, which are by this means incloſed as it were in a bag of paſte; this done, ſhe fills up with earth the empty ſpace that is above the bag. There is another bee which does the ſame with roſe leaves, and in the ſubſtance of a thick poſt. A friend of mine had a piece of wood cut from a ſtrong poſt that ſupported the roof of a cart-houſe, full of theſe cells or round holes, three-eighths of an inch diameter, and about three-fourths deep, each of which was filled with theſe roſe-leaf caſes, finely covered in at top and bottom.

The maſon bee is ſo called by Reaumur from the manner of it's building it's neſt. Theſe bees collect with their jaws ſmall parcels of earth and ſand, which they glue together with a ſtrong cement, which is furniſhed from the proboſcis; and of this they form a ſimple but commodious habitation, which is generally placed along walls that are expoſed to the ſouth. Each neſt reſembles a lump of rude earth, of about ſix or ſeven inches diameter, thrown againſt the wall; the labour of conſtructing ſo large

large an edifice muſt be very great, as the bee can only carry a few grains at a time. The exterior form is rude and irregular, but the conſtruction and art exhibited in the interior parts make up for this ſeeming defect; it is generally divided into twelve or fifteen cells, ſeparated from each other by a thick wall; in each of theſe an egg is depoſited by the parent bee. The cells are not conſtructed all at once, for when one is finiſhed ſhe places an egg therein, with a ſufficient quantity of honey to nouriſh the larva; ſhe then builds another. When the inſect is arrived at a proper ſtate, it penetrates through it's incloſures by means of it's ſtrong jaws. When all the bees have quitted the neſt, there are as many holes on the ſurface thereof as there are cells within. We find no neutral bees among this ſpecies, or at leaſt we do not know of any being yet diſcovered.

Another ſpecies of the ſolitary bee (apis centuncularis, Linn.) conſtructs her neſt in pieces of rotten wood, and has therefore been called the carpenter bee.* She divides it into ſtages, diſpoſing them ſometimes in three rows, with partitions curiouſly left between each; in theſe ſhe depoſits her eggs, with the food neceſſary for the young ones when hatched. They ſeparate the wood in a very expeditious manner, by dividing it's ligneous fibres, or threads, till they have made a proper ſized hole.

The art and ſagacity diſplayed by another bee,† whoſe neſt is conſtructed of ſingle pieces of leaves, is truly wonderful. The neſt itſelf is cylindrical, formed of ſeveral cells, placed one within the other as thimbles are in a hardware ſhop. The cells conſiſt of

* Geoffroy Hiſt. abregée des Inſectes, tom. 2, p. 401.

† Reaumur Memoires pour l'Hiſtoire des Inſectes, tom. 6, par. 1, p. 122.

of ſeveral pieces cut from one leaf, of forms and proportions proper to coincide with the place each is intended to occupy. The outer caſe, or cover, is formed with equal care and exactneſs. In a word, ſays M. Bonnet, there is ſo much exactneſs, ſymmetry, uniformity, and ſkill, in this little maſter-piece, that we ſhould not believe it to be the work of a fly, if we did not know at what ſchool ſhe learnt the art of conſtructing it. In each cell the mother depoſits an almoſt liquid ſubſtance, and yet ſo nicely are the cells formed, as not to ſuffer any of this ſubſtance to be loſt. But to ſee the detail of the works of this bee, and the curious mechaniſm of it's cells, we muſt refer the reader to Mr. de Reaumur's admirable hiſtory of inſects.

Of the maſon ichneumon waſp * (ſphex, Linn.). The proceedings of this are totally different from thoſe of the common waſp, though equally curious with them. It generally begins it's work in May, and continues at it for the greateſt part of June. The true object of her labour ſeems to be the digging of a hole a few inches deep in the ground; yet in the conſtructing of this ſhe forms a hollow tube above ground, the baſe of which is the opening of the hole, and which it raiſes as high above ground as the hole is deep below; it is formed with a great deal of care, reſembling a groſs kind of fillagree work, conſiſting of the ſand drawn from the hole. The ſand out of which ſhe excavates her cell is nearly as hard as a common ſtone; this it readily ſoftens with a penetrating liquor, with which ſhe is well provided; a drop or two of it is imbibed immediately by the ſand on which it falls, which is inſtantly rendered ſo ſoft, that ſhe can ſeparate and knead

* Reaumur Mem. pour l'Hiſtoire des Inſectes, tom. xi. par. 2, p. 9.

knead it with her teeth and fore feet, forming it into a ſmall ball, which ſhe places on the edge of the hole as the foundation-ſtone of the pillar ſhe is going to erect: the whole of it is formed of ſuch balls, ranged circularly, and then placed one above the other. She leaves her work at intervals, probably in order to renew her ſtock of that liquor which is ſo neceſſary for her operations; theſe intervals are of ſhort duration; ſhe ſoon returns to her work, and labours with ſo much activity and ardour, that in a few hours ſhe will dig a hole two or three inches deep, and raiſe a hollow pillar two inches high. After the column has been raiſed a certain heighth perpendicularly from the hole, it begins to curve a little, which curvature increaſes till it is finiſhed, though the cylindrical form is maintained: ſhe conſtructs ſeveral of theſe holes all of the ſame form, and for the ſame purpoſe.

It is eaſy to ſee why the hole was dug in the ground; that it was deſtined to receive an egg; but it is not ſo eaſy to perceive why the tube of ſand was formed. By attending to the labours of the waſp, one end, however, may be diſcovered; it will be found to ſerve the purpoſe of a ſcaffold, and that the balls are as uſeful to the waſp, as materials, &c. to the maſon; and are, therefore, placed as much within her reach as poſſible. She uſes them to ſtop and fill up the hole after ſhe has depoſited an egg therein, ſo that the pillar is then deſtroyed, and not the leaſt remains left in the neſt. The parent waſp generally leaves ten or twelve worms as proviſion neceſſary and proper for the growth of the young larva: no purveyor could take better precautions than our waſp, for ſhe has received her inſtructions from HIM who provides for the neceſſities of all his creatures. In ſelecting the

4 worms,

worms, ſhe chuſes them of a proper ſize, that they may be ſufficient in quantity, and of an age that will not be in danger of periſhing with hunger, in which caſe they would have been corrupted; ſhe therefore ſelects them when they have their full growth. It is alſo obſerved, that if ſhe chuſes a larger ſort ſhe gives a leſs number of them, and ſo reciprocally.

"By theſe and ſuch like inſtances, every rational mind may confirm itſelf in favour of a Divine agency; for human reaſon, if it be ſo diſpoſed, may collect and be convinced from the various operations in the viſible world, that there is a God, and that he is one; * a truth that is proved by innumerable teſtimonies; for the univerſe is as a theatre, on which the evidence of the exiſtence of a God and his unity are continually exhibited; and from theſe it may be ſeen, that God is the ſole operator by and through nature: for it is clear that nature cannot regard uſes as the ends of her operations, or diſpoſe ſuch uſes into their orders and forms. This is in the power of none but a wiſe being, and of conſequence of none but God, whoſe wiſdom being infinite, can ſo order and form the univerſe, as to make it a coherent and uniform work, all promoting and forming a complex of uſes in orderly arrangement, for the ſervice of man, who is to be a conſtituent of heaven: for the Divine Love cannot deſign any other end beſides the eternal happineſs of the human race, by the communication of itſelf, and the Divine Wiſdom can produce nothing but uſes

* The ſyſtem one, one Maker ſtands confeſs'd,
The prime, the one, the wond'rous and the bleſs'd,
The one in various forms of unity expreſs'd.
Brooke's Univerſal Beauty, b. iii.

ufes for the promotion of that end. By contemplating the world under this enlarged idea, every wife man may difcern that the Creator of the univerfe is one,* and that his effence is love and wifdom;" and that he effects whatfoever is done in nature, by his own operation, through the medium of the various celeftial and fpiritual hierarchies, gradually defcending from the higheft orders of this immenfe chain to the loweft.

Between the loweft and higheft degree of corporeal or fpiritual perfection, there is an almoft infinite number of intermediate degrees: the refult of thefe degrees compofes THE UNIVERSAL CHAIN. This unites all beings, connects all worlds, and comprehends all fpheres. One SOLE BEING is out of this chain, and that is HE that formed it.† Again, life itfelf, and confequently the Lord, is the fupreme, only, and infinite ufe; all other exiftencies in heaven or earth, whether fpiritual or natural, are only ultimate effects, or manifeftations from that one infinite caufe, exhibiting emblems of the ONE, ETERNAL, INFINITE ufe.

From a retrofpective view of this chapter, we may obferve a ftriking difference between man and the lower orders of animal creation. Man is born totally ignorant; fo much fo, that he has no knowledge even of the mother's breaft, till he has been brought

* Hence ENDLESS GOOD; hence ENDLESS ORDER fprings;
Hence that importance in minuteft things;
And endlefs hence dependence muft endure,
BLEST IN HIS WILL, and in his power fecure.

Brooke's Univerfal Beauty, b. vi.

† Bonnet's Contemplation of Nature.

brought acquainted with it by repeated trials; he has no innate ideas, is unable to chuse what is proper for his food; he cannot form his voice to any articulate pronunciation, or to exprefs the affections of love: whereas, the beaft, the bird, and the infect, are born to all that knowledge which is neceffary for the gratification of thofe defires, or that love which forms their life; and confequently in the knowledge of every thing relating to their well being, their food, their habitations, the commerce of the fexes, their provifion for their young, &c.: from the impulfe of the pleafure arifing from thefe innate defires and affections, the larva is alfo prompted to feek and afpire after a change of it's earthly ftate. If it were not foreign to the fubject in hand, it might be eafy to fhew, by a variety of reafons, that this imperfection of man at his nativity conftitutes his real perfection, and places him infinitely, if I may fo fpeak, above the brute creation: for man is not created relatively perfect, but formed a recipient of all perfection.

From this view of things, we may, however, perceive that animals are born in order, and confequently the Divine agency influences or acts on them more immediately. The fame wifdom which has conftructed and arranged their various organs with fo much art, that they may concur to one determinate end, directs the animal towards this end. Hence it executes with precifion the works we fo much admire: hence it feems to act as if it was capable of reafoning. It is excited to all this by that ADORABLE MIND which has traced out to every infect it's little circle, as he has marked out to each planet it's proper orbit. When, therefore, we fee an infect working a neft, a chryfalis, &c. we fhould view

it

it with respect, because we are beholding a scene behind which the SUPREME ARTIST is concealed from our eyes.

We may hence, also, perceive that the operations of insects are the ultimate result of the principles of life, upon their organization, which corresponds to the part they are to act in the grand machine of the world; they are, indeed, but small parts, but then these parts concur to produce one general effect, by their being interwoven with more important ones; so that the thread spun by a caterpillar has it's relations to the universe as well as the ring of Saturn.* But how immense the number of parts, which are interposed between this thread and the ring of Saturn, and between SATURN and the worlds of SYRIUS! If the universe is one whole, the thread of the caterpillar will also be connected with the worlds of Syrius. How great must that mind be which can comprehend this immense chain of various relations, and can perceive them all to resolve into UNITY, unity manifested in JEHOVAH JESUS! It behoves us to remain in the place that has been allotted for us, from whence we can only discover some links of the chain. One day we shall discover more, and see things more distinctly: mean while we may consider these proceedings of the insect race, which are so diversified and replete with industry, as an agreeable spectacle that furnishes us with an inexhaustible source of real pleasure, and useful instruction; that leads us to the Author of the universe as it were by the thread of the caterpillar, and which makes us admire in the variety of their means, and in their tendency to the same end, the fecundity and wisdom of the ORDAINING MIND.

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* Bonnet's Contemplation of Nature.

As no insects exceed the termites in their wonderful œconomy, wise contrivances, and stupendous buildings, it will be proper to give the reader some account of them, which we are enabled to do from the excellent paper describing them, which was written by the late Mr. Smeathman, and published in the Philosophical Transactions for the year .

The termites are represented by Linnæus as the greatest plagues of both Indies, and are indeed every way between the tropics so deemed, from the vast damages they cause, and the losses which are experienced, in consequence of their eating and perforating wooden buildings, utensils, furniture, &c. which are totally destroyed by them, if not timely prevented; for nothing less hard than metal or stone can escape their most destructive jaws.

They have been taken notice of by various travellers, in different parts of the torrid zone; and indeed, where numerous, as is the case in all equinoctial countries and islands that are not fully cultivated, if a person has not been incited by curiosity to observe them, he must have been very fortunate, who, after a short residence, has not been compelled to it for the safety of his property.

These insects have generally obtained the name of ants; it may be presumed, from the similarity in their manner of living, which is in large communities, that erect very extraordinary nests, for the most part on the surface of the ground; from whence their excursions are made through subterraneous passages, or covered galleries, which they build, whenever necessity obliges, or plunder induce induces them to march above ground, and at a great diſtance from their habitations, carry on a buſineſs of depredation and deſtruction, ſcarce credible but to thoſe who have ſeen it; but notwithſtanding they live in communities, and are like the ants omnivorous, though like them at a certain period they are furniſhed with four wings, and emigrate or colonize at the ſame ſeaſon, they are by no means the ſame kind of inſects, nor does their form correſpond with that of ants in any one ſtate of their exiſtence.

The termites reſemble the ants alſo in their provident and diligent labour, but ſurpaſs them, as well as the bees, waſps, beavers, and all other animals, in the arts of building, as much as the Europeans excel the leaſt cultivated ſavages. It is more than probable they excel them as much in ſagacity, and the arts of government; it is certain they ſhew more ſubſtantial inſtances of their ingenuity and induſtry than any other animals; and do, in fact, lay up vaſt magazines of proviſions and other ſtores; a degree of prudence, which has of late years been denied, perhaps without reaſon, to the ants.

The communities conſiſt of one male and one female, (who are generally the common parents of the whole, or greater part of the reſt) and of three orders of inſects, apparently of very different ſpecies, but really the ſame, which together compoſe great commonwealths, or rather monarchies.

The great Linnæus having ſeen or heard of but two of theſe orders, has claſſed the genus erroneouſly; for he has placed it among the aptera, or inſects without wings; whereas the chief order,

order, that is to ſay, the inſect in it's perfect ſtate, having four wings, without any ſting, it belongs to the neuroptera, in which claſs it will conſtitute a new genus of many ſpecies.

The different ſpecies of this genus reſemble each other in form, in their manner of living, and in their good and bad qualities; but differ as much as birds in the manner of building their habitations or neſts, and in the choice of the materials of which they compoſe them.

There are ſome ſpecies which build upon the ſurface of the ground, or part above, and part beneath; and one or two ſpecies, perhaps more, that build on the ſtem or branches of trees.

Of every ſpecies there are three orders; firſt, the working inſects, which, for brevity, we ſhall generally call labourers; next the fighting ones, or ſoldiers, which do no kind of labour; and laſt of all, the winged ones, or perfect inſects, which are male and female, and capable of propagation: theſe might very appoſitely be called the nobility, or gentry, for they neither labour, nor toil, nor fight, being quite incapable of either, and almoſt of ſelf-defence. Theſe only are capable of being elected kings or queens; and nature has ſo ordered it, that they emigrate within a few weeks after they are elevated to this ſtate, and either eſtabliſh new kingdoms, or periſh within a day or two.

The TERMES BELLICOSUS being the largeſt ſpecies, is moſt remarkable, and beſt known on the coaſt of Africa. It erects immenſe buildings of well-tempered clay, or earth, which are contrived and finiſhed with ſuch art and ingenuity, that we are at a loſs to ſay whether they are moſt to be admired on that account, or for their enormous magnitude and ſolidity.

The reaſon that the larger termites have been moſt remarked is obvious; they not only build larger and more curious neſts, but are alſo more numerous, and do infinitely more miſchief to mankind. When theſe inſects attack ſuch things as we would not wiſh to have injured, we muſt conſider them as moſt pernicious; but when they are employed in deſtroying decayed trees, and ſubſtances which only incumber the ſurface of the earth, they may juſtly be ſuppoſed very uſeful; and for the reaſon that they are in one ſenſe moſt pernicious, they are in the other moſt uſeful. In this reſpect they reſemble very much the common flies, which are regarded by mankind in general as noxious, and at beſt as uſeleſs beings in the creation.

The neſts of this ſpecies are ſo numerous all over the iſland of Bananas, and the adjacent continent of Africa, that it is ſcarce poſſible to ſtand upon any open place, ſuch as a rice plantation, or other clear ſpot, where one of theſe buildings is not to be ſeen almoſt cloſe to each other. In ſome parts near Senegal, as mentioned by M. Adanſon, their number, magnitude, and cloſeneſs of ſituation, make them appear like the villages of the natives.

Theſe buildings are uſually termed hills, by natives as well as ſtrangers, from their outward appearance, which is that of little hills, more or leſs conical, generally very much in the form of ſugar loaves, and about ten or twelve feet in perpendicular height above the common ſurface of the ground.

Theſe

These hills continue quite bare until they are six or eight feet high; but in time the dead barren clay, of which they are composed, becomes fertilized by the genial power of the elements in these prolific climates, and the addition of vegetable salts and other matters brought by the wind; and in the second or third year, the hillock, if not over-shaded by trees, becomes like the rest of the earth, almost covered with grass and other plants; and in the dry season, when the herbage is burnt up by the rays of the sun, it is not much unlike a very large hay-cock.

Every one of these buildings consists of two distinct parts, the exterior and the interior.

The exterior is one large shell, in the manner of a dome, large and strong enough to inclose and shelter the interior from the vicissitudes of the weather, and the inhabitants from the attacks of natural or accidental enemies. It is always, therefore, much stronger than the interior building, which is the habitable part, divided with a wonderful kind of regularity and contrivance into an amazing number of apartments, for the residence of the king and queen, and the nursing of their numerous progeny; or for magazines, which are always found well filled with stores and provisions.

These hills make their first appearance above ground by a little turret or two, in the shape of sugar loaves, which are run a foot high, or more; soon after, at some little distance, while the former are increasing in height and size, they raise others, and so go on increasing the number, and widening them at the base, till their works below are covered with these turrets, which they always

always raiſe the higheſt and largeſt in the middle, and by filling up the intervals between each turret, collect them as it were into one dome.

They are not very curious or exact about theſe turrets, except in making them very ſolid and ſtrong; and when, by the junction of them, the dome is completed, for which purpoſe the turrets anſwer as ſcaffolds, they take away the middle ones entirely, except the tops, (which joined together make the crown of the cupola) and apply the clay to the building of the works within, or to erecting freſh turrets for the purpoſe of raiſing the hillock ſtill higher; ſo that no doubt ſome part of the clay is uſed ſeveral times, like the boards and poſts of a maſon's ſcaffold.

The outward ſhell, or dome, is not only of uſe to protect and ſupport the interior buildings from external violence, and the heavy rains, but to collect and preſerve a regular degree of genial warmth and moiſture, which ſeems very neceſſary for hatching the eggs and cheriſhing the young ones.

The royal chamber, which, on account of it's being adapted for, and occupied by the king and queen, appears to be, in the opinion of this little people, of the moſt conſequence, being always ſituated as near the center of the interior building as poſſible, and generally about the height of the common ſurface of the ground, at a pace or two from the hillock; it is always nearly in the ſhape of half an egg, or an obtuſe oval within, and may be ſuppoſed to repreſent a long oven.

In the infant ſtate of the colony, it is not above an inch, or thereabouts, in length; but in time will be increaſed to ſix or eight inches, or more, in the clear, being always in proportion to the ſize of the queen, who, increaſing in bulk as in age, at length requires a chamber of ſuch dimenſions.

The floor is perfectly horizontal, and in large hillocks, ſometimes an inch thick and upward of ſolid clay; the roof alſo, which is one ſolid and well-turned oval arch, is generally of about the ſame ſolidity, but in ſome places it is not a quarter of an inch thick; this is on the ſides where it joins the floor, and where the doors or entrances are made level therewith, at pretty equal diſtances from each other.

Theſe entrances will not admit any animal larger than the ſoldiers or labourers; ſo that the king, and the queen (who is, when full grown, a thouſand times the weight of a king) can never poſſibly go out.

The royal chamber, if in a large hillock, is ſurrounded by an innumerable quantity of others, of different ſizes, ſhapes, and dimenſions; but all of them arched in one way or another, ſometimes circular, and ſometimes elliptical or oval.

Theſe either open into each other, or communicate by paſſages as wide, and being always empty, are evidently made for the ſoldiers and attendants; of whom, it will ſoon appear, great numbers are neceſſary, and of courſe always in waiting.

Theſe

Theſe apartments are joined by the magazines and nurſeries; the former are chambers of clay, and are always well filled with proviſions, which to the naked eye ſeem to conſiſt of the raſpings of wood and plants, which the termites deſtroy, but are found in the microſcope to be principally the gums or inſpiſſated juices of plants. Theſe are thrown together in little maſſes, ſome of which are finer than others, and reſemble the ſugar about preſerved fruits; others are like tears of gum, one quite tranſparent, another like amber, a third brown, and a fourth quite opake, as we ſee often in parcels of ordinary gums.

Theſe magazines are intermixed with the nurſeries, which are buildings totally different from the reſt of the apartments; for theſe are compoſed entirely of wooden materials, ſeemingly joined together with gums. They are called nurſeries becauſe they are invariably occupied by the eggs and young ones, which appear at firſt in the ſhape of labourers, but white as ſnow. Theſe buildings are exceedingly compact, and divided into many very ſmall irregular-ſhaped chambers, not one of which is to be found of half an inch in width; they are placed all round the royal apartments, and as near as poſſible to them.

When the neſt is in the infant ſtate, the nurſeries are cloſe to the royal chamber; but as in proceſs of time the queen enlarges, it is neceſſary to enlarge the chamber for her accommodation; and as ſhe then lays a greater number of eggs, and requires a greater number of attendants, ſo it is neceſſary to enlarge and increaſe the number of the adjacent apartments; for which purpoſe, the ſmall nurſeries, which are firſt built, are taken to pieces,