MICROSCOPIC ILLUSTRATIONS.

BY

C. R. GORING, M.D. AND ANDREW PRITCHARD.

WITH COLOURED ENGRAVINGS.

PRICE 10s.

Fig. 30.

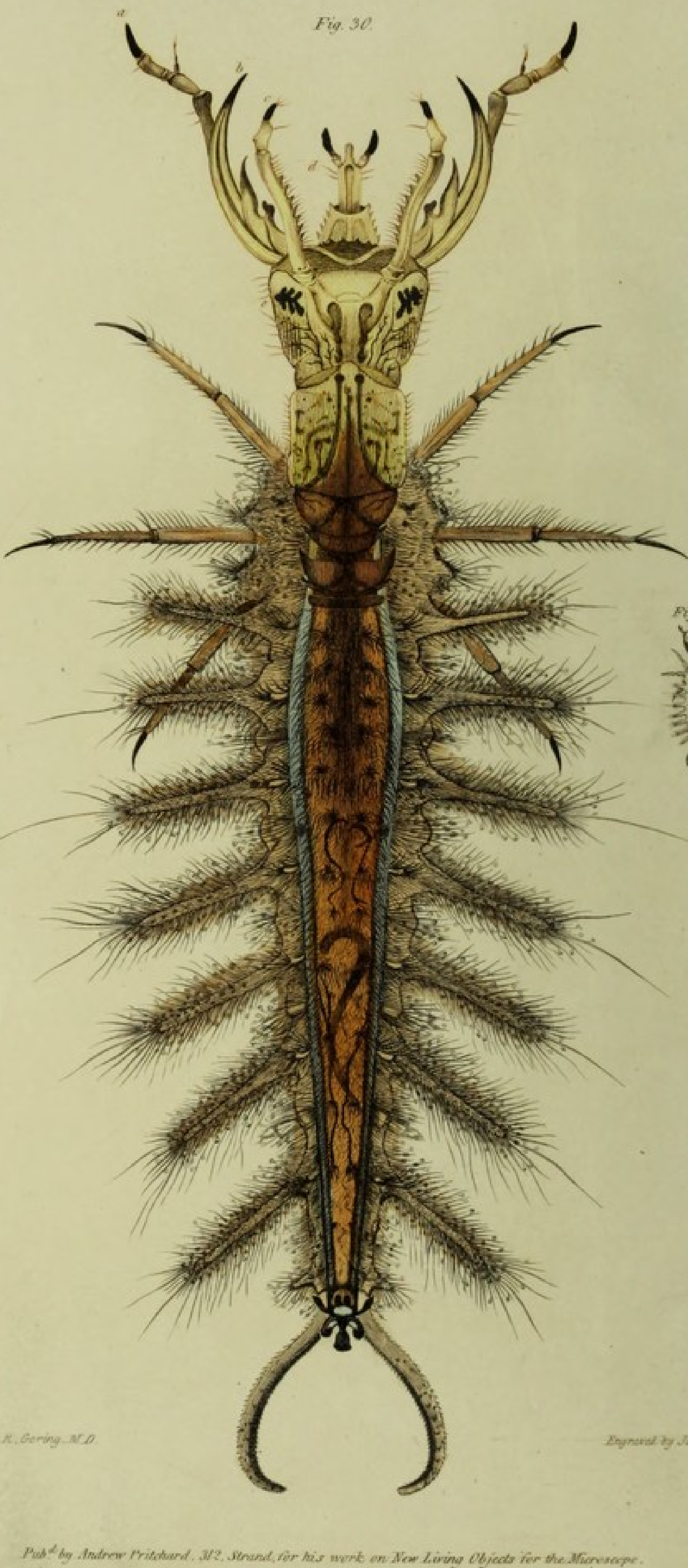

Fig. 31.

Drawn by C. R. Goring M.D.

Engraved by John Cleghorn

Pub.d by Andrew Pritchard, 312, Strand, for his work on New Living Objects for the Microscope.
1 May 1829.

MICROSCOPIC ILLUSTRATIONS

OF A FEW

NEW, POPULAR, AND DIVERTING

LIVING OBJECTS;

WITH THEIR NATURAL HISTORY, &c. &c.;

CONJOINED WITH

ACCURATE DESCRIPTIONS OF THE LATEST IMPROVEMENTS

IN THE

NEW MICROSCOPES;

THE BEST METHODS OF CONSTRUCTING THEIR MOUNTINGS, APPARATUS, &c.;

AND

COMPLETE INSTRUCTIONS FOR USING THEM.

Illustrated by highly-finished Coloured Engravings, from Magnified Drawings of the
ACTUAL LIVING SUBJECTS.

BY

C. R. GORING, M. D.

AND

ANDREW PRITCHARD,

HON. MEM. SOC. ARTS EDIN. &c.

" Legent hæc nostra nepotes."

LONDON:

WHITTAKER, TREACHER, & Co. Ave-Maria-Lane.

1830.

Mr. Pritchard having for some years devoted a large share of his attention to making and examining Drawings for accompanying the Specifications of Patented Inventions, informs gentlemen concerned in Patents, that from the extensive experience he has acquired, he is enabled to give his *Drawings* that degree of effectiveness and accuracy without which it is impossible to attain that correctness in the specification upon which the security and consequent value of every Patent entirely depends.

Mr. P. has completed his *Hollow Triangular* Stem Microscope, (mentioned at page 46,) for his Sapphire Lenses.—312, Strand.

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ADDRESS.

The management and expense of conducting the publication of this work from its commencement having devolved on me, as well as the remuneration for the copyright of the elaborate drawings which illustrate it, it is necessary for me in that capacity to offer some apology for presenting to the public a fragment like the present, which carries in it much internal evidence of being only the commencement of a regular work on a much more extended scale. I beg to state that its construction is such, that each of its chapters is in itself a distinct tract, containing much original matter not found in any other work, especially the instructions for managing the Aplanatic Engiscope, which also apply to most microscopes, and when thoroughly understood will enable an observer to deal with almost any instrument he may possess. For these reasons, and the very flattering manner in which the publication has been spoken of by the conductors of a scientific journal pre-eminently qualified to scrutinize its merits*, I have judged it my duty to present it to the public, as a treatise not wholly unworthy of patronage. The great difficulty, expense, and anxiety, attendant on conducting works of this description *periodically in Numbers*, with the small consideration bestowed on them by the public, *in that form*, render this step further advisable. The time, I believe, is not very distant when the entire work will be produced, with those drawings named in the Exordium, and many others in my possession.

A. PRITCHARD.

312, Strand, (opposite Somerset-House,)
March 1830.

* Edinburgh Journal of Science, vol. x. p. 360.

EXORDIUM.

The discovery of a set of objects for ascertaining the defining and penetrating powers of microscopes, has founded a new era in the history of those instruments. The thick aplanatic object-glass for diverging rays, and the Amician reflecting microscope, have in consequence been perfected. The substitution of diamond and sapphire lenses, for those made of glass, in the single microscope, with the ingenious and most effective method of illumination, contrived by Dr. Wollaston, may also in some measure be attributed to the same source. It may surely be affirmed that no improvements at all commensurate to these in magnitude and importance are likely to be made hereafter. Microscopes are now placed completely on a level with telescopes, and, like them, must remain stationary in their construction.

In my writings in the Quarterly Journal of Science, I have had the honour to lay before the public an account of most of the above-mentioned improvements; but as periodical publications are considered of small value, whatever their merit may be, when their date is passed, it becomes necessary to rescue matter worthy of notice from the oblivion to which it is too frequently consigned in them, by presenting it to the public in another form. I humbly conceive that at no period was a regular work on the Microscope and its objects more imperiously called for than at present: since the publication of Adams's book nothing of the sort has been seen in print in this country. Observers with the *new instruments* must be content to derive the necessary information concerning the management of them from the artists by whom they are fabricated, or from the periodicals aforesaid; but experience has constantly shewn that nothing short of *written and specific* directions are sufficient to enable individuals of ordinary calibre to make these instruments *do their best.* For example, I do not believe that out of ten observers with Amician reflectors, more than one could be found at this present moment fully capable of causing that admirable instrument to put *forth its whole mettle;* nor are those who use the compound aplanatics, or even single microscopes, much more skilful, as far as I can judge from my own experience: they usually take it for granted, that their instruments will do any thing and every thing under the necessary favourable circumstances; but these they are frequently unable to command at will. It must not be concealed that the difficulty of demonstrating many test objects satisfactorily is very considerable, even with the best microscopes, and perhaps exceeds that of separating the most refractory double star, or catching a glimpse of the faintest object in the heavens, with a telescope.

My peculiar province in the present work will be the *instrumental department and the test objects.* I shall do my utmost to communicate all the experience and tact which I have acquired to my reader, and shall add to, abstract from, change, alter, and improve the various tracts I have already written, as the subject may require; or I shall give entirely fresh matter.

Mr. Pritchard undertakes the department of natural history, the appearances under the microscope, and the description of the drawings, &c. He is already known to the public as the author of a paper in the Quarterly Journal " on the Art of forming Diamonds into single Lenses for Microscopes," and by two treatises *on Optical Instruments,* which he had the honour to write for the Society for the Diffusion of Useful Knowledge. I intended originally to have completed the work myself, but my health broke down before I had even got my drawings completed. I have been compelled to associate myself with a partner in consequence: I trust, however, that the public will have no reason to find fault with the arrangement, for Mr. P. has great practical acquaintance with the microscope.

Though it may savour somewhat of egotism, I cannot refrain from stating some of the difficulties which I experienced in making the drawings of the *living objects,* though I know very well that people of first-rate talent explode difficulties, and will hardly allow of their existence, except with bunglers and half-taught amateurs. I wish I had been one of those favoured individuals with whom the most arduous achievements of all sorts

———————— " are no more difficile,
Than for a blackbird to whistle."

HUDIBRAS.

If any portrait-painter had to execute a likeness of some person afflicted with chorea, who could not be prevailed upon to be quiet for more than half a minute together, who was perpetually jigging about the apartment, and exhibiting his tail instead of his head, &c. &c. I think he would be compelled to admit that he had undertaken a task which would at least require time and patience for its completion; but if, in addition, the said person was to be removed to a distance, so that the artist could only see him with a powerful telescope, and had to follow his motions as well as he could, and be content to catch a glimpse of him crossing his field of view now and then, according to the humour and good pleasure of the said individual, I think the worthy limner would begin to think that after all there was *some* difficulty to contend with.

Now this case I conceive to be an exact parallel to that of drawing living objects with a microscope.

Their incorrigible restlessness so baulks and baffles the artist, that he is frequently compelled to lay down his pencil to regain his lost temper, and fresh courage to proceed: in many cases his best resource is to study the object *till he has got all its features by heart*—then to set them down on paper—study again, and gradually correct them; by the time he has made half a dozen rough sketches he will get pretty near the truth: he may then commence a regular drawing. I can safely say that I have drawn many of my objects *five or six times over* before I could arrive at my portraiture. I have heard a great deal about shutting one's eyes after having made an observation, and *drawing from the impression left on the retina.* This, I suspect, is better in theory than in practice, and it is evident that, unless the object is *stationary,* the last impression must be so confounded with the preceding ones that no distinct image can be left.

But it will probably be asked, why I did not kill my object before I drew it, instead of giving myself all this unnecessary trouble? I answer, that I never could make a drawing to my mind from a dead aquatic larva or insect.

Such is the extreme delicacy of their organs, and so rapid their decomposition in water, that, long before a drawing can be executed, the main and capital parts of the internal, and even external structure, in most subjects, will become confused and unintelligible. If they are removed out of the water a still greater change is effected by their drying: their colours vanish, and their whole appearance is totally changed; to say nothing of the fact, that a dead aquatic insect so loses the peculiar distinctive character derived from its favourite attitude and position, that though the component parts might, in some instances, be correctly given, the *tout ensemble* would be scarcely recognized. Some of the proportions,—length of the body and legs, &c.—may, however, be measured from the dead subject; and this help I have always had recourse to when I could spare a specimen for destruction. All attempts to preserve these creatures in spirits, turpentine, &c. are useless, from the excessive corrugation these liquids produce. I also made various attempts to confine them in a narrow compass, so as to prevent much latitude of motion; but was compelled to desist from the project, finding that they got into constrained and unnatural positions, and injured themselves by struggling.

I suspect that other individuals have met with the same obstacles as myself in making drawings of living microscopic objects; for I think it may be affirmed, without any illiberality, that, with very few exceptions, those of my predecessors are proportionally more rude and incorrect than those of any other subjects of natural history whatever; their various lineaments and features being frequently false, and exaggerated to a degree amounting to caricature. If it is supposed that I can see the moats in my neighbours' drawings, without being able to see the beams in my own, let my designs of the Monoculus (water flee), and the larva of the Musca Chamæleon, be compared with those of Swammerdam*, the only ones, I believe, in existence, except my own, and with the image of the veritable living objects in the solar achromatic, and I think it must be allowed that mine will be found tolerable substitutes for the real objects, and that I have effected a radical reform in the drawings of microscopic subjects, equivalent to that which I have carried into effect with regard to the instruments. I must observe, however, that I have made my drawings at that period of the growth of the larva or crysalis in which I thought it made *the best and most interesting object,* and that they vary greatly in their appearance, according to the degree of maturity to which they have arrived. There are also many varieties, very closely resembling each other, which it is not very easy to particularize ; but I am quite confident, that when the genuine object is procured, in the state in which I drew it, the correctness of my execution will be recognized.

The specimens which I have selected are those which experience has shewn to excite the strongest emotions of pleasure and satisfaction in the great mass of observers of all ranks ; whom I have always found to be most delighted by *comparatively large living objects,* seen with *medium powers.* In fact, they seem to afford the same sort of gratification with a menagerie of living wild beasts on the

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* These caricatures have been handed down from bookmaker to bookmaker, from the days of Swammerdam, as correct and authentic, and requiring no reform whatever. Drawings of living microscopic objects are very *scarce,* another proof, perhaps, of the difficulty of making them.

large scale; and most certainly many of them wonderfully emulate the ferocity, voracity, cunning, and cruelty of the mammalia. They prey on each other, and fight with a degree of determined obstinacy not inferior to that of any beings whatever. They have likewise a thousand diverting pranks and humours, quite peculiar to themselves. In addition to these amiable and amusing qualities, they possess such a high degree of transparency, that their unique and beautiful internal machinery is as clearly perceptible as if they were made of glass; so that, without any dissection, we can unravel all the mysterious workings of their nature; such as the circulation of the blood, the pulsations of the heart, the peristaltic motion of the intestines, and the play of every muscular fibre. This property of transparency is not possessed by any other living beings with which I am acquainted, except the *animalcula infusoria*. I may observe, that no *perfect insects* present so many facilities for adaptation to the microscope, or can be so easily preserved and managed; so that the larvæ, &c. appear to me peculiarly and exclusively devoted to the consideration of microscopists.

Their natural history will be given by Mr. P., with every particular likely to interest the reader concerning their peculiar habits and instincts; such as their mode of locomotion, and of taking their prey; the food which they most affect; their relative dispositions towards each other, and other beings with whom they associate; with full directions how, when, and where to procure them; and how they may be preserved in health and vigour for observation, &c. &c.

In contradistinction to these, which are all *easy and* *popular objects,* will be appended (as before mentioned) a full and particular account of the TEST OBJECTS, comprising all the new discoveries. These must be considered as scientific objects, and exhibit all those curious, delicate, and difficult minutiæ, which gratify a connoisseur, and strain the powers of his instrument to the uttermost. They possess the same interest for the microscopic student which the double stars, the remote clusters, faint nebulæ, and other very distant objects, do for the astronomer.

I do not feel myself called upon to state more concerning the nature and object of this work; and I humbly hope that truth and justice to myself and partner, and our joint publication, does not require me to have said less.

I shall conclude this introduction by a vindication of microscopic science, and its votaries, from the aspersions which have been cast upon them by the inconsiderate; many of whom have been pleased to assert, that microscopes have, of late, received a degree of patronage from the most illustrious and distinguished *savans,* to which they are not legitimately entitled. Were they applicable to no other purposes than the dissection of blackguard vermin, the observation of stinking ditch-water, or the amorous passions of ants and worms, I should, perhaps, for argument's sake, admit that they were but the tools of a puny, pitiful pedant, whose passions and amusements were of a trifling, if not of a degrading complexion: but I would ask whether, in the hands of men like Bauer, they are not applied to the development of the most curious, important, and interesting details of anatomy and physiology, which, without their assistance, could never have been known?—and whether the finest and most delicate parts of the structure of animals, in their extreme penetralia, are not rendered equally intelligible with the coarsest and most evident parts of their fabric, by means of these instruments?

None are apt to treat microscopists with more contempt than some astronomers, and even mere star-gazers.

I shall always possess the most profound veneration for astronomy, as the most sublime of all the sciences; but star-gazing is a distinct department, though frequently confounded with it; and is, in my opinion, little better than downright microsophizing. To the telescope certainly belongs the inspection of the *great* and *sublime* works of the creation; to the microscope belongs the *petites* and *beautiful* ones: if the former shews us the world above, the latter exhibits the world beneath us; telescopic objects are numbered, those of the microscope inexhaustible.

Nature*, I should say its supreme Author, has been pleased to bestow so exquisite a degree of finishing upon many of his works, that they can be only appreciated by man with the assistance of the microscope. Surely he who is but a *work of God* may be allowed *to admire the works of his Creator,* without incurring derision or ridicule, even though they are minutiæ. *Trifles* are said to take only with frivolous minds; but *minutiæ are not necessarily trifles,* as it will be easy to prove. It is not only, in my opinion, unscientific, but even swinish and ridiculous, to contemn any thing merely on account of its minute-

* The eternal *deification* of nature by men of science—(for deified it surely is when spoken of as an active agent)—is, in my opinion, both improper and unphilosophical; for, *if taken up in an ill-natured way,* it may (according to the rigid import of the language) be construed into an *avowal of atheism.*

ness. To say nothing of the hackneyed argument, that greatness and littleness exist only by comparison, I will ask, if the Automaton Chess-player had been made on a scale of 1-20th of an inch to a foot, or even much less, it would, in consequence, become despicable as a work of art?

Suppose some individual, greatly distinguished by his talents in ship-building, in making astronomical instruments, or steam-engines, &c., was also to evince a passion for making minute automata and watch-work, such as tarantula spiders, minute singing birds, musical seals, or even such curiosities as a coach drawn by fleas, &c. would it shew good breeding, or good taste, to despise or ridicule his minute labours, while we admired his grander and more imposing works?

Now it does appear to me, that the Supreme Being does, in some sense, resemble such an individual; for *his power loves to display itself in every way in which it can be displayed, whether upon the minute or grand scale,* in the creation of animalcules, as well as of fixed stars; and I cannot help thinking myself, that those who spurn and *scoff at the minute works of God**, be they what they may, while they *affect an admiration of his great wonders,* are guilty of a species of impiety, and must be either liars, or hypocrites, or fools.

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* A friend of mine, who makes more use of his imagination than of his judgment, and is fond of quizzing microscopists, tells a story about a learned Dutchman, who having finished a decent folio on the anatomy and physiology of a bee, fell down on his knees to ask pardon of God, for not having done sufficient justice to the wonderful subject. If a folio could *fairly* be written on the structure of a bee, (and perhaps it might, if every part of it could be *perfectly* dissected,) surely it would in some measure

Men are perpetually wondering what can be the use of bugs, and fleas, and wasps, and such kind of vermin; and speak of them as absolute blots in the escutcheon of the Almighty. The use of these little insects is surely to teach man *a perpetual lesson of humility.* He is extremely apt to fancy himself the only being of real importance in this planet, and that every thing in it has been made for his exclusive use and accommodation; whereas a very little consideration must teach him that the said fleas, and bugs, and wasps, &c. *are intended to enjoy themselves in their own way just as he does;* that is to say, without greatly considering the convenience, comforts, or happiness of other beings, I consider it as certain that bugs were intended to prey upon man, as that man and the other prædaceous mammalia were intended to destroy the weaker animals. If a bug (I beg pardon—a *cimex lectularius*) could reason, it would probably suppose that man was of no other use in the creation than to prepare its habitation and supply its food; and would think that no better evidence need be adduced to prove the immense importance of a bug than that such bountiful provision had been made for it, &c.

If mere utility is to be made the standard of excellence, what a large part of that of most of the sciences consists in their effect *as counterpoises to superstition and barbarism!* and in this point microscopic science surely has its voice among the rest.—All men are apt to despise their neighbours' pursuits, and to dignify their own as the only ones of real importance and value: but while the use of

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justify, or at least palliate, the pious enthusiasm of the Hollander, supposing the said treatise to have had a real existence.

the microscope is sanctioned by the examples of Pond, of Amici, of Wollaston, of Herschel*, and of Brewster, who disdain not to relax from their severer studies in such pursuits, he must be very hardy and fastidious indeed who dares to deride and condemn them.

Great disgrace has been brought on microscopic science by the manner in which it has been perverted to the support of preconceived opinions and hypothetical views, as well as to a spirit of wonder-making. I hope that a new and golden age of observation will now commence.

C. R. G.

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* In No. III. Edinburgh Philosophical Journal, Art. 20, is a beautiful model of scientific investigation with the microscope, by Mr. H., as worthy, perhaps, of his genius, as any thing he ever wrote, entitled, "On certain Optical Phenomena exhibited by Mother of Pearl, depending on its internal structure;" and in Art. 32, of the same volume, "An account of Professor Amici's Discoveries relative to the motion of the Sap in Plants."

CHAPTER I.

Practical Remarks on Microscopes for Viewing and Drawing Aquatic Larva, &c.

The instrument which I used in executing the drawings was a single microscope mounted with three achromatic lenses of the 9-10th, 6-10th, and 2-10th of an inch sidereal focus. Had I not possessed these, I should probably have used sapphires, or even equivalent common ones; for I greatly prefer a single microscope as *a drawing tool,* from its being so very handy and manageable, and taking up so little room on the table. All the necessary motions were given to the optical part, and not to the stage, in order that living objects should be disturbed as little as possible. I always found it make a great difference for the better when they were allowed to remain unmoved, for their natural restlessness, when exasperated by motion, renders them completely intractable; when undisturbed, they will sometimes remain quiet for half a minute together. An aquatic live-box, of a little larger diameter than the length of the insect to be drawn, answers best to confine them : they may be kept quite closed up, for *they do not appear to me to require air to support their existence.* I was in the habit also of observing them with a compound aplanatic microscope, having a boot to slide over the objective end, so that it could be introduced into the large transparent vessel filled with water, which was their usual abode, and in which they would remain pretty quiescent, especially when well supplied with food. I must remark that *Thames water* is utterly poisonous to nearly the whole race of aquatic insects. I presume it is not necessary to say that every species of *camera lucida,* and all the contrivances which may be used for tracing inanimate objects, are altogether useless in drawing living ones. The *colours of every object* are given as seen with the 9-10th focus lens, having its full aperture, as they appear in mere day-light* without any artificial illumination whatever. The tints of these objects become fainter and fainter, and the shades darker and darker, as the magnifying power is increased. I did not find it necessary to employ any power beyond that of the simple 2-10th focus, in order to develop the whole of their structure : superior powers seem to me merely to magnify, without showing any thing about them (except the circulation) more satisfactorily, and do not take in a sufficient portion of the object for a pleasing view. When we want to examine these objects merely for the purpose of amusement, it will be advisable to use compound instruments, on account of their

* I utterly disapprove of lamp-light for larvæ; it gives indeed a strong outline, but confuses and more than half obliterates the *viscera,* while it makes the colours very dingy and dull.

large field of view, luxurious accommodations, and arrangements: their powers must be made equivalent to the single lenses I employed, namely, one inch, half an inch, and a quarter of an inch focus, which require their objectives to be about four, two, and one inch focus respectively, (as the weakest compound body which can be applied usually quadruples the power of the object-glass.) For the reasons stated above, all the requisite motions and adjustments must here also be given to the optical part, and not to the stage. It will also be found a very great convenience if the stage is so constructed as to admit of being altogether removed, so that any large body, such as a square vase on a large flat slider, containing the objects, can be substituted in its place, in order that there shall be no necessity to remove the insects from their usual places of abode in the said vessels, &c. as they are very apt to receive injury and become restless by such removal. In order to effect this very desirable arrangement successfully, it will be necessary that the bar of the microscope, instead of working upon the stand with a *cradle joint,* should possess a capability of turning round by moving in a *ball and socket,* or some other similar contrivance, so that the space occupied by the stage may *fold down on one side,* and allow of the introduction of the jar, &c. into it on its appropriate stand; when, all the necessary adjustments being possessed by the optical part, the instrument *is just as perfect and manageable without its stage as with it, and may be used upon any large body whatever,* which will be found a great convenience. This construction also gives great facilities for demonstrating all sorts of test objects, as well as for *verifying and proving the nature of bodies in-*

spected—(a subject which is as yet understood by few observers).

With respect to the exhibition of larvæ, &c. in the solar microscope, it may be observed generally that *whatever object-glass shews them well in a compound aplanatic, with the assistance of the body and eye-glasses,* will shew them *unassisted in the solar instrument,* because the distance to which the rays are suffered to diverge does the work of the compound body in giving the necessary amplification, which it is the peculiar property of this instrument to effect to a vast extent, without altering the size of the field of view. A solar microscope may in fact be defined in its optical principle as a mere object-glass, forming an image on a skreen, instead of the space included in the field bar of a compound body.

C. R. G.

CHAPTER II.

On the Larva and Pupa of a Straw-coloured Plumed Culex or Gnat.

TRANSPARENCY is a quality so essential to the display of the internal organization of living objects, that many devoid of it are often disregarded as of comparatively little interest. The object now before us, however, is so remarkably pervious to light, that under the microscope we are enabled to view every part of its interior structure with facility. Indeed it is diaphanous in such a degree as to render it difficult to be discovered in the waters in which it resides, for it assimilates nearly in colour to them during the *infant part* of its larva state.

Had its pellucid nature been its only quality, as an object for the microscope, it would have been worthy of attention; but it possesses others which render it a subject of the highest admiration to all who have seen it under a good instrument.

This larva, which is produced from an egg deposited by the perfect insect, inhabits still waters, and may be found in canals and clear ponds which have a sandy or gravelly bottom, but is seldom met with in places where there is much herbage or water grass.

The most certain time to procure it is during the months of May and June, though it may occasionally be obtained on warm days in December and the other winter months, provided the wind is not very high, a circumstance which it is important to attend to, and which will be again adverted to in our remarks on the weather best suited for procuring aquatic insects.

The best method of obtaining this creature is by means of a collecting net*. This, after it has been im-

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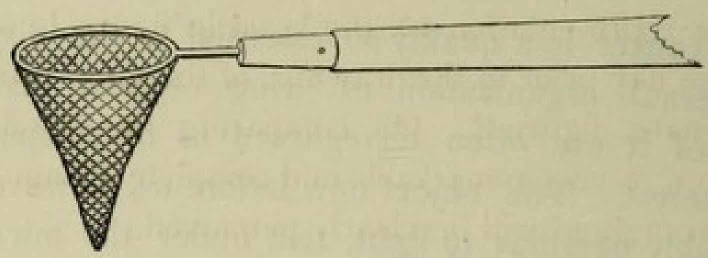
* (§ 1.) The *collecting net* found by experience to be best adapted for taking larva and small aquatic insects is represented in the annexed engraving.



It consists of a cone formed of silk taffety or fine muslin; the former being preferable, as more free from small knots and loose filaments, to which the insects might attach themselves. This cone, which partially filters the water, is to be attached to a brass wire ring of about five or six inches diameter, having a screw formed on the wire connected with the ring. This screw is made to fit into the ferule at the end of a common walking-stick, and when not in use, the net can be unscrewed, and carried in the pocket. The stick should have a cap to cover the hole in the ferule when not in use, to prevent dirt or other matters from filling it up when employed for walking. When the material of which the net is formed is very fine, it is advisable to enclose it in a coarser net; this I have endeavoured to indicate by lines representing the meshes of the net shewn in the engraving.

After using this net, the collector must always remember to turn it inside mersed in the water, near the edge, must be taken out, and its contents removed into a glass jar. It must then be carefully examined by removing small quantities at a time into a white saucer, or small wide-mouthed phial. When it has been examined in this vessel with a hand-magnifier, it should, if it contain the object sought for, be removed to a store-jar; if not, it may be thrown away, and another portion inspected as before, until all the water taken at a draught has been examined.

Although nearly a quarter of an inch long in its *nascent* state, this larva can scarcely be observed without a hand-magnifier of about two or three inches focus, (unless the collector be short-sighted,) as all its parts are nearly colourless, except two pair of shell-like bodies, which have a metallic appearance, and are nearly opaque, as shewn at *b* and *d* in the magnified side-view, figure 1.

The representation of the larva in figure 1, was taken only the day prior to the drawing of the same being in the pupa state, figure 2. On comparing the two drawings, however, a very remarkable and complete change of structure throughout will be clearly perceived.

In the larva, figure 1, the obvious and curious parts are the shell-like bodies *b* and *d*, two of which are situated near the head, and the other two in the third division from the lower extremity. The first pair are inclined towards each other, while the others lie in parallel planes, as repre-

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out, in order to wash from it any animalcula which may have adhered to its sides when the draught of water was emptied from it. If this is not done, it often happens that when the net is employed for collecting other kinds of insects, those that remain of the former collection will be mixed with the new ones, and they will often destroy each other when this precaution has been omitted.

sented in the plan or bird's-eye view, drawn of the natural size in figure 3. The other parts of its structure, which appear equally singular and curious, are a number of globules *a*, which are situated near the first pair of conchoidal bodies *b*. These globules have a slight oscillatory motion in different directions, and, like the shells, seem to have a metallic lustre. From the exquisite polish of these globules, they reflect the forms of surrounding objects, as window-bars, &c. which are indicated in the drawing by small squares, resembling the images formed by convex mirrors.

When the larva, as shewn in figure 3, of its full size, is examined from above, it exhibits the position and decussation of the various muscles lying along the back, which are observed to cross at the joints, and at points situated midway between them.

The alimentary canal appears to contain some particles of a pinkish-coloured matter, and has a slight peristaltic motion : but every part of the object, as seen beneath the microscope, is so accurately noted in the drawing, that a more minute description must be deemed superfluous.

If the insect has a sufficient supply of food, it only continues for about three weeks in the larva state, when it suddenly changes to the pupa, shewn in the drawing, figure 2. When it is desirable to preserve it for the microscope, this change may be retarded by keeping it in clear spring or river water. The former seldom offers sustenance to animalcula, and therefore effects this object; which is often very desirable, on account of the scarcity of this species.

The transformation of this animal from the larva to the pupa is one of the most singular and wonderful changes that can be conceived; and, under the microscope, presents to the admirer of nature a most curious and interesting spectacle. Although the whole operation is under the immediate inspection of the observer, yet so complete is the change, that its former organization can scarcely be recognized in its new state of existence.

If we now compare the different parts of the larva with the pupa, we remark a very striking change in the tail, which, in the previous state of being, was composed of twenty-two beautifully plumed branches; while, in the latter, it is converted into two fine membranous tissues, ramified with numerous blood-vessels. This change appears the more remarkable, as not the slightest resemblance can be discovered between them; nor can any vestiges of the former tail be found in the water. The partial disappearance of the shell-like bodies is another curious circumstance. The two lower of them, it may be conjectured, go to form the new tail; for if the number of joints be counted from the head, the new tail will be found appended to that joint which was nearest them in the larva state, as referred to by the dotted line *d*, connecting figures 1 and 2. The two small horns *c*, *c*, which form the white-plumed antennæ of this species of gnat, when in its perfect state, are discernible in the larva, folded up under the skin near the head, at *c* in figure 1. The alimentary canal appears nearly to vanish in the pupa, as in that state there is no necessity for it, the insect then entirely abstaining from food; while, near this canal, the two intertwined blood-vessels seen in the larva have now become more distinct, and are supplied with several anastomosing branches.

During the latter part of the day on which the drawing, figure 2, was taken, the rudiments of the legs of the perfect insect might be seen, folded within that part which appears to be the head of the pupa; and several of the globules had vanished, those remaining longest that were situated nearest the head. It may be necessary to observe, that the head of the pupa floats just under the surface of the water; and the insect, in this state, is nearly upright in that fluid; while the larva rests on its belly or sides, at the bottom of the pond or vessel in which it is kept.

The circuitous manner in which the Creator appears to from this species of gnat, and many other of His smaller productions, is truly wonderful. Other creatures are formed directly, either from the egg or the maternal womb. As, however, the Deity does nothing in vain, it may be presumed that He must have had in view some important object in the preliminary steps through which these beings have to pass; as from the *egg* to the *larva, crysalis,* and perfect insect; and, however low these minutiæ of nature may be held in the estimation of the unthinking mass of mankind, this most elaborate proceeding renders it not improbable that they may be deemed by Him the choicest and most exquisite of His productions. These mysterious, creative operations of nature, as detected and unravelled by microscopes, are surely GRAND AND CAPITAL SUBJECTS FOR OBSERVATION. I should pity the spirit of the man who scorned to be amused by inspecting these MARVELLOUS METAMORPHOSES, and disdained to be informed of the manner in which they are effected. *What a magnificent spectacle must such a transformation present in the solar achromatic microscope, exhibited to a whole company with all the accuracy and fidelity which the pictures formed by that instrument are capable of displaying!*

The colour of the larva when young is a faint and scarcely perceptible yellow; but as it approaches the change it assumes a richer and deeper colouring, and all its internal parts acquire their definite forms and tints, as exhibited in the drawing.

The natural history of this identical species of culex is but little known, as it has not been noticed by any writer on entomology. The intense interest, however, which, under the microscope, it excites in the observer, will always render it an object of value. Other species of the gnat are well known; and a description of the common gnat, from the egg to the perfect insect, has been illustrated by Swammerdam, in his work entitled "*Biblia Naturæ, sive Historia Insectorum**;" in which are two folio plates entirely devoted to it. This, however, is very different from the species exhibited in our drawings. Indeed the larva and pupa of the common gnat are too opaque and uninteresting to be of much value as microscopic objects, except in their transfiguration.

A curious circumstance attends the observation of this insect: so rapid is its locomotion, that it torments the eye while attempting to delineate it, presenting alternately its head and tail to the observer. This it effects by bending itself laterally into a circular form, and suddenly whisking round in the opposite direction to that in which it just bent itself.

So truly surprising is the change in this larva, *not effected, as in other insects, by casting the outer skin, but by an actual conversion of one form of matter into another*, that it would be worthy the constant attention of the naturalist

* Tom. II. Tab. xxxi. et xxxii. 1737.

to watch its progress during the whole time of its transformation under the microscope, whenever it may occur. Had Dr. Goring been aware of the approaching change, he would have been tempted, though labouring under ill health at the time, to continue his observations with the microscope during the whole night in which it was effected.

Many species of this genus of insects are, in their perfect state, possessed of a sheathed proboscis, containing instruments with which they are enabled to pierce the skin of men and cattle, injecting at the same time an acrimonious fluid into the wound. The species we are now describing, however, has not been examined minutely enough to determine the existence of similar organs. It is of a light straw colour, and has two beautiful antennæ or feelers. In the male these are filiform, or threadlike; while, in the female of most species, they are feathered. The whole appearance is so much like a moth that a superficial observer might mistake it for that insect*.

The wings, also, of this gnat are of a delicate straw colour, and would make very beautiful objects, when mounted between two pieces of talc in sliders. Some species have their wings marginated, and covered with fine scales. These, as well as the feathers on the edges, are good objects for the microscope, and exhibit five or six longitudinal lines on each, which are so strongly marked as to be seen with any kind of light, and do not require superior excellence in the instrument to shew them. The whole wing may be seen very beautifully, under the im-

* Dr. G. regrets that he has not given a figure of the perfect insect, for the satisfaction of entomologists.

proved Amician Engiscope, with its lowest power, which is equivalent to a lens of a quarter of an inch focus. To the larva and crysalis of insects this instrument cannot be applied satisfactorily, as it does not take in the extent of field necessary to shew the whole at once. On this account the achromatic compound microscope has the decided advantage, from the low power and large area which can be obtained by it. In examining this larva with the microscope, it will be best seen when the light is thrown obliquely on it; though, when low powers are used, much attention to this particular is not required.

These insects generate while hovering in the air, and the female lays her eggs in the water. The species we are now describing appears to be very choice in selecting an unfrequented spot, where she may deposit them free from danger. This is, probably, the cause why this larva is discovered with so much difficulty, the collector being seldom able to procure them two seasons consecutively in the same place.

A. P.

CHAPTER III.

Larva and Crysalis of the Ephemera Marginata.*

When this larva issues from the egg, which it does at the decline of summer, it has at intervals an unsteady motion, in a manner apparently involuntary. During this stage it is scarcely visible to the unassisted eye, and is very pellucid. As it increases in size, the serpentine vessels attached to the sides of the animal become more apparent, and the tail assumes that rich feathered appearance which, in conjunction with the paddles, forms its pre-eminent beauty.

While the insect is very young, it is well adapted as an object for the solar achromatic microscope, in which it will afford an ample fund of amusement, when thrown on a screen, and dilated to the extent of about two feet in length. If the instrument is truly *aplanatic*, every part of the insect's internal organization may be seen distinctly;

* It may, perhaps, be termed either, according to its state of growth.

and the peristaltic motion of the intestines, the circulation of the blood, and the pulsation of the heart, can be observed without the least trouble, by any number of persons. In this latter circumstance the principal advantage of this instrument consists; for it cannot be denied that an aplanatic compound microscope will exhibit these appearances with equal truth, and without any risk of killing or injuring the object by exposure to the heat of the sun's rays condensed upon it.

As the creature continues growing, it assumes a variety of colouring, and becomes more opaque as its change approaches towards completion, which takes place in a few months from the time it leaves the egg. The eyes are reticulated, as represented in figure 4, and are of a citron colour; while the body exhibits a most beautiful play of different tints, and finally assumes that of a rich brown, with various shadings. The paddles have now a dark fluid in their blood-vessels, and the elytra, or wing cases of the future insect, become more and more apparent daily.

During the infant state of this larva's existence it is very transparent, exhibiting, under the microscope, in a most surprising manner, the circulation of the blood along the large arteries in the body, legs, and tail. While traversing the tail, the blood resembles a string of globules. The part which exhibits the most rapid circulation is the lower lip*.

The passage of the blood through the head has a very singular appearance. It runs through a vessel which passes quite round the body of the larva, constituting a

* The powers best adapted for viewing the circulation run from one-tenth to one-twentieth of an inch.

band, which, incurvating itself on the head, forms, as it were, a semicircular chain around the base of each antenna. In a more advanced stage, the lower part only of this vessel is visible, the part near the head being concealed by the crustaceous covering, as may be seen in the drawing, figure 4; which is a magnified representation of the larva, taken immediately previous to its change to a perfect insect.

The larva, of its full size, is shewn in figure 5; and figure 6 is a view of the perfect insect.

When the larva is dead, the particles of the blood may be distinctly discerned in its forked tail, of an oblong figure; and their motion is perceptible in the limbs for nearly an hour after their separation from the body. There is an apparent pulsation in the oval organ in the penultimate joint of the body, which, was it not for its odd situation, I should suppose to be the heart of the insect.

The peristaltic motion of the alimentary canal will also present, under a good instrument, a beautiful and interesting appearance.

The three-pronged tail of this insect, in its advanced age, is beautifully fringed with clusters of fine, straight, smooth hairs, or bristles, four in each bunch, as represented in figure 4. As the time for its transformation approaches, the central prong of the tail becomes more transparent, and assumes the appearance of a jointed tube, or shell-like case; while the two exterior ones distinctly exhibit portions of the tail of the perfect insect inclosed within them, as shewn in the drawing. The same may be observed as to the legs, which are seen to contain those of the perfect fly.

This larva is produced from an egg, deposited by the perfect insect in the waters of pools or ditches, among duck-weed, and the water-grasses. Its deposition is mild and inoffensive. It is incapable of destroying any thing but small animalcula, while it is itself the prey of all kinds of water-beetles and the larger larvæ.

It feeds on the larvæ of the smaller kinds of tipulæ, or crane flies, as well as on aquatic vegetables. Short pieces of grass, &c. are frequently seen in it, when examined under the microscope during the spring season.

When it is intended to collect this larva, a mild calm day should be selected; for if there be any cold wind, it retreats into the mud at the bottom of the water. It may be easily taken with the collecting net described in Note, § 1, which must be introduced among the grasses and water-plants to which they attach themselves. Having carefully introduced the net at that side of the pond which is most exposed to the sun's rays, by gently dragging it among the floating duck-weed, many hundreds may often be collected at a single draught.

These larvæ may be kept alive, for many weeks together, in a tumbler of water, with duck-weed floating on its surface; and will be ready to be applied to the microscope whenever required.

The rapidity with which it moves is truly astonishing. Besides its six legs, it employs the six double paddles attached diagonally to the serpentine vessels on each side of its body and its tail, for the purpose of rowing and balancing itself, and two other paddles for steering, making in all fourteen. Even when the creature it at rest, if in health, all except the lowest two, or steering paddles, are in rapid motion; a circumstance which renders those beautiful ramifications of the blood-vessels shewn in the drawing, figure 4, difficult to be viewed while the larva is alive.

Independent of its locomotion, by means of its legs, paddles, and tail, it possesses a power of leaping or springing in the water, which it effects by incurvating its body backwards, and then suddenly straightening it, by which kind of motion it raises itself to the surface of the water with great celerity.

When the crysalis approximates to its perfect state, it swims more elegantly: its motions now appear entirely subservient to its will, and at the same time it leaps with greater velocity. Within a few days, however, of its change, it becomes rather sluggish, and attaches itself to the stalks of water-plants, on which it will remain for hours together, if undisturbed, only moving its paddles at intervals.

At the period of its transformation to the perfect state, some parts of the insect assume a metallic lustre, as if the space between the crysalis (which may now be called the case of the animal, every part of the latter being perceptible through it,) and the inclosed insect, were partly filled with mercury. This appearance is ultimately extended over the whole body, and is probably occasioned by the bursting of the skin of the larva, and the entrance of water confining a small quantity of air or gas, which is probably evolved during the change; and which, by insinuating itself between the case and the insect, may facilitate the process. After remaining a few minutes in this state, and making occasional efforts to disentangle itself, it bursts forth from its watery dwelling, and wings its flight into the aerial regions, either leaving the entire skin behind it in the water, or carrying part of it away.

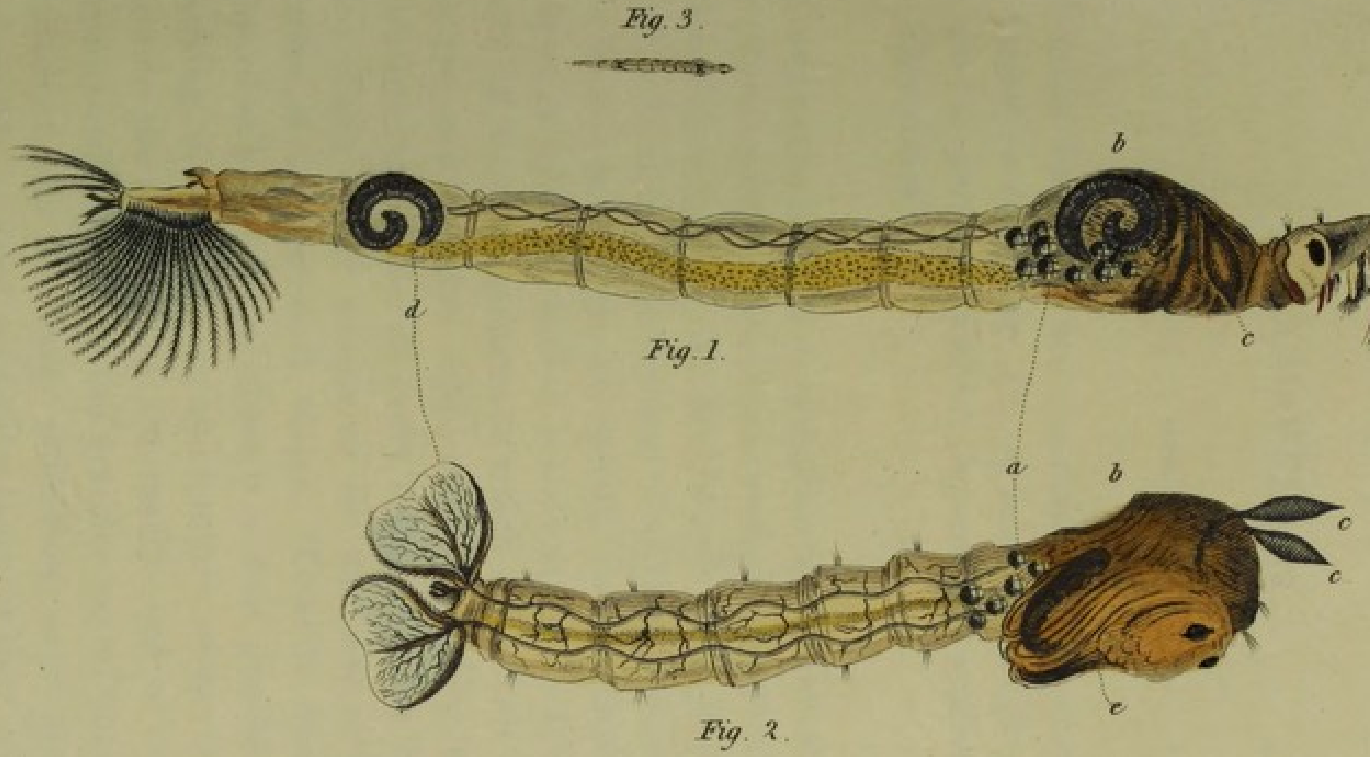
The exuviæ, or skin, which it sheds, on assuming the perfect form, is a very fine transparent object for the single microscope, with a lens of the tenth of an inch focus. In this state it affords much useful information, as to its structure, formation, &c. of which the paddles, tail, &c. furnish no inconsiderable portion. If it be thought desirable to expedite the casting of the exuviæ (for it does this several times before its final change), it may be effected by removing the insect from the water in which it is found into spring water. This effect is most probably produced by the water mechanically altering the dimensions of the skin or case which inclosed the insect, and thereby suffering it to escape with great ease; or, perhaps, from the same cause which produces this effect in the common spider when deprived of sustenance. These skins should all be mounted in sliders, in the order in which the insect sheds them, that, by comparing them together under the microscope, we may ascertain with precision the progress made during each change.

When the crysalis is divested of its envelope, it remains apparently inert on some neighbouring plant for a few minutes, where it casts off from its wings the last pellicle, which is a thin and delicate membrane, formed under the elytra of the crysalis. It then appears in the imago state, with its biforked tail and wings, as represented of the full size in figure 6.

Having become a perfect Ephemera, it hovers about in the air, the male and female generate, the latter drops her eggs in the water, and both die, existing only a few short hours, to perform all the offices destined for them to fulfil in the economy of nature.

In the transformation of this insect, as in that of many others, *the subsequent animal is formed while externally appearing under another shape*; and when it makes its appearance, we are astonished at the apparently sudden change which all its members have undergone; but when, by the assistance of the microscope on these transparent objects, we are enabled to detect their gradual formation in disguise, a great portion of our wonder vanishes. It was otherwise with the insect described in the former chapter; for in that, a total conversion of all its internal and external organization was effected in the space of a night; and as it was so transparent as to permit the light to traverse freely through it, every internal, as well as external change, could have been detected by the microscope.

A.P.



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CHAPTER IV.

Whether there is a best possible way of constructing the stand, or mounting, &c., of microscopes (the specific purpose or purposes to which they are to be applied being first determined)?

I APPREHEND that the construction of all kinds of mechanical implements, tools, utensils, musical, philosophical and mathematical instruments, &c. may be reduced to *fixed principles*, and that one best possible way of making them, may, and can be discovered, (when the specific and particular end and object of their fabrication is duly settled). It is otherwise with all those manufactures which are of an ornamental nature, and therefore subject to the caprice of taste and opinion; and also with every thing made for the gratification of any of our senses, or for the ease and accommodation of our personal wants. Thus it would be very absurd to pretend, that there is a best possible system of cooking, or making caps and bonnets, unless we choose to assume the position, that the specific end of cooking and mantua-making, being the gratification of the whims and fancies of *some particular individual*, even these arts are reduceable to fixed principles (such as they are). Every thing connected with the fine arts always resolves itself into *a matter of opinion*, about which it is perfectly useless to contend, because every man considers his own private judgment, however *outrè* or singular, as of equal value at least with that of his neighbour's. The standard of taste is, then, a mere chimera, because it differs like the face, or form of the limbs, in every particular specimen of the human race; unless, indeed, it might be ascertained by taking the average of that of the whole species.

However, mankind seem to have come to a common decision concerning the utility, excellence, and superiority of many things, and to consider them as incapable, or nearly so, of any *real improvement*. This is the case with regard to many points, even determined by the judgment of the senses; but more so with regard to those whose value is supposed to be ascertained by the test of experience. Thus a variety of mechanical tools, &c. may be considered as erected into standards, and not at all likely to undergo modification in future. Even musical instruments, as regards *the quality of their tone and sound*, seem to have arrived at a regular and determined mode of construction.

Now, if so many other things have been perfected and erected into standards, by the common consent of the human race, why should not microscopes also? Why should we not bend the whole force and power of our invention and reflection, towards the fabrication of every thing connected with them, till every point is effected in the best possible manner? These instruments have undergone a complete revolution in their optical parts, and become truly dignified and respectable: assuredly their mechanical structure should correspond with the advance which has taken place in their optical constitution.

However, like other things, they are varied in their construction to serve particular purposes. Thus, if made merely for commerce, or to look at, or to wear in the waistcoat pocket, like a snuff-box, they must evidently be made on a plan quite different from that required for scientific observations.

I pretend not to meddle with matters concerning commerce; the *trade* understand them far better than I do, and shall therefore merely observe, that several individuals experienced in business have assured me, that the first thing to be considered in the construction of a microscope, is *its price;* and the second, *the size of its case, and how it is to look when packed in it*, with all its little eye traps and trinkets about it. It is frequently sold in two minutes, long before the merits of its construction can be known, therefore one kind is just as good as another, the public at large being no judges or connoisseurs in such matters.

Again, instruments may be made expressly for transparent objects, or opaque ones, or even some particular class of those bodies, for lamp light only, or for that of the atmosphere, for drawing, for public exhibition, &c. all of which circumstances will produce a variation in their fabric, while they are correctly adapted to their intended use, and, therefore, perfect in their kind. The construction which I wish to discover myself, is that of *an approximation to a standard for general purposes;* and I think the *principles* at least of such a structure, may be ascertained, though *the best possible way* of carrying them into effect, perhaps, *cannot* at present, at least by myself.

In the first chapter of this work I have already sketched an outline of the kind of instrument which I here propose now to fill up and reduce to a determinate form, but shall first detail a few of the obstacles which all who attempt to reform the construction of microscopes may be expected to encounter. First, there is the inveterate hatred and contempt of all innovation whatever, which seems to form a part of our nature, when arrived at a certain period of life. Men long used to some particular way of doing any thing, cannot endure the idea of going to school again, and learning to act upon a new system. The very idea of *the possibility of being taught any thing*, galls and wounds their self-love to the quick : if this concerns a matter relative to their particular profession, or something, perhaps, on which they peculiarly pique themselves, they become altogether indignant and furious*. If by any possibility they are brought

* I had a Spanish cook who piqued herself very much upon frying fish, and who certainly cooked it most inimitably, according to her own country fashion, that is, quite plain, and in oil. I once wanted some smelts fried in the English way, *i. e.* with egg and crumbs in lard. Though cooking is notoriously a matter of taste, yet I think cooks are more obstinate and bigotted, in their own way, than any other artists whatever. I suspected I should have a tough job, so I resolved to be very gracious, and accordingly stepped down to Teresa's laboratory, with a brandy bottle in my hand, to smooth her over, and resolved to go about the bush very cleverly. It did not do though. Having prefaced the subject with a glass, I entered into the detail, and thought I was getting on famously, as she heard me to an end very patiently, with merely a few short coughs. She then, however, burst at once into a volcanic paroxysm of rage, and as she always spoke Spanish when in a passion, I could but very imperfectly understand her. After a volley of invocations and execrations, her oration was, I believe, something to the tune of what follows :—" Holy Mother of God, look down upon me! Fry fish in lard with egg and crumbs!!! What beasts these English heretics are!!! *You teach me to fry fish? You? You?* [Here she lifted up the frying-pan, which she had just been polishing in the inside with a brickbat.] By St. Jago and St. Dennis"—I did not wait to hear any more, but sneaked up stairs again, with my tail betwixt my legs, just as a well-bred dog does out of a room when he sees preparations making for kicking him out,) blessing my stars that I did not get a spank with the frying-pan on that part of me which escaped last. Finally, I ate the fish, fried in oil, and before Teresa would be pacified, was obliged to recant my filthy and damnable heresies, and say

to recognize the necessity of some change, they must make it themselves; what a disgraceful and lamentable poverty of genius would it not shew, to copy a good thing which had been invented by another man!

It cannot be denied, moreover, that there really is a great deal of trouble in getting up new philosophical instruments of all sorts. There are fresh patterns to be made, and tried, and re-made; workmen to instruct afresh, and after all, particular parts of the instrument may not fulfil the intended purpose, and must be remodelled; all of which circumstances occasion a great deal of annoyance and expense, and naturally render men averse from the adoption of new constructions; more especially as the public at large never can be imbued with a sense of the difficulties, expense, and loss of time, occasioned by what are called, *out of the way jobs*, and consequently can never be induced to pay for them, so as to remunerate the artists employed.

If it is indeed true, that conceit is given to man to console him for want of talent, and that the less of one of these qualities he may possess the more he is likely to have of the other; what must be the consequence, should it happen that an individual, possessing seventy-five parts of conceit

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I was only *in fun*; that her way was much the best; and, moreover, give her two more glasses of brandy; and thus ended my unfortunate expedition. (I should not have truckled to her at this rate, but that she was the most industrious, cleanly, and honest domestic that ever poor microsopher had.) Now what this she Spaniard expressed, with the fierce energy of her clime and country, every man, I suspect, feels more or less, when any attempt is made to put him out of his way in matters in which he thinks it is his exclusive province to dictate. I have never forgot Teresa's lesson, and expect about as much luck in reforming microscopes as I had in teaching her to fry fish.

and twenty-five of talent, comes in contact with something invented, or recommended by a man who has but twenty-five of the former quality and seventy-five of the latter? Is it likely he will adopt it? Never. He will imagine that he can produce something infinitely better, and will be still more strenuous in this opinion if he happens not to possess a grain of experience on the subject under deliberation. All these considerations have had so much weight with me, that I have more than once determined never to meddle with the stands and apparatus of microscopes at all, but leave men to settle them according to their own fancies; but my friends have told me, that I have as good a right to consider an ounce of my own wit equal to a ton of my neighbour's as other men have, and that I ought to make the experiment, of giving a construction of my own, whether it may be adopted or not. I shall therefore state my own views on the subject, and for every particular structure recommended, shall give a reason which every man may, of course, either admit or disprove, together with the construction deduced from it. First, then, I say, that the stage should be motionless, and that *the optical part only should possess the requisite power of traversing* and adjustment; because living objects are much more quiet when allowed to remain at rest, and therefore more easily observed: if some one who has been less plagued by them than I have, chooses to say that it makes no difference whether they are moved about or not, I will give up the point; but still insist on the propriety of making the instrument *perform all its adjustments as perfectly without the stage as with it,* for then we may remove the stage altogether if we please, and substitute any thing we think proper in its place, and all will go on as before. This arrangement gives us the *power of examining small parts of large bodies without detaching them from their wholes.*

Thus we can examine the contents of a vase of polypi, or aquatic insects, or a small part of a large specimen of a mineral, or a nosegay of flowers, with the insects which inhabit them ; or *with an erecting eyepiece* we may apply the instrument to a turning-lathe or some piece of delicate machinery, and work upon it much more comfortably than by the help of single lenses. But for these purposes *the space occupied by the stage must be left free and open ;* and to obtain this accommodation the bar of the microscope must swing round on its stand in any direction, on a ball and socket joint, which conjoined with a rotatory motion of the arm on the top of the said bar, will almost always enable us to gain the position required. An instrument which does not possess all these properties *will only do half the work it ought to perform.* It must be evident, also, that this construction gives the utmost facility for introducing a lamp or candle, either close behind the stage, for transparent bodies, or before it, for opaque ones ; and this arrangement is a point of the last moment for demonstrating and verifying the nature of a variety of objects, particularly proof opaque ones, as I shall shew in due season, when I come to treat on them and on the subject of *verification.* No microscope, which is from any cause lame or impotent, either in its optical or mechanical construction, can be fit for such purposes.

The stage must also possess a capability of turning round on a pivot, so that by tilting the microscope we may be enabled to view the side or elevation of a body as well as its plan ; for example, the curve of a small lens, when laid flat on its face, the edge of a razor, the point of a needle, &c., without using any particular apparatus to preserve such bodies in the position in which we wish to see them. The use of such a mode of observing, in cases of dissection, must be manifest; for in this way the side of an insect, &c. may be viewed and worked upon without disturbing the parts laid open, in the horizontal position, and thereby occasioning much extra trouble and confusion. By turning the subject round on the stage, every elevation or side view of it may, of course, be successively obtained.

There is yet another advantage to be gained by a rotatory motion in the stage: for if we employ a diagonal objective, and tilt both the stage and the bar into a horizontal position, so that the body of the microscope shall *be under the stage,* we can examine crystallizations of salts without being annoyed by the steam which arises from them during consolidation, and which is almost certain to condense on the object glass when used in any other position. In the present case this is impossible, for nothing but the under surface of the glass on which the salt is placed, is presented towards the object glass. All sorts of fluids, and the bodies contained in them, may in the same way be managed without being troublesome; and thus *chemical actions* of all sorts may be studied under a magnifying power.

Moreover, the stage must be enabled to shift down to the end of its bar, so that we may use object glasses of long foci, and also place any large bulky body upon it without building up the whole instrument to an extravagant height, and thereby rendering it top-heavy and rickety. It must also be of such strength as not to spring under the weight of our hands when used for dissection; for if it does, it will be utterly impossible to preserve a steady focus, which will be found a dreadful nuisance with a high power, and indeed with any power. Its size must also be such as to afford a sufficient support for the hands. The distance of the hole in which the slider holder is fixed from the bar, must also be such as to allow a slider to turn completely round, otherwise we cannot get *test objects* into that position relative to the light in which only they can be demonstrated. (This is especially the case with the markings on the scales of beetles and butterflies.)

I do not much approve of attaching illuminators to the stage, either for opaque or diaphanous objects. It will be found much more commodious to cause the *spectrum for opaque objects to travel along with the body*. Accordingly, a condenser should be attached to it. Both the mirror and condensing lens under the stage should be caused to swing round by means of a spring socket and pinching screw working on a round bar, so that they may be instantly removed out of the way when not wanted, without being detached from the bar.

The large illuminating mirror should (*if not of very considerable dimensions,*) be made *oval*, and should work upon a swivel joint at the bottom instead of the side, otherwise it will be rendered unserviceable, for the long axis of the ellipse cannot otherwise be brought into the position necessary to give a round spectrum when placed at the requisite angle for illumination, say 45 degrees. The reason for the ellipticity of the mirror is this :—An image of it is constantly formed in the optic or visual pencil, at the eyepiece, as may be seen with a magnifier whenever bodies are viewed by the intercepted or transmitted light which it furnishes. Now unless this image is of equal size with the said visual pencil, an effect is produced not very dissimilar to that of mutilating the pencil in some other way, *and exactly the same as to the quantity of light lost.* Now a round mirror (unless it is of such size as to allow for the cutting off occasioned by its angular position,) gives an elliptic pencil. But I presume it is always advisable not to increase the bulk of any part of an optical instrument when it can be avoided; consequently the true form for the mirror is an ellipse. This form does not *easily* admit of the use of a concave reflector; but I disapprove of them, as they always seem to me to occasion a certain indistinctness in vision by interrupted light, and if wanted only for illuminating opaque objects, by the help of silver cups, may be dispensed with; for a much better action is produced by a plane mirror, co-operating with a condensing lens. Because an angular plane mirror and a condensing glass produce a round spectrum; whereas a concave mirror, when tilted, always gives an oblong one; however, in the present construction, I always suppose that when silver cups are employed, *the condenser is to act by itself without any mirror at all,* by which arrangement the maximum of illumination is given.

The size of the mirror is determined by its distance from the object glass, or single magnifier used, and by the angle of aperture possessed by them. The longer the bar, and the greater the aperture of the optical part, the larger must be its dimensions to fill up the visual pencil.

The reverse of the mirror will be best occupied by *a surface of plaster of Paris,* to reflect *the light of the sun,* which will be found of great use *in ascertaining the true tints of transparent objects,* the colours of which are shewn by this sort of light, with the utmost truth and delicacy, far better than when brought out by a piece of ground glass interposed between them and the polished mirror. The double action of the mirror will be completely commanded by the most inexperienced observer, if a milled head is attached to its transverse axis, as will be shewn in its proper place.

Now these are, I think, the *main and capital points* to be attended to in the construction of a *stand*. As, however, every question is said to have two handles to it, I shall endeavour to discuss the merits of some opposite constructions. First, then, it has been said, that the double motion of a ball and socket-joint is of a most unmanageable nature, and that a cradle joint is a true, regular, and far superior movement: this I admit, and should say, that if a telescope had, by means of a ball and socket, to follow the motion of a star, no motion could be more unappropriate and detestable; but in a microscope it happens always to be a *fixture*, and when clamped tight by means of a pinching-screw, is as steady as a rock.

This observation may appear very unnecessary to my readers in general; but I have met with individuals of such obtuse understandings, that they cannot be brought to comprehend that a telescope performs a part of its motion by means of its cradle joint, whereas *that of a microscope is the result of a traversing motion in its arm, combined with a rotatory one on the top of the bar*, and therefore has nothing to do with that on the head of the stand, be it what it may, which is always a *pro tempore* fixture.

Again it has been said, that by giving the motions and adjustments to the optical part, it is rendered much less steady than it might be under other circumstances; that it is like mounting a telescope on a mop-stick, that immobility is of most virtual importance for observation, &c. I answer, that by making *the work sufficiently strong and solid, and the optical part no larger or longer than is necessary,* the instrument is rendered abundantly steady, and free from tremor even with its highest powers.

At the same time I willingly admit, that if the body is made very long or large, it will be almost impossible to combine the stability requisite for practical purposes with a capability of traversing and adjustment.

It has been asserted, that if after we have adjusted our light for viewing a transparent object satisfactorily, we throw the axis of the optical part out of the position which we first selected, we must begin our work of illumination over again, or lose the effect of the original one. This is true *beyond certain limits,* but the body of a microscope may be moved very considerably, without in the least affecting the vision of ordinary transparent objects, and (to opaque bodies of course, the observation cannot apply). Farther it is said, that the employment of cones and diaphragms below the stage, is of vast use in developing the nature of many transparent bodies, and that if these are employed, the most perverse and prejudiced antagonist cannot refuse to admit, that any diversion of the optical part from the line of adjustment, must utterly destroy, not only distinctness, but nearly all vision whatever. All this is most true, but it will be recollected, that *unless the said diaphragms act on the Wollastonian principle,* their utility is very confined, and merely serves to prevent exceedingly faint diaphanous bodies from being drowned by the quantity of light passed through them : pretty nearly the same effect may always be produced, by cutting off the object glass until the pencil of light at the eye becomes of the same size without the diaphragms as with them, (for they reduce its diameter exceedingly); *all vision ultimately depending upon the state of this said visual pencil of light.*

To obviate these objections let there be a large roomy slider holder, with a good steel spring, so as to pinch the plates together pretty tight; *the object can then be moved about by the hands in any direction, and the body may remain a fixture,* save as to the adjustment of the focus. I have always found that people like to move an object about with their hands, even when they have screw motions for traversing, and indeed I prefer it myself, (*provided the object does not yield too easily,*) even with very high powers.

Lastly, it has been remarked, with great justice, that if we choose to employ any of the generation of camera lucida's for drawing objects, they can only be used with microscopes, in which the body is *altogether immoveable.* Nothing is more certain. At the same time I cannot refrain from expressing my hatred and contempt of the whole tribe, as rather impediments than helps to a real draughtsman. This much I will venture to say, that if a man cannot draw *without them*, he cannot *with them.*

The slider-holder enables the present construction to operate with these nuisances, for the adjustment of the focus will not *sensibly* disturb that of the image on the paper, and if it should, a very little motion, backwards or forwards, given to the drawing, will re-arrange it. The only aid which I can with confidence recommend, as of real utility, is a micrometer, composed of glass, placed in the field bar of the microscope, and divided into about 40 or 50 parts to the inch, with double divisions, or very strong lines at every fifth space. These should be rubbed over with black lead, after which they must be burnished with the edge of a piece of hard wood, *so as to clean the surface of the glass without rubbing the black lead out of the divisions,* (a device of the late Dr. Wollaston, and bearing the stamp of his original and penetrating genius, trifling as it is). Then let another piece of thin plane glass be smeared with Canada balsam, and cemented upon the divisions, which will preserve them for ever. Now if corresponding black lines, of any scale required, are placed under the paper on which we draw, we can with great facility put in our outline in the most correct proportions. Or if the paper is too opaque, a frame with black silk threads stretched upon it, may be laid upon it till the sketch is completed. The contrivance can be used with my microscope as well as with any other.

Mr. Lister has constructed the stand of a microscope with a particular view to the use of the camera lucida: accordingly his body is motionless and of considerable length, so as to clear a large space on the table for the field of view. The ocular end is, moreover, firmly lashed to the legs of the stand, (which is very solid,) by means of steadying rods, forming altogether the best construction for the use of long heavy bodies and cameræ lucidæ which I have seen.

It must be most evident that a single microscope requires exactly the same powers, properties, and capabilities as a compound one. I should, therefore, construct its stand and apparatus precisely in the same manner as that of a compound one, only it may be made on a much smaller scale: as little strength is required for carrying single magnifiers, triangular drawn tubes may be used instead of the triangular gun metal bar of the compound (to be hereafter described). The drawing of triangular tubes is a novelty produced by Mr. Pritchard expressly for his diamond and sapphire instruments.

I therefore conclude that the *principles*, at least, of the best possible construction for the mechanical part of microscopes, may be defined. I have attempted to reduce them to practice in an instrument, the patterns of which I have executed with my own hands, and Mr. Pritchard (who is professionally versed in such matters) has made a mechanical drawing of it, which he will describe in the next chapter. Before, however, the description proceeds, I must beg a boon of my readers and the microscopic world at large, viz., to permit me to supplant the term *compound microscope* by the word ENGISCOPE, which seems to me more apposite.

It is derived from two Greek words, ἐγγὺς, near, and σκοπέω, to view, and, therefore, well expresses an instrument for viewing close objects, or *for viewing objects closely*, and is in strong contradistinction to the term telescope, derived, as my readers well know, from τέλος, an end, or distant limit, and σκοπέω, and therefore denoting an instrument for viewing distant objects. The term microscope, derived from μικρος, small, and σκοπέω, signifies an instrument for examining small objects, which is perfectly correct also, but in bad contradistinction to the telescope, which would have to be named megalascope, to oppose it (from μέγας, great, and σκοπεω,) which expression would be perfectly accurate when applied to the telescope, for it views very large objects, such as the totality of a planet or the sun, &c. Now a compound microscope and a telescope pass into each other by insensible degrees: a species of telescope can always be made of the former, and a kind of microscope of the latter, but both of the most execrable kind. To this last, namely, a short spy-glass, or perspective glass, with a long pull-out tube, so as to permit it to adapt itself to rays which are considerably divergent, the term Engiscope has already been applied by Martin and others, but I think most unwarrantably, for such an execrable piece of trumpery is wholly unworthy of a separate existence, or a separate name; it is just as easy to make a piece of velvet of an ass's hide as to make an object glass, which shall answer both for a telescope and a compound microscope, be its focus what it may. *The only veritable engiscope is the latter instrument,* with an objective glass truly adapted to act with divergent rays; a short telescope may be made of six inches focus, and a long compound microscope, with an object glass also of six inches focus, but the construction of each must be utterly different, or they will only *nominally* be what they are called.

I therefore hope that I shall be allowed *(as I have reformed and revolutionized both the optical and mechanical structure of microscopes) to change their names also,* and shall therefore take the liberty of using the term engiscope, as aforesaid, instead of compound microscope, and retaining the expressions *microscope or simple microscope,* for *convenience sake,* to denominate what is now called a *single microscope,* in opposition to a compound.

The term compound microscope will then be applied appositely to all those instruments with which we view real objects instead of images of them, constructed by combining two or more lenses together; for the optical part of *what is commonly called a single microscope* may be made of as many as *four glasses,* whereas the optical part of a compound (as it is usually termed) does *not necessarily consist*

Fig. 4.

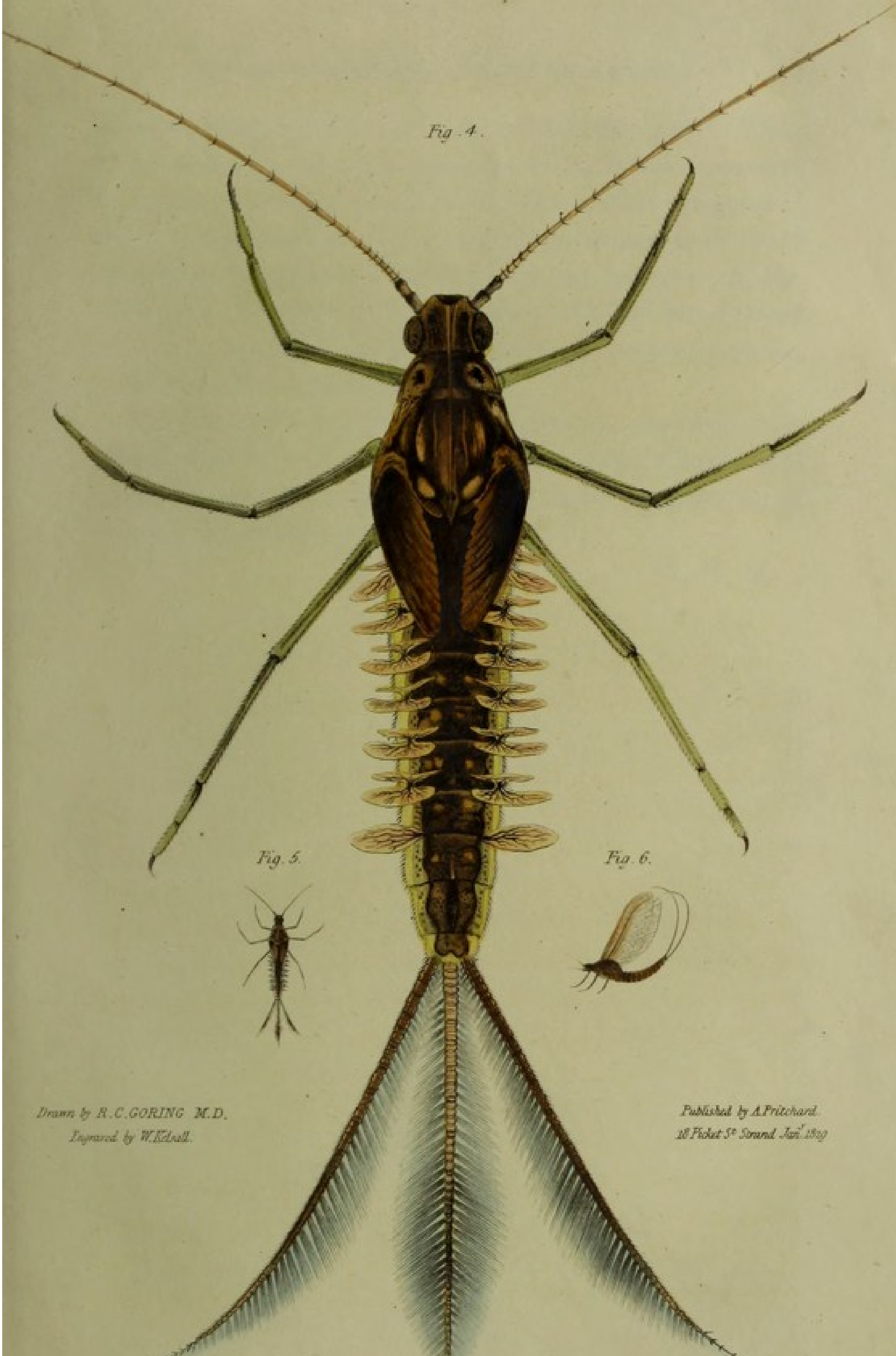

Fig. 5.

Fig. 6.

Drawn by R. C. GORING M.D.
Engraved by W. Kelsall.

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of more than two, viz., an object and ocular glass. Thus if we retain the old terms, how are we to define *accurately* a single microscope composed of two double aplanatics? Are we to christen it a single quadruple or double doublet? or a simple compound? This will be as ludicrous as Mr. Callaghan O'Brallaghan's definition of the first bit of bread he eat in England, which it seems was a roasted potatoe, cooked in a brass saucepan.

It is presumed, therefore, with due deference to the opinions of better men, that the term *engiscope* is lawful and orthodox, and will, probably, be adopted by posterity, if not by the present generation.

C. R. G.

CHAPTER V.

Description of an Operative Aplanatic Engiscope.*

It is necessary to premise that figures 7, 8, 10, 11, 12, 14, 17, 18, 19, 20, and letter A, are drawn *one-quarter* of the real size ; all the rest are *one-sixth*, except figure 23, which is of the true size.

Figure 7 represents a geometrical elevation of the instrument, just removed from its case, the body, *a*, being screwed on, and the triangular bar, *b*, somewhat elevated above the stage, which is fixed in sitû. To begin from the foundation,—the legs are all of the same thickness, but tapered in *breadth* towards their extremities, in order to obtain strength where most required. In the upper one is a hole to receive the projecting pin at the end of the circular bar, *c*. Underneath the pillar, *d*, is a screw nut, *e*, which lets down, to obviate the springing of the legs. The pillar, *d*,

* Aplanatic, derived from the priv. α and πλανη, error, means free from *both kinds of aberration*, or devoid of *all* errors. The term was invented by Mr. Herschel, and is of great value and utility.—Achromatic, derived from the priv. α, and χρωματιζω, to colour, means free from all prismatic colour, or aberration *only*, and therefore does not denote *a perfect* object-glass or instrument. Thus we might say, such an objective was *achromatic* but *not aplanatic*, which would mean that it was free from colour, but not from the indistinctness arising from spherical aberration.

is constructed of two pieces of very stout tube, moving stiffly in each other. At the head of this pillar is a socket, *f*, to receive the ball shewn in figure 8. This universal joint is made in the customary manner, but the socket has a slit for the neck of the ball, only through *one-quarter* of a circle, to avoid weakening it unnecessarily. It is pinched by a screw, *g*, with a vice-handle. The ball, the socket of the circular bar, *h*, together with the stage pin, *i*, are all cast in one piece, as shewn in plan, fig. 8. The stage, *j*, has a circular aperture, which has a sink and two nicks in it, together with a square hole, *k*, (as seen in fig. 9). There is likewise an arrow pointing to a nick in the socket, *h*, to show when it is truly at right angles to the bar, *b*. It fixes on to the pin, *i*, which is clamped tight by a screw, *l*: into the bottom of this screw is inserted a piece of metal, the end of which is worked to correspond to the curve of the pin, *i*, which causes it to clamp tight with a very slight effort, and preserves the pin from injury. Within the socket, *h*, is soldered a stout tube, forming the external bar, *c*. On this circular bar slide the split sockets, *m, m, m,* carrying the condensing lens, *n*, the inferior pin, *i*, for holding the stage, and the oval mirror, *o*, all travel up and down at pleasure, and may either be moved out of the way, by turning them one-quarter round, or stripped off altogether, if thought more convenient. Their clamping screws fix them tight in any required position. A nick is made in *front* of each of the sockets, and a line drawn on the front of the bar, to show when the condenser and mirror, &c. are truly in the axis of the aperture of the stage. The oval mirror is plain, but its reverse is formed of plaster of Paris. It revolves on a vertical axis, *p*, and on an horizontal one, *q*, the motions of both of which are governed by the milled head, *r*. The triangular gun metal bar, *b*, is truncated at its edges, and is therefore strictly speaking an hexagon, *this form giving greater strength in proportion to the space occupied by it than a perfect triangle would*, while it still possesses the property of being locked fast when pinched on only one side: it is evident that even an *equilateral* hexagon would, when *pinched on one side*, always cause two others to bear close against a *triangular* containing tube. This bar slides up and down in the external circular one, *c*, between two plates of metal, pierced with triangular apertures to receive it: one is soldered in at the summit of the socket, *h*, the other below the milled head, *s*, and springs are placed on the same side as the rack, both above and below the pinion, to steady the bar and give the friction necessary to prevent it from falling from its position by gravitation. If the present stand was made to operate *solely with an engiscopic refracting body*, it would be better to omit the rack work of the upright bar altogether, and substitute a pinching screw for it, giving a fine movement to the body *within the neck of the arm*, by a screw on Ramsden's principle. In its anterior side is sunk the rack which adjusts the focus by means of the milled head, *s*, which is repeated on the opposite side. Rack work is not perhaps the best sort of movement which might be contrived, but it is *good enough*, when *well executed*, for all practical purposes. On the top of this triangular bar is fixed the gun metal wheel, *t*, within the teeth of which works an endless screw, the milled head of which, *u*, is seen in the drawing. Above the wheel is shewn the triangular pinion socket, *v*, which carries the arm, *w*, which is also of gun metal, truncated at its edges with a sunk rack on its superior side, exactly on the principle of the other: this bar is worked by a pinion, *x*, seen in the cross elevation of this socket and bar, fig. 10. Diamond and sapphire lenses, and all sorts of simple microscopes, are attached to this arm, by being thrust into the hole at its other extremity, as drawn in the engraving.

The superiority of *sapphire* lenses *over those of glass* seems now universally recognised, and virtually, the superiority of *diamonds over sapphires*. (For whatever will prove the former of these propositions will most assuredly prove the latter also.) If these substances possessed no other advantages over glass save their invulnerability and capability of being burnished into their brass settings, these properties, coupled with their extreme thinness, the natural result of their shallow curves, when properly executed, (and which allows more room for the object and for the illumination of it, if opaque, with any given power and aperture,) and their superior magnifying power with a given curve, also would fully justify the patronage they have received. But their most important properties are their *faint spherical and chromatic aberration*, as will be duly demonstrated in its proper place.

The pinion, *x*, fig. 10, has a projecting square at each end, to receive the ivory milled lever, *y*, or milled head, *z*, on either side. The whole of this socket revolves on the upright triangular bar, *b*, and is kept in its place by the gun-metal garter-piece, shewn at *a*, and has a saddle-piece well screwed on, covering it over, to prevent the loosening of the pinion, by the action of the milled lever. The endless screw may be detached from the wheel, *t*, by slackening the pinching screw, *b*, which serves to keep the pinion in gear, the said endless screw being affixed to a separate piece, which turns round on the projecting and inferior part of the socket, by means of a pivot: the pinching screw, '*b*, operating in an arc, formed to receive it. This wheel and endless screw are absolutely necessary to enable us to command the motions of the arm when the axis of the body of the instrument is not perpendicular, or nearly so.

The body, *a*, is constructed on the smallest scale on which it can well be made without impairing its optical properties. The only true way of preventing the generation of false light is to allow so much space in the body that the rays proceeding from the object-glass shall not impinge on any part of the tube; for no sensible light is produced until they flash against something. Into the superior part of the eye tube, '*c*, are screwed the various inverting eye-glasses, and into its inferior part, '*d*, the erecting glasses, *A*. Upon the neck of the object end, '*e*, are screwed the various object-glasses, one of which is represented attached in the plate. Upon this neck also slides the illuminator, '*f*, for opaque objects; it has a split socket and clamping screw, '*g*, by which it is adjusted, and is composed of a plain convex lens, having an inch and a half of aperture, and the same focus. Operating *by lamp-light*, with another isosceles convex of same power and diameter screwed to it, these curves have been found by experiment the best both for refracting the maximum of light, and for preventing any loss of it by reflection from the convex surfaces of the lenses. '*h* is the cap of one of the eye-pieces *in dotted lines*; it is supposed to be removed for the purpose of applying the *camera lucida*, fig. 11, which is thrust on over the eye tube, a side view whereof is represented at fig. 12. By far the best species of camera lucida is, I think, this (which is the invention of Professor Amici), and is composed of a simple piece of thick plate glass, with truly parallel surfaces, placed at an angle of 45°, and *reflecting an* *image while we see through it,* for it allows the point of the pencil, the drawing on the paper, and the image to be seen at the same identical moment, *without any dodging or effort.* Care must be taken to have a sufficient thickness of glass, to prevent the visual pencil from reaching the inferior surface, otherwise there will be two images.

Figure 13 is a micrometer, to be placed in the field-bar of one of the lowest eye-pieces. It is made of glass, with divisions of 40 or 50 parts to the inch, which are filled with black lead, well burnished in, and secured by another piece of glass being cemented over them.

Figure 14 is a square bar, sliding up and down in the square tube in the stage, *k,* fig. 9. It carries the illuminator, *f,* when it is thought advisable not to load the body with it.

Figure 15 represents the lengthening tube, *'i,* with the direct boot, *'k,* drawn over it. The lengthening piece screws on in place of the object-glass, which is again attached to its extremity. This piece, from its narrowness, will generate false light; it must, therefore, be lined with black velvet, which is, perhaps, the best substance to stifle it when generated.

Figure 16 is the diagonal boot. It is constructed in the same manner as the other, but has a plane metallic speculum or rectangular prism of glass placed at *'l,* to reflect the rays received at right angles. It is necessary that the piece of plate glass which is affixed to the extremity of the cones of these boots, should be very perfect, and set in truly parallel.

Dr. Brewster first conceived the project of causing an aplanatic objective to be so constructed that it should be capable of acting in water instead of air (*v.* his Treatise on

New Philosophical Instruments). I am afraid it would be very difficult to make a *naked* object-glass water-tight, and at the same time to adjust it perfectly; and after all *it would only serve to act in water,* and would be useless out of it. The present arrangement really seems to answer every practical purpose completely well, though certainly Dr. B's plan is the *more scientific* way of doing the thing.

Figure 17 is a cup or silver speculum, which slides over the end of the object-glass.

Figure 18 is a shade to slide over the lengthening piece *'i,* figures 15 and 16.

Figure 19 is a small cone, to slide over the object-glass when acting by plain artificial light.

Figure 20 is the arm by which the optical part of the Amician Catadioptric Engiscope is attached to the present stand: it must be considerably longer than the other, and, like it, racked to its extremity, to admit of its being taken out of the socket. By means of its swivel and pinching-screw, it allows the body to turn round and present itself either in front or at the sides of the stage.

Figure 21 is the aquatic live-box, with an extra pierced lid,*'m,* for aëreal insects and land objects, &c. There should be about half a dozen of these, of different sizes, varying from that given in the plate, to about 2-10ths of an inch in diameter. It would be found a convenience if the larger ones had *watch-glasses* fixed into them, with their curves applying to each other, and their concavities pointing outwards, instead of the plane glasses, as given in the drawing; for by this arrangement, when used with *very low powers* for exhibiting a grand *melée* of aquatic insects, &c., taking in nearly their whole area, the *edges* of the field will be as distinct as its *centre;* (the foci of these two parts of the visible superficies being always different with a *flat object,* and a *low power* even with the best aplanatics).

The glasses, whether flat or concave, must be well cemented into their cells by painters' ground white lead, or opticians' cement, that the box may be completely water-tight, and the tubes themselves may be greased for the same purpose, if necessary. These boxes are as useful pieces of microscopic apparatus as ever were invented. I believe they were originally constructed by Mr. W. Tulley, at the instigation of Mr. Lister, to hold flies, in order that their feet might be commodiously examined while adhering to the upper glass. Dr. Goring, however, first converted them into *aquatic* boxes, *by piercing a hole in their lids,* and making them water-tight, &c.: these trifling alterations have rendered them what they now are, for *without the hole in the lid* they are quite unmanageable.

Figure 22 represents the *black ground box,* (an invention of Mr. Lister), which in the present instrument also forms a stage for the single microscope and for dissection.

At *'n,* is seen its lid, of which a side view is given at *'o*; at *'p,* its bottom with its side view also; its interior surface is lined with black silk velvet, and so is the superior surface of the lid; the sides of the cone *'q,* are well blacked; at *'r is seen a disk,* also covered with black silk velvet, which acts along with the silver specula. Its arm revolves on the top of the cone, and can be removed altogether, if necessary; at its extremity is a hole, in which is inserted the cradle-joint, which carries a brass needle; a small piece of brass tube, stuffed with cork, is affixed to one of its extremities, and to the other a pair of forceps, which are represented of their full size at figure 23. These are constructed as usual, except that a hole is drilled through them at 's, to enable them forcibly to grasp the head of a common pin.

Figure 24 is the piece which carries the wheel of diaphragms, 't is the plan of their underside. There should be about five apertures, varying from half an inch to 1-10th in diameter. This apparatus screws on to any of the aquatic boxes, also to the slider-holder, figs. 25 and 26, and the false stage or black ground, figure 22, in place of the bottom, '*p*. It was invented by Monsieur Le Baillif, at Paris; but we have long been in the habit of using *cones* for the same purpose in England.

Figure 27 is a *contractor*, which drops into the sink formed in the aperture of the stage, when too large for carrying on dissections, or other operations of a similar nature; it has two bayonet catches, which secure it by being turned one quarter round; into the aperture of this latter piece, a small slider-holder may be advantageously fixed, (to be used with the Amician Engiscope, or the simple microscope) which should likewise be made to fix to the top of the false stage, figure 22, when its lid is removed.

Figure 25 represents a plan of the four pillar slider-holder, which is by far the best contrivance hitherto invented, for attaching all sorts of objects in sliders and between slips of glass, &c. to the stage; its elevation is shewn at figure 26, with the two pins which secure it. In the plan are drawn the two cross connecting bars, '*u*, '*u*, between which and the superior plate all large opaque sliders, &c. are placed. There is another plate below the first: between these two a common transparent slider is shewn. The helical spring is of steel of some strength, so that the sliders shall not be permitted to move about between the plates *too easily*. The holes at the corners of the plates which slide up and down on the pillars, must be sufficiently large to prevent any clinging or sticking.

Figure 28 shews a plan and profile of an *adapter*, which carries a small aquatic live box, to be used with the wheel of diaphragms ; it has a bayonet catch to fix the box securely, independent of its gravity.

Figure 29 is a frame and slip of glass for crystallizations of salts.

Such is the description of an instrument, which will be found a *regular working tool,* either for amusement or scientific investigation. It is not pretended (be it always remembered) that it is a perfect or standard instrument, but Dr. G. hopes it will be found an *approximation* to one.

A. P.

CHAPTER VI.

Manner of Observing with and Managing the Operative Aplanatic Engiscope.

Select an apartment on the ground floor, if possible, which has a northern exposure, and the casement of which (it should have only one) is not overshadowed by trees or buildings, but presents a clear view of the open sky,—skylights are not proper for a microscopic study. In such a room I would recommend you to keep your instruments, and apparatus, &c. open, and at all times ready for observation, but take especial care to keep it locked, as if it was the case of your microscope,—which, in fact, it may be termed. Have the fear of the cat before your eyes, and also of all those busy, intermeddling, officious, housewives, who, under pretence of dusting, cleaning, and setting to rights, will subvert and revolutionize the whole economy of your observatory, and perhaps throw half your tackle behind the fire. Never allow the apartment to be cleaned until you have secured your apparatus. I think it myself a great convenience (and I am not singular in my opinion) to have an apartment especially devoted to my microscopes, as much as the observatory of the astronomer is to his transit and circles, for then there is no loss of time when you wish to go to work, and you are sure to find every thing just where you left it. I cannot be plagued by eternally packing and unpacking my implements, &c. but this is no rule for those who like such occupation. Have caps to cover the objective and eye-glasses of your instruments, and get a little nest of drawers to stand on your table, to keep talc sliders, &c. in, with a glass cover or two (like those of watchmakers) to secure the more delicate parts of your apparatus ; the rest will suffer no harm from the *dust.* Procure a tripod stand, like those used for small telescopes, and of such height that when you sit down and turn the body of your instrument against the sky, like a telescope, the eye-piece may present itself in a commodious position for observation. You will also, probably, want a tripod stool, to rest your engiscope upon, when placed in a *vertical* posture for dissecting and similar uses, as tables generally run too high for the purpose, and are always more or less unsteady. In towns the tremor occasioned by the transition of carriages is frequently a great nuisance in the upper stories of a house, more particularly if your mountings are rickety and unstable.

Now, courteous disciple, I will endeavour to instruct thee how to manage thy tackle, and will, moreover, have the extreme complaisance to suppose thee (in all microscopic matters at least) one of the *awkward squad,* as stupid as an owl, and as ignorant as a cart-horse. I will tell thee as well as I can all that thou art *to do,* and all that thou art *not to do.* I will try to make thee know the right end of thy instrument from the wrong one; how to put a fly's eye before the object-glass, and a fool's eye before the eye-piece; with many other things equally curious, important, and interesting; and if perchance I shall succeed in learning thee how to deal with the instrument under consideration, together with the Amician reflector, the management of *all others* thou canst meet with will be as easy to thee as the guidance of a cock-boat is to the seaman who can work a line-of-battle ship*.

It will be necessary for me to premise somewhat concerning the optical part; though it is not my intention to treat upon it in a regular way in this chapter, as a full and particular account thereof will be given hereafter. I shall speak of it now only as an *appendage* to the mechanical fabric of the engiscope, and the directions relative to its use will be only of a general nature, but still sufficient for *practical purposes*. The optical part, then, is divided into the *objective* and *ocular*; the objective glass is situated at 'e, in figure 7, and screws on to the neck of the body; it is always *next the object* of which it forms an image or picture, which is viewed by the ocular or eye-glass at 'c, always situated

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* All these instruments are, in fact, managed exactly upon the *same principles*, and he who can use the more complicated construction is sure to be able to operate with the simpler ones. It will hardly be expected (for it would be utterly foreign to the object of this work) that I am to transfer the contents of a trading optician's window and shop into the present treatise, and give figures of each article with reiterated instructions for using every particular variety, beginning with the simple machine, (which Master Isaac Newton Chucklehead's mamma buys for 7s. 6d. to teach her dear child to be a philosopher, and learn him to impale flies and daddy longlegs,) and then wade through the rest of the rubbish in succession. I confess that in my youth, when ignorant of better things, I have been hugely delighted by turning over the article microscope in the Encyclopedia Britannica, and in Rees's work, together with Adams, by Kanmacher, where all these wonders of art are displayed at full length, with expensive plates, &c. I cannot conceive that the public will at this time of day relish any thing of the sort, and shall therefore confine myself to giving *one* figure of each new instrument, which will of course be that which I suppose to be the *most improved and perfect*.

next the eye, (for be it remembered, that in strict language we do not view the object itself in an engiscope, but its image or picture.)

Several aplanatic object-glasses and eye-glasses accompany the instrument; their powers or foci are generally marked upon them, but the high powers may be known from the low ones by this simple rule, viz.; the *largest* object-glasses are the *lowest* in power, and the *longest eye-pieces,* having the *largest glasses* in them, are also the *lowest* powers. Now the total power of the body, or optical part of the engiscope, is the result of that of its object-glass, multiplied by or combined with that of the eye-piece; therefore the *highest power* will be given by the *smallest object-glass* used with the *shortest eye-piece,* and the lowest by the *largest object-glass* with the *longest eye-piece.* The eye-pieces mentioned above are all of the *inverting kind,* like those belonging to astronomical telescopes; there is, however, a pair of erecting glasses, A, to screw into the bottom of the pull-out tube, which with the former make *erecting eye-pieces*; these are used for dissecting, &c., and also for giving *very low* powers when wanted below the scale of the weakest inverting ones. The use of all these I shall shew in their proper places. Each object-glass combines with each eye-piece, whatever their number may be, according to the fancy of the observer, but the power which results from the combination can only be known by trial, and should be given by the maker of the instrument, in a written paper.

The object-glasses are frequently made to combine with each other: in this case the power which is produced, (if in contact) is about the *sum of the power of each taken* separately. Again, a farther increase of power is obtained by the elongation of the body, effected by drawing out the tube, (c): whenever the length of the body is doubled, for example, the power is also doubled (*cæteris paribus*).

In winter it will be proper to cause the instrument to be slightly warmed at the fire before it is used, until it is of about the same warmth with the human body, otherwise the perspiration from the eye will be perpetually condensing on the eye-glasses, &c. and greatly impede vision.

Always begin to examine your object with the lowest power you have, unless it is very minute; it may be laid down as a general rule, that large objects require low powers, and small ones high powers; that the low powers shew the whole or general view of an object, and the high ones only its parts in succession.

Never use high powers unless absolutely necessary, for as the power increases, so does the difficulty of finding the object, and of adjusting the focus. The colours also grow fainter and more diluted, and the shades darker and darker, until all ease and satisfaction in observation, together with all certain vision, fade away, and so very small a portion of the object is seen, that it is difficult to know what we are looking at. Recollect that *a really good aplanatic object-glass shews every thing with very low powers*; in fact in this property its goodness and beauty consist: do not plume yourself, therefore, upon having an instrument which shews objects with *very high powers*, but with *very low ones*.

Where, however, from the minuteness of an object, it becomes really necessary to use a high power, always select a *small deep object-glass*, and use it along with a *shallow or long eye-piece*, in preference to using an object-glass of low power, with a short or powerful eye-piece, for magnifying power is much more valuable and effective, when derived from the object-glass than from the eye-piece, (this is a subject which I shall recur to hereafter).

When you clean the eye-glasses, (a point of great importance to pure vision), do not remove more than one at a time, and be sure to replace it before you begin with another: by these means you will be sure to preserve the component glasses in their proper places: recollect that if they become intermingled, they will be useless. Keep a piece of well-dusted shamois leather, *slightly impregnated* with some of the *finest putty* or *crocus powder*, in a little box, to wipe them with, (for it is of consequence to preserve it from dust and damp): the former will scratch the glasses, and the latter prevent you from wiping them clean. As to the object-glasses, endeavour to keep them as clean as possible without wiping, and merely use a camel's hair-pencil to brush them with, for wiping them hard with any thing has always a tendency to destroy their adjustment, unless they are firmly burnished into their cells.

Now I shall suppose that you want to view some transparent inanimate object mounted in a slider. There are several ways of doing this, according to the position in which you choose to preserve your instrument, whether directed upwards towards the sky, horizontally, or vertically *looking downwards*, &c. The first is the best method for direct day-light; the second for lamp or candle-light; the last is the worst of all for either, and should not be resorted to when the others can be used. There are, however, intermediate positions between the horizontal and vertical ones; say angles of 40 and 45 degrees, which are comfortable and convenient for the observer, though, I think, unfavourable to the action of the illuminative part of the instrument. I shall proceed to give directions, on the supposition that you wish to see in the simplest and best possible manner.

1st.—MANNER OF MOUNTING, FOR VIEWING INANIMATE TRANSPARENT OBJECTS, BY PURE INTERCEPTED DAY-LIGHT.

When the instrument is first removed from its case, the circular bar, *c,* will be locked fast into the upper or longest leg, by means of its projecting pin ; it is loosened by drawing the internal tube of the pillar a little out ; for which purpose, grasp the ball and socket in one hand and the legs in the other : by pulling in opposite directions the inner tube will be detached, and the pillar heightened in any degree requisite for observation, at the same time the bar will be left at freedom, to move in any direction by means of the ball and socket : immediately underneath the pillar is an adjusting screw, *e,* by means of which the pillar gains the support of a *fourth leg,* and is rendered incapable of springing ; it can be used when great steadiness is required : it should but *barely* touch the table or stand on which the engiscope is placed.

Having then spread out the legs, and arranged the optical part according to the preceding directions, attach the slider-holder, figure 25, to the stage: this is done by inserting the projecting catches into the nicks, and turning it one quarter round : this fixes it fast, so that it cannot fall out whatever may be the position in which it is placed : pass the slider between the plates until the object appears within the aperture; slacken the pinching screws of the split sockets belonging to the mirror and condensing lens, (if necessary), and turn them one quarter round, so as to be out of the way of the body, or they may be removed altogether by sliding them off the bar; then, by means of the double action of the ball and socket, elevate the bar until the instrument, when placed on its tripod stand, comes into the position of a telescope directed towards the heavens*, at any angle you please; note that the ball performs the office of a cradle joint, by being moved up and down in the *quadrant slit* of the socket. Thus, if you wish the bar to point upwards, and the ocular end of the body downwards, (as will be the case in the present instance), make the following arrangement; move the neck of the ball†, by grasping the *bar* until it is about half-way between the upper and lower end of the quadrant slit, (*just as if it was a common cradle joint*): the body thus forms an angle of about 45 degrees, and will be in the required position, (but unless the motion now to be described has been previously accomplished), in a direction directly opposite to that now required, for *you will only be able to observe with it by looking downwards*, whereas you are to look upwards. To effect the object at present in view, turn the ball completely round *in the plane of the bar*, until the end of the bar comes into the place of the eye-piece. The instrument

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* In fine weather it will not be improper to let down the upper part of the casement; some microscopists have recommended us to select a *white cloud*, if possible, to furnish our intercepted light; I think myself that the blue light of a clear atmosphere is preferable, especially for test objects.

† In order to attain the complete mastery of the motion of the ball and socket, it will not be amiss for a beginner to slacken the pinching-screw by means of the lever: he will then, by moving it about fearlessly, *in every possible direction*, acquire a knowledge of its capabilities much more easily than he can do by the most diffuse directions.

is then fit for use, (at least when placed on its tripod stand and directed towards the sky); remember, that by the motion of the ball as *a cradle joint*, conjoined with the *rotatory movement* natural to it, every possible position is attained. All you have now to do will be to adjust the focus, and to bring the body to bear on the part of the object you wish to see. The adjustment of the focus* is accomplished by means of the milled head, *s*, and the traversing motion of the body is governed by the rack work at *v*, coupled with the rotatory movement of the arm on the top of the bar, which is regulated by the milled head at *z*: the method of managing this part of the instrument, will be gained with the utmost facility by a little practice. In the present case it will not be very necessary, as you may move the object about at will with your hands between the plates of the slider-holder.

When you look through the instrument, be sure to place your eye quite close to the eye-piece, otherwise the whole field of view will not be visible, and note, moreover, if you see a round disk of light, at least when the object is not in the slider-holder; if you do not, it is a sign that something is wrong; perhaps the body is not placed directly before the aperture of the slider-holder, or may not be truly directed towards the light, &c. It only remains for

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* The locality or place of the object will always be a little removed from the focus of the object-glass, whatever it may be: thus, if the objective should be one inch focus, (I suppose it so marked by the optician), the object, when seen distinctly, will be about an inch and 1-10th, or thereabouts, distant from it; if, however, the focus is long, say two inches, the object may, perhaps, adjust itself to two and a half inches: it is impossible to determine the focal point precisely otherwise than by trial: when found, it may be marked on the bar.

me to observe, that the method of using the instrument just described, is by far the best and simplest with which I am acquainted for all sorts of transparent objects, and should, therefore, always be used when practicable ; and this observation applies to all sorts of microscopes and engiscopes. Occasionally, however, the weather is so dull and gloomy, that we see better by artificial light : I therefore now give the

2nd. METHOD OF MOUNTING FOR VIEWING TRANSPARENT OBJECTS BY ARTIFICIAL LIGHT.

Setting out on the supposition that the instrument has been just removed from its case, and is in the position given in the plate, proceed as follows :—Place it on a table ; detach the bar from the front leg, as before ; move the mirror and condensing lens to one side ; then turn the bar round till it assumes an horizontal position, *keeping the neck of the ball at the bottom of the quadrant slit*, in the position in which it is represented in the drawing : its rotatory action is the only one at present required. This arrangement will leave the space, both behind and before the stage, open for the introduction of a lamp or candle, &c. The condensing compound lens, *f*, attached to the body, together with the plane-convex one, *n*, under the stage, and the mirror, must remain inert and unemployed, in this as in the preceding mode of observation, and may be removed altogether. Adjust the height of the instrument to suit that of your light and eye, by drawing the tube of the pillar in or out : place your light centrically behind the aperture of the stage, at two, four, or six inches distance from it, according to the strength of the illumination required, observing always to preserve a perfect round disk of light in your field of view, and every thing goes on as before, the candle or lamp supplanting the day-light. You may, if you please, tilt the instrument *a little* out of the horizontal plane, for convenience of observation.

3rd. MODE OF MOUNTING FOR VIEWING DIAPHANOUS BODIES BY REFLECTED DAY-LIGHT, EITHER IN AN HORIZONTAL OR VERTICAL POSITION.

For the horizontal position every thing is arranged in the same way as when artificial light is employed ; only, now *the oval mirror comes into use,* which must be placed truly in the axis of the body, and the aperture in the stage. For this purpose, cause the mark on its split socket to tally with the line drawn on the bar, and then clamp the split socket tight by the screw, *m* : then, having first removed your instrument out of the direct light proceeding from the window, by placing it in the middle of the apartment, proceed to reflect the light given by the said window into the body of your instrument, as follows. I must premise, that it will be necessary that the engiscope should so present itself towards the window *that its pillar and bar should not impede the light* : thus, supposing the window is on your left hand, the pillar and bar must be on your right, and *vice versâ, so that nothing shall be between the window and the mirror*. Observe, that a direct lateral position of the window is the most convenient and manageable. Then, by means of the milled head, draw the mirror round on its axis at the bottom of the arm *p*, until it fronts the casement; then all that is requisite is, to turn the milled head, *r*, and along with it the mirror, round, until its light fills your field of view; which will be at an angle of about forty-five degrees, if the window is directly opposite the mirror, and your bar parallel with it. You may now, if you please, use the condensing lens, *n*, but I *do not recommend it*, as, along with an increase of brightness it generates a degree of confusion and nebulosity. If employed, see that it is clamped tight into its true position on the bar. Like the mirror, it should be as close to the stage as possible.

If you wish to be exactly acquainted with the colour of transparent bodies, use the plaster of Paris side of the mirror to reflect the light of the *sun*, in an apartment exposed to it. With this intent, place the instrument on a table on which the sun falls, in such a manner, however, that it shall only impinge on the mirror, and leave the rest of the engiscope in shade; then proceed with it as if it were day-light. This, in my opinion, is the only way in which the light of the sun can be employed with advantage for illumination, and it brings out *colours* with the most perfect fidelity.

When the instrument is used in the VERTICAL POSITION, it is, of course, in the attitude represented in the plate, and is governed precisely in the manner just described. I do not like this position at all: it should, I think, only be used with bodies which must be *confined to the stage by their gravity alone*, which case may sometimes occur; but I have made most ample provision for presenting all sorts of objects in any position, *without regard to their gravitation*, by means of the aquatic wet and dry glass boxes, and the slider-holder, &c. I think that the practice of *poring* *downwards* (the ordinary way of observation with microscopists of the old school,) is peculiarly detrimental to the head and eyes, having a great tendency to determine the blood to them.—*We never hear of astronomers, who are perpetually looking upwards, having their sight injured, like observers with microscopes*, though they have to look, if possible, still more steadfastly and intently than the latter, with the highest powers. I had nearly forgot to mention a circumstance very necessary to be attended to in the management of the mirror; it is this,—to keep the milled head, *r*, *invariably outwards*. It is not made to travel completely round, nor is it necessary; for every possible position required for practical purposes can be attained without its traversing more than the *half* of a circle, by reversing the superior or inferior end of the ellipse, according to circumstances. Thus, supposing there were two windows in an apartment, one on the right, and the other on the left of the instrument, it would command either, without revolving on its inferior axis, *merely by being tilted on the right or left side.*

Way of Viewing Crystallizations of Salts and Various Chemical Actions.

Use the mounting (No. 2); screw on the lengthening piece, *i*, and attach the diagonal boot (fig. 16) to it. By means of the wheel and endless screw let down the arm of the instrument till the body shall be considerably below the aperture of the stage; then take off the lid of one of the aquatic boxes, and fix the other part, first warmed at the fire, upon the stage; which turn round on its pivot until its surface with the box shall *point downwards;* then insert a drop of the salt to be viewed upon the *inferior* glass of the box (now, by virtue of its position, the superior one);

turn the boot round on the lengthening piece until its projecting cone shall look upwards, and adjust the focus *by means of the wheel and endless screw, which now performs this office,* while the rack-work used under other circumstances, for the same purpose, now *only gives a traversing movement.* Many chemical actions, between various bodies, both fluid and solid, may also be viewed in this way. Moreover, crystallizations, &c. can be seen under any of the usual modes of mounting, by placing the salts or other bodies between the glasses of the aquatic boxes, with the closed or pierced lids, as the occasion may demand ; only, whenever there is *evaporation* or *evolution of gas,* remember to employ the *pierced lids.*

I think, nevertheless, that the best way of viewing salts is, to use the glass slip, with its frame (fig. 29), and merely to rub the liquid salt over its surface, allowing it to drip a little at an angle of 45, before it is placed in the slider-holder. *The glass must not be warmed in this method ;* and the salt must be allowed to crystallize very slowly, in its own natural way. By this process, though somewhat tedious, *none but the veritable microscopic crystals are obtained.* Deliquescent salts, in *damp weather,* can, however, hardly be brought to consolidate in this way.

I hope the description of the method of management is now tolerably complete, as concerns *transparent inanimate objects ;* but the method of dealing with living ones requires some illustration.

4th. WAY OF MOUNTING FOR TRANSPARENT LIVING OBJECTS.

These are not seen well by artificial light, as I have already observed, their internal machinery being utterly confused by it; though from what cause, unless it be its *divergency,* I cannot easily comprehend.

It will be rather difficult to get a power low enough, with the present instrument, to obtain a general view of a number of the larger aquatic larvæ; for I do not think the present engiscope will carry an object-glass of longer focus than two inches; which, with the lowest *inverting* eye-piece, will be fully twice too high—(for, be it observed, the lower the power is the more of an object it will include in the field of view, and the higher the less); but, with the erecting eye-piece thrust pretty far into the body, a power will be obtained that will easily include a space of one and a half, two, or even three inches; therefore use the erecting glasses A, screwed on to the bottom of the internal tube of the body, and draw it in or out, until it just takes in the area of your largest aquatic live box, and use the first or third way of mounting.

The method of using the *aquatic live-box* is as follows: Take off the lid, applying your finger to the hole in it, or stop it up, *pro tempore,* with a bit of wax; then pour in some water to the depth required, and insert your larvæ, and apply the inner part to it, observing still *to keep the lid undermost:* having slid it on far enough to keep the water from escaping, place the box in such a position that the *hole* in the lid shall *point upwards*; then, by squeezing the lid on farther (having, of course, first removed your finger or bit of wax from the hole), you may expel all the air, and as much of the water as may be superfluous. It is now fit for use; (for the pressure of the atmosphere prevents the water from coming out of the hole) by being placed in the aperture of the stage, and turned *one quarter* round. A single drop of water, containing animalcules, may be placed between the glasses of the smaller boxes; and, if the tubes are made air-tight by a little grease, and the hole stopped up, may be kept for weeks together without evaporating.

If very delicate and exceedingly transparent animalcules are to be examined, use the adapter (fig. 28), with the smallest aquatic live-box mounted upon it, and secured by the bayonet-catch: let it be placed between the connecting *cross-bars, 'u 'u,* and the *superior plate* of the slider-holder, which arrangement permits the adapter to be moved about: screw the wheel of diaphragms (fig. 24,) on to the bottom of the slider-holder, and see that the body of the engiscope is truly concentric with the hole or diaphragm; otherwise you will have no light. Recollect, that *the body of the instrument must now be stationary,* and that you must move the slip about with your fingers. *Whenever the diaphragms are employed, the body must be a fixture, or nearly so.*

A very useful way of observing aquatic insects and larvæ is, by means of the direct or diagonal boot drawn over the lengthening piece, *'i,* of your object-glass, which may then be inserted into the reservoir in which they are kept. The method of mounting is as follows: Unscrew the body from the arm, *w,* and attach fig. 15 or 16 to it, instead of its usual neck: see that the plane-glass at their ends is as far removed from the object-glass as possible (for *the less water you have to look through the more distinct will be the vision);* detach the stage from its pivot by slackening the screw, *l,* and clamp it tight on the lower pivot, *i,* having previously removed the condenser, *n,* altogether: then place the glass vessel on the stage, which must be truly horizontal, and clamped tight by the pinching screw, *l;* insert the body into the reservoir, by rescrewing it, with its new appendage, on to the arm, *w*, again. If you want to observe laterally, or to take a periscopic view of the contents of the vessel, use the diagonal boot in place of the direct one; and, by turning it round on the lengthening piece, any object situated on the sides of the vessel, such as polypi or vorticellæ, may be observed without disturbing them. The object-glasses apply either to the ordinary neck of the body, or to the lengthening piece over which the boots slide. Dissections may frequently be carried on under the surface of fluids by means of these boots, with great effect, which can hardly be accomplished in the common way.

Whenever the instrument is in a vertical position (as will of course be the case in the present instance,) *or when it is not far off from it,* the lever *y* may be used with great advantage. In observing live subjects it is peculiarly useful, for *it enables us to follow their movements much more rapidly* than can be done by means of the wheel and endless screw; and *the double motion of the arm being, by its assistance, governed entirely by one hand, the other is left at liberty to adjust the focus* (which is, of course, perpetually changing, according to the motion of the insects observed); it is attached to the pinion on either side of the rack-work, according to circumstances, by being pushed on the square projecting pin. The wheel must then be detached from the endless screw, by slackening the clamping screw, '*b*, and drawing the piece which carries the said endless screw backwards *away from the wheel,* causing it to traverse over a portion of the arc which it forms on its pivot, and fixing it afresh, so that it shall not catch the teeth of the wheel: *the arm then moves freely round on the top of the bar, and is subservient to the action* *of the lever,* the milled head of which operates upon the pinion in place of the ordinary one, and is governed by the *thumb and index finger ;* while the others act upon its extremity, and give the rotatory movement which was before performed by the wheel, &c. Moreover, whenever the lengthening piece is in use for transparent objects not contained in fluids, the shade (fig. 18,) may be employed. It slides down completely over the object observed, and *guards it effectually from all rays of light not transmitted through it,* so that it is observed *purely as a diaphanous body,* and not partially also as an opaque one (as is frequently the case with transparent objects treated in the common way). This piece of apparatus is of much use in *verification.*

The stage may, moreover, be removed altogether ; and the bar being in the horizontal position, the vase may be placed on a proper support in its stead, and observed *from without,* as well as from within.

5th. METHOD OF MOUNTING THE DIAMOND AND SAPPHIRE MICROSCOPES FOR TRANSPATENT OBJECTS.

When the use of the engiscopic part of the instrument is thoroughly attained, nothing can be more easy than the management of them. All that is requisite is, to unscrew the body from the arm ; and, by detaching the teeth of the wheel from the endless screw, according to the directions already given, to *reverse the ends of the arm,* so that the microscopes shall come into play ; when the rotatory movement must be again secured, by bringing the endless screw in contact with the wheel, and clamping it tight : thus the instrument becomes converted into a simple microscope, of the first quality, which is to be used *exactly as the engiscope was:* I can give *no better* directions concerning it. The sapphire and diamond lenses have their own peculiar settings* in a species of dish or cup, which is attached to the arm by being thrust into the hole at its extremity. The aplanatic lenses should also have settings on which they can be screwed at pleasure, to be used as simple microscopes. If, at any time, when bodies are merely laid upon the stage, and confined to it only by their gravity (the stand being used vertically, as in dissections, for example), the face should come into too close contact with the stage, the apparatus (fig. 21,) must be used, which is inserted into the aperture, like the live-boxes and slider-holder: the object being laid upon it, due space will be afforded for the nose, and the breath will be less likely to steam the lenses. The arm, *w*, is made to turn round in any position most convenient to the observer. The adapter (fig. 28), which is to be used between the *bars* of the slider-holder, to carry a small aquatic live-box or the like, affords another species of convenience, of a similar nature, and serves to elevate the face of the observer above the stage.

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* The superior cohesion of the precious stones admits of their being burnished into a cell, which is again fixed into the setting. This arrangement allows the lenses to be shifted about without difficulty, or risk of losing them. If they are plano-convex, as they should be, another advantage results, which is, that they may be used either with their flat or convex side towards tbe object, according as great distinctness, or a large field of view may be required (for you cannot have these qualities combined). Remember, therefore, *if you want a large field of view, and do not, at the same time, require a large aperture, united with great distinctness, to place the lens with its flat side next the eye.* If, on the contrary, you *must have a very large aperture, conjoined with the utmost possible degree of distinctness, then place the convex side next your eye.*

OPAQUE OBJECTS.

Opaque objects seldom require such high powers, or such large apertures, as transparent ones. Their colours are best brought out by daylight, natural or condensed; but artificial light, perhaps, shews them best in all other respects.

They should always be viewed upon a *black ground* of some description. The more sombre, and dingy, and faint their tints are, the greater need there is of a black ground to stifle all heterogeneous light.

As they only reflect or radiate light, a much stronger illumination is requisite for them than for diaphanous bodies, which almost always transmit a great deal more light than opaque ones are capable of reflecting. Moreover, they seldom present flat surfaces, as most pellucid bodies can be made to do. This, when the power is considerable, causes one part of the object to be indistinct, while another is seen accurately: this must always be allowed for. A very perfect instrument can only have *one point in focus at once,* and, consequently, can only shew one point distinctly at once, all the rest *not on the plane of the focus* being confused.

The direct light of the sun is utterly improper for exhibiting opaque bodies, being polarised and decomposed by them, so as to give rise to all sorts of optical deceptions: neither can it be modified or dulled by *refraction* through rubbed glass, or any sort of semi-pellucid substances, and thus rendered fit for use: by *reflection* from white *unpolished* surfaces it may, but it is then no stronger than the light of the atmosphere.

6th. METHOD OF OBSERVING OPAQUE OBJECTS BY DAY-LIGHT, PLAIN OR CONDENSED.

Employ the mounting (No. 2,) recommended for transparent objects by artificial light.

If your object is contained in a slider, insert it into the holder in the usual manner: turn your back diagonally towards the window, and place the engiscope on a table, in a convenient position for observation in that direction, so that the light of the window may fall full upon your object, without being intercepted by your head: the nearer you are to the window the better, provided its direct light does not get into your eyes. You then proceed to the adjustment of the focus, &c. as before described. If your power is considerable, or the day dull, you will require a condensed light: to obtain it, attach the condenser, '*f*, to the neck of the body, by means of its clamping screw and split socket, '*g*; unscrew the double convex lens from the other, and remember to use only the plano-convex, with its *plane* side presented towards the light, and *its convex side towards the object:* slide it up or down upon the neck of the body; and adjust, also, by the help of the joint, *v*, until you get a good spectrum of light upon your slider. (It will be well, in the first instance, to form an image of the window upon your object, and then to push the illumination a little closer to it, so as to obliterate the image.) You will in this way get the maximum of brightness:—the crown of the convex side of the bull's eye, or condenser, when properly adjusted, will be about an inch, or an inch and a quarter, from the object.

If you think it more commodious, you may attach the

Fig. 30.

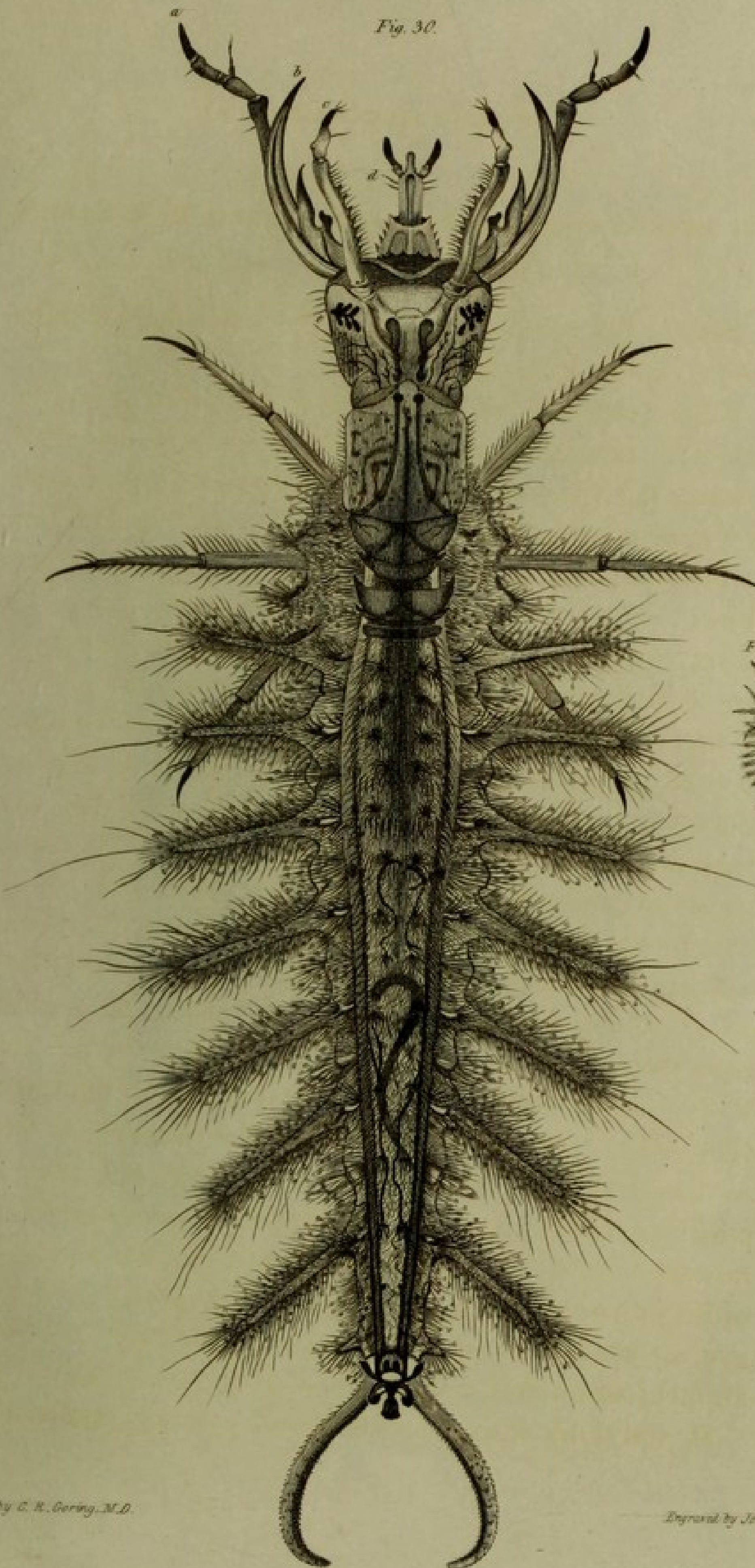
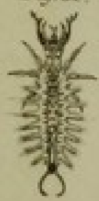


Fig. 31.



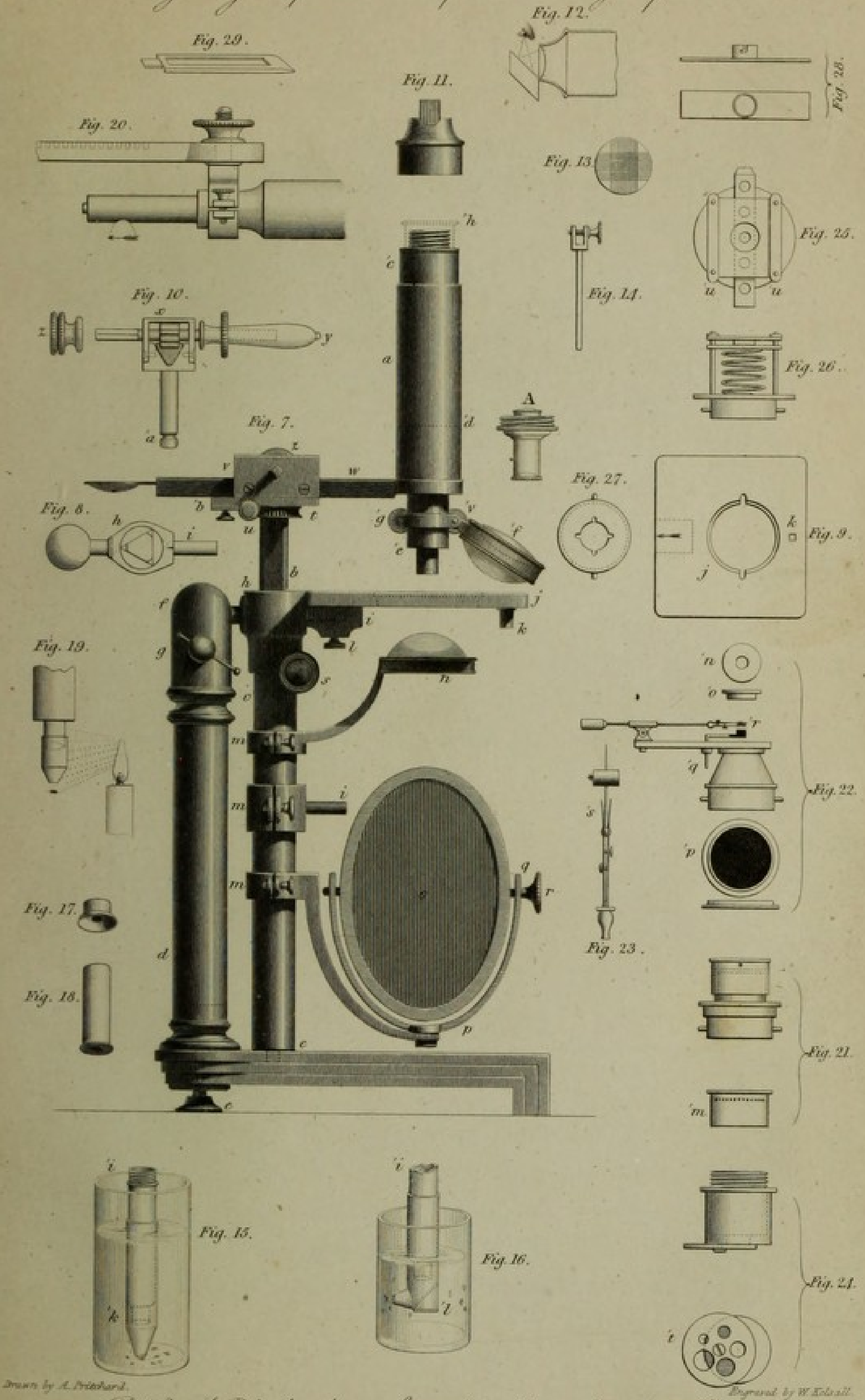
Drawn by C. R. Goring, M.D.

Engraved by John Cleghorn

Pub.d by Andrew Pritchard, 312, Strand, for his work on New Living Objects for the Microscope.

1 May, 1829.

Goring's Operative Aplanatic Engiscope.



Drawn by A. Pritchard.

Engraved by W. Kelsall.

Pub. by A. Pritchard. 312 Strand, for his work on the Microscope.
1 May. 1829.

condenser to the *stage, instead of the body*—(only, in this case, if you move the optical part, you will lose your light). To effect this, remove the setting of the lens altogether from the split socket, by unscrewing the joint, *v*, and fix it afresh, by means of its screw, into the square bar, fig. 14, which insert into the square hole in the stage. The adjustment is effected now by pushing the illuminator up and down in the stage, combined with the motion of its joint, *v*, as before. I think, however, it will be found adviseable only to attach the condenser to the stage *when artificial light is employed;* for, in this latter case, the weight of an additional lens is applied to the condenser, which might overload the *body*, if dependent from it.

If you wish to view opaque terrestrial living objects, put them into the suitable live-boxes, with the *pierced covers*, to admit air. These said boxes, with one or the other of their lids, may be used to hold nearly any object.

7th. METHOD OF OBSERVING OPAQUE OBJECTS BY ARTIFICIAL LIGHT, EITHER PLAIN, CONDENSED, OR REVERBERATED, BY SILVER CUPS.

Use the mounting (No. 2,) as before: close the shutters of your apartment, if you mean to observe in this way in the day-time: procure a telescope candlestick, or one which has an arm moving up and down upon a bar, so that it can be adjusted to any height as a candle burns down—(the sliding-tube of the pillar will, in some measure, serve this purpose, if you have not a proper candlestick), and get a piece of an *old rushlight*, to afford your illumination.—Don't laugh, but do as I bid you : and, more-over, a pair of scissars, to trim it. A piece of rushlight (please your worship) well trimmed, gives a *remarkably steady light, without flaring or flickering*, and is just as *intense* as that afforded by oil, or tallow, or gas itself, burnt in any other way. The *intensity* of the light is the thing wanted, not the *quantity*. Perhaps a *wax* rush-light might be an improvement. Now, this rushlight, adjusted to the proper height, is to be placed before your stage, aud as near to your object and object-glass as may be, without burning them : but you must take especial care that its *direct light* does not get into the body of the en-giscope, or it will utterly destroy all distinct vision : on this account it must be always placed a little *on one side* of the objective; and, if the focus of the said object-glass is longer than half an inch, it will be highly adviseable to use a conical shade (fig. 19,) drawn over it, reaching almost to the object itself; which will, moreover, always be some security against burning it, or injuring the ob-ject-glass itself. The object, if below a certain size, will, of course, be seen upon a ground of some sort, and this must be a *black one:* if on a slider, it must be gummed upon black paper ; or, if mounted upon a cork cylinder, having a pin thrust through it, the surface of the cylinder must be blacked with lampblack and glue, before the ob-ject is applied to it : but, if it is of a nature to be held by the nippers, Mr. Lister's black ground (fig. 22,) must be employed, to bring it out in true relief; for it is far blacker than any other, and stifles all heterogeneous light much more perfectly. This is attached to the stage in the same way as the live-box or slider-holder ; and is, in fact, the same piece of apparatus which constitutes the false stage for the simple microscopes, and for dissecting; with the top and bottom, '*n*, '*p*, applied in their proper places, and to close it up. In the present case, its dark abyss is to form the ground against which the object is examined. At the other end of the needle is a piece of cork, contained in a bit of brass tube. This is to receive the pin by which insects are retained in their drawers in entomological cabinets, which can thus be taken out and examined without injury; more especially if the pins have been thrust through them *diagonally*, which is a great convenience when applied to the microscope, as it allows their backs and bellies to be freely presented to the action of the object-glass. The nippers, seen of their natural size at fig. 23, are drilled through at *s*, so as to lay hold of the *head* of a pin, and retain it firmly, so that it can be twisted about in any direction, without risk of detaching it. This will be found a most useful contrivance for holding the cork cylinders, and *all objects whatsoever mounted on pins*. The swivel which carries the nippers, &c. is thrust into the arm, and in that manner used, as shewn in the plate.

The mode of observation by plain artificial light corresponds with that by plain day-light. It is one of the simplest and best ways of viewing opaque objects; and the contrast of the strong divergent lights and shadows cast by the rushlight, brings out, and enables us to comprehend, the foreshortenings and perspective of the complicated details frequent in irregular opaque subjects, and thus to verify their true nature, construction, and relative position, much better than, I think, any other sort of illumination.

Never forget that, *when observing* with the *candle before the stage*, you must *hold your breath*, *or have a handker-*

chief tied over your mouth : a single puff is all that is necessary to cause the flame of the light to play over the object and destroy it—(and thus, in fits of absence, have I destroyed many valuable ones). What renders a rush-light so useful is, that it will not, *of itself,* flare over your object: it can, moreover, on account of its smallness, be got *closer* to an object *with impunity* than any other artificial light; and thus, in fact, gives the most intense sort of plain illumination; for the intensity of light decreases according to the square of its distance from the object.

When observing faint, sombre, and dull opaque objects, especially if high powers are used, a vast increment of apparent brightness is obtained, if all light is excluded from the eye save that of the visual pencil. Thus, it will be found a great assistance if a large blackened pasteboard shade, nearly a foot in diameter, is made to fasten upon the eye-piece, and thus completely to exclude the direct light of the candle, &c.; or, still better, if a black hood, like those used by astronomers, is made to cover up the face completely, but with an aperture for the body of the instrument. Such an arrangement, also, saves us the trouble of shutting one eye; and the enlargement produced in the aperture of the iris, by keeping the eyes in the dark, enables the faintest rays to affect the retina.

CONDENSED ARTIFICIAL LIGHT

Is procured by the action of the double illuminator, *f*; whenever it is used by lamp or candle-light, the double convex must be screwed on, still preserving the convex side of the plano, or bull's eye, next the object. The split socket must be clamped tight in such a position on the neck of the body, that it shall present the face of the illuminator in a lateral position relative to it, so that the rays of the candle, &c. shall fall conveniently upon it ; its distance from which should be about an inch and a half, and its distance from the object should also be about an inch, which will give the maximum of illumination, with a large spectrum, so as to illu'me a considerable space. I think, whenever this condenser is used, the flame of an Argand lamp should be employed, shaded, however, by an *external copper tube,* with an aperture in its inferior part just large enough to expose the flame, placed over the usual glass one. This will give increased effect and splendour to the object, by preserving the apartment in gloom, and thus allowing the iris to expand itself.

I do not think a more *intense* light is got with an Argand lamp than with a rushlight, but certainly a far greater quantity of it.

SILVER CUPS, OR SPECULA,

Afford a very brilliant and intense light, *almost without shadow*, because it plays vertically upon the summit of an object, like the sun of tropical climates. This is the only species of illumination which will bring out many opaque objects properly (a fly's foot or human hair, for example); but for others, requiring *shade* for their verification, it is altogether improper. (The markings on the scales of butterflies, &c. are a good illustration.)

Each object-glass must have a cup attached to it capable of adjustment, by being moved up and down upon the tube in which the object-glass is set, *so as to cause the focus of the latter to coincide with that of the cup,* (the maximum of brightness cannot otherwise be attained). *The object must always be held by the nippers, or mounted on a cork cylinder, when it is to be illuminated by cups:* when the nippers only are employed the disk, 'r, must be placed between them and the illuminating lens, &c. so as to prevent any false light from getting into the object-glass, and also to furnish a *black ground.*

Remove the bottom of the black box, 'p, and fix the condenser, *n*, in such a position, by means of its tightening screw, that its convexity shall be inserted into the bottom of the said black box, which will be found its best position either for day-light or candle-light. The engiscope must then be placed on the tripod stand (mounting No. 1,) and directed against the sky, (the best way, perhaps, of using the cups with *day-light*), or it may be used in an horizontal or vertical position, and the light reflected by the oval mirror; but when *artificial light* is preferred, use the mounting, No. 2, and place an Argand lamp about an inch and a half from the condenser, *n*, taking care that its flame is concentric with it, and a most intense illumination will be procured, even with powers equal to the 1-60th of an inch focus. Cups, when *properly managed*, give a brighter light than can be procured by any other means*.

Please to remember that the condenser under the stage, and that represented attached to the body, are expressly and exclusively devoted to opaque objects.

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* The cups may be used without the assistance of the condenser, but, of course, in this way give a much more feeble light.

8th. MOUNTING FOR DISSECTIONS, &c.

Dissections are generally performed on opaque subjects, though it may be sometimes necessary to dissect transparent ones also. The *erecting* eye-piece must, of course, always be employed, by sliding it up and down in the body; with various objectives the power may be made gradually to advance from a mere nothing up to the 1-20th of an inch (which I conceive to be the utmost which can be used) and still allow sufficient space between the object and the object-glass for the anatomist to manage his implements, and to procure the necessary illumination.

Mount the engiscope in the vertical position, and see that the bar is locked fast in its front leg, to give the utmost degree of stability; place it on the tripod stool, before recommended, with the *front* of the stage before you, and the pillar next to the window—(a diagonal position for yourself and the instrument relative to it, will be most convenient, to allow the light to fall freely on your subject.) Use the single condenser, *n*, to furnish your light, if necessary; it may be moved round the neck of the body, to suit your convenience. You may also employ the lengthening piece, '*i*, if you please, which will allow you to fix the stage on the pivot and sliding socket, *i*, and give a lower position for it. If you use the latter, see that it is clamped very fast, that it may not give way with the weight of your hands.

If you do not find it advisable to employ the false stage, fig. 22, which procures a separate rest for the little fingers, while the thumb and index finger operate, drop the piece, fig. 27, into the aperture of the stage, and fix it by turning it one-quarter round. Then place the piece of cork or wood, &c.

on which you dissect in the smaller aperture of this, and proceed. I should recommend you to get the leaves of two Pembroke or other tables placed on each side of you, to rest your elbows upon at pleasure, and likewise to procure several pieces of board, about $1\frac{1}{2}$ inch thick, to place under the instrument, to depress or elevate it without the help of the slide in the pillar (which, when called into effect, always unlocks the bar.)

Your operations can always be carried on under the surface of liquids, by the help of the direct or diagonal boots.

When you wish to get at the side of your subject without disturbing its surface, mount in the position, No. 2, and turn your stage round on the pivot, *i*, until it comes to be in the plane of the bar: every lateral view can then be obtained at pleasure, by turning the object round, and you can operate in this position as well as in the vertical one. You may also, by help of the ball and socket, tilt the body at any required angle, and still adjust the stage to the horizontal position, as before, taking care to pinch it fast by means of the screw, *l*, before you begin to work again.

There are no tools for dissection equal to *very fine scissars,—they always cut without dragging or tearing;* there is, however, the greatest difficulty in procuring them. The Sheffield workmen are the only ones capable of making them sufficiently delicate*. You may, of course, dissect with

* Miniature scissars have been made only half an inch in length quite perfect: now a pair constructed with blades like these, but in other respects like those for some operations on the eyes (*i. e.* without ears), having one arm inserted in a long handle, and the other left short, playing against a feeble spring to keep it open, is the sort of tool required. It is held like a pin, and cuts by the pressure of the index finger on the short arm.

simple microscopes of *low powers* as well as with the engiscope, but the present stand is not so well adapted for them as a separate one would be.

9th. MOUNTING THE DIAMOND AND SAPPHIRE MICROSCOPES FOR OPAQUE OBJECTS.

It is one of the vices of simple microscopes that they can only shew opaque objects *with cups*, at least if their powers exceed one-quarter of an inch. The lower foci shew opaque objects admirably with day-light, the stand being in the vertical position. When used for plain day-light in an horizontal one, all that is necessary is to assume such an attitude relative to the window that the head shall not intercept its light.—For example, if you sit with the bar horizontal and parallel with the window, the light will naturally fall *between the stage and the magnifier* upon the object. When cups are employed, they act precisely like those attached to the engiscope, and magnifiers thus mounted are managed in the same way.

10th. THE AMICIAN CATADIOPTRIC ENGISCOPE

Is attached to the present stand by means of the arm, fig. 20, and is managed precisely on the *same principle* as the refracting aplanatics. The body turns round upon a swivel, by means of the pinching screw, to suit the convenience of the observer; and the only real peculiarity in observing with the reflecting engiscope is that *the optical part is always at right angles to that of the refracting one in any given mode of mounting or observation*, just as the eye tube of the Newtonian telescope is relatively to that of a refractor *cæteris paribus ;* but this instrument, as well as the simple and compound microscopes, are probably best on their *appropriate stands,* of which full and particular descriptions will be given hereafter. It is only for the sake of those who should like to have the three instruments jumbled together that they are adapted to the same stand in the present case.

Courteous reader, I have endeavoured to supply the place of a *viva voce* lecture on the instrument, and to infuse into thee such knowledge as I possess, touching the management of the aplanatic engiscope, &c. I hope it will be found sufficient for ordinary objects ; but under the head of *Test Objects* I shall enter into the subject still more minutely, and give still more precise and specific instructions, as the case may seem to require. I cannot help thinking, however, that the directions *already given* will be found much more explicit, clear, and intelligible, as well as more full, particular, and diffuse, than any others hitherto given in print. *Valeant quantum valere possunt.* By their assistance thou shalt be enabled to enter into a course of researches *very nearly* as profitable to thyself and fellow creatures as if thou wert engaged in the sublime and important occupation of determining whether the small star of ε Bootis, is of a greenish blue, or bluish green ; or whether some nebula is very gradually or very suddenly much brighter in the middle.

C. R. G.

CHAPTER VII.

*On the Larva of a Species of British Hydrophilus**.

IN examining the peculiarities of the structure and habits of this larva, the faculty which most strikingly attracts our attention, is its ferocious and savage disposition, and the fitness of its organs for the exercise of its ravenous propensities. It may be safely asserted that no species of larva is known that is provided with weapons of destruction so powerful, so numerous, and well adapted to their end, as those which this creature possesses. It is on this account that it has been popularly called the WATER DEVIL. Its size is but little inferior to that of the larva of any of the

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* The Hydrophilus, or Water Lover, according to the Linnean classification, belongs to the order Coleoptera, or those insects which are furnished with crustaceous *elytra,* or wing cases, but which are never developed in the *larva* state, being generally formed while in the pupa or crysalis. This order includes all the numerous tribes of beetles, and has fifty-seven genera, principally distinguished by the different formation of their antennæ. The Hydrophilus is nearly allied to the *Dytiscus,* or Diver, another water beetle, which it resembles in many particulars. From the want of sufficient description of them in the larva state it is difficult to determine the exact species to which the present specimen belongs, though I believe it allied to the former genus, from the feathered brachia or plumed swimmers along the sides. According to the observations of different naturalists, it appears to remain in the larva state about two years. It is smaller than the Hydrophilus *Pyceus,* or Water Clock, and larger than the *Caribus,* Water Lover.

British Coleoptera, as it measures, when arrived at maturity, an inch and a half in length, while the superior strength and courage manifested in its attacks on small fish, and other animals larger than itself, is truly surprising.

About the latter end of April, and during the month of May, small nests of these insects are often found floating among the weeds and water plants, in stagnant pools, and are frequently taken in the nets of those who are searching for the early species of animalcules. They are in the form of balls, of a dusky white colour, and a silky texture, and have each a small stem of the same nature as the nest, by means of which it is attached to the roots or stalks of weeds at the bottom of the water. In this situation it remains during the winter, and is thus effectually preserved from the effects of intense cold. Early in the spring, the stem or cable to which we have referred, is detached from the weeds, by the winds which at that time prevail, and the nest rises to the surface of the water, and there floating, imbibes the genial influence of the sun. These nests may be taken and placed in a bason of water, and, as the season advances, hatched by the heat of the sun. On the larvæ leaving the nest, which they accomplish by gnawing a hole in the side, the infant larva immediately descends to the bottom of the vessel, with its jaws extended in search of prey, and eagerly devours all the small aquatic insects that are within its reach ; if, however, there is a scarcity of food in the immediate neighbourhood of the nest, the larva of the same brood may be seen to attack and devour each other.

In its infant state this larva is very transparent ; hence its internal structure may be clearly distinguished. The circulation along the principal artery on each side of the body can be distinctly observed, together with the violent alternate motion of the vermiform body, near the lower extremity.

It is at this time about a quarter of an inch in length, and swims very nimbly. The colour of the head is a strong Indian yellow, with darker shadings of a bright chesnut. It is more sparingly covered with hairs than at a more advanced period of its age; and the head is larger, in proportion to the size of the body, than when the creature has arrived at maturity. In this respect it resembles the mode of growth of many other creatures, in which the head seems to be developed and perfected before the rest of the system.

The manner in which this larva treats its prey, evinces an extraordinary degree of instinct. Many of the creatures on which it feeds, are crustaceous about the head and back; hence their most vulnerable part is the belly. This part, therefore, the larva attacks, and to accomplish its aim, swims underneath the intended victim, and bending back its head, which is even with the surface of its back, is enabled to reach its prey by means of its jointed antennæ, *a*, figure 30, which represents a magnified view of the larva taken while young. Its next operation is to pierce it with the mandibles, *b*. Having thus secured its object, it immediately ascends to the top of the water, and holding its prey above the surface, so as to prevent it struggling, shakes it as a dog would a rat. The prey, however, of this larva, is often larger than its destroyer. Its next operation is to insert the piercer and sucker, *d*, which is capable of being thrust out or withdrawn at pleasure. When the juices of the victim are not easily procured by suction or exhaustion, the serrated pair of forceps, *c*, is employed to tear and masticate it, and thus cause the juices to be more easily obtained. If its food is plentiful, this larva arrives at its full growth in the course of three or four weeks, and is then nearly opaque, and thickly covered with hair. It can be kept several days without food, and by this exinanition its structure becomes considerably more transparent*, while its natural ferocity is greatly increased, so that it will attack and fight with creatures much larger than itself, and even with its own species. It may be remarked, that it studiously avoids any contest with the *nepa*, or water-scorpion.

On a fine sunny day the larvæ arise to the surface of the water, and delight to bask in the sun, but if watched, they remain motionless, with their claws extended. If a stick, or any other substance, be presented to them, they will immediately seize it, and will sometimes suffer themselves to be cut into pieces before they relinquish their hold. Their bite has been considered poisonous by many persons, as it takes a greater length of time to heal than other wounds of the same extent, so that caution should be used in taking them.

Touching the anatomy of this creature, it may be observed, that the sucker, marked *d*, is contained in a crustaceous sheath, and may be considerably protruded or completely withdrawn at the pleasure of the larva : in the engraving it is shewn extended to about three quarters of its length. The eyes are compound, but of a peculiar conformation, being composed of seven oval lenses, arranged like leaves upon a branch ; in the drawing they are

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* The subject represented in the engraving was starved, in order to render its interior organization more clear : it may be observed that its intestinal canal is quite empty.

denoted by the letter *e*. The whole of the head and thorax is curiously marked with a number of lines and spots. The legs are six in number; they are thickly set with rows of hair on their opposite sides, and each is furnished with a sharp claw. The number of swimmers on each side is seven; they are covered with hairs, and in the specimen from which the drawing was taken, a vast number of *vorticella*, or bell polypi, were attached. These will be recognized in the magnified drawing by their bell-shaped figure. They sometimes infest this species of larva to such a degree, as considerably to impede its motions in swimming. On each side of the abdomen, which commences near the origin of the first pair of brachia, or swimmers, arise the great vessels distinguishable in the coloured engraving by their light blue colour; the two are probably united near the tail, where an exceedingly curious process is also distinctly exhibited. The whole surface of the body is thickly covered with hairs, and several tufts are disposed in clusters, with some regularity, down the back and sides. These hairs, and indeed all the external markings on the body, are so much more distinct in a black than in a coloured engraving, that I have given a black impression in addition to the usual coloured plate. In this the flexible pulsatory organ that has been before alluded to, as in perpetual motion, is distinctly shewn. Its form resembles the letter *S*, inverted: it however varies a little during its vibrating motions in the intestinal canal. The use of the curious appendages at the lower extremity of the body, is unknown. Its tail is biforked and crustaceous, and is marked as shewn in the plate. In figure 31 is given a representation of the larva, of its natural size and proportions, at the *period of the growth of the larva at which the* *drawing was taken.* As it approaches maturity it casts its skin several times, from each of which it escapes by a rent formed down the back.

After this creature has remained for a considerable time in the larva state, it buries itself in a hole, which it forms for that purpose near the edge of the water, and after passing through the crysalis state, it emerges in the form of a perfect beetle. Several species of this genus have been described by different naturalists, particularly by Dr. Turton, but the precise characteristics of the perfect insect which is produced from this identical species of larva, are at present unknown; it will be recollected, however, that this circumstance does not render it a whit less valuable as a microscopic object.

A. P.