XXX. Memoir upon the compound and smooth or simple eyes of insects, and on the manner in which these two species of eyes concur in vision

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this question. Dr. Thomson, a respectable chemist, I believe, but (as far as his History of the Royal Society, and his ill-judged interference in this business, furnish evidence) a man of very moderate mathematical and philosophical attainments, affirms that "the point *can only* be settled by repeating the observations." The Chevalier Delambre, the most excellent theoretical and practical astronomer now living, *is of a different opinion*. Whether your scientific readers will concur in sentiment, on this purely astronomical inquiry, with the chemist or the astronomer, it is not difficult to predict.

When a writer has rendered himself notorious for assuming an air and tone of superiority and infallibility in all his controversial productions, which ill accords with his palpable mediocrity of talent and knowledge; and when he is indiscreet enough to libel a whole class (and that class comprehending such men as Archimedes and Newton and Laplace) for the supposed mistake or misconduct of an individual; it would neither be ungenerous nor unjust to lower his pretensions, and completely expose his numerous blunders. But it is a task which, however beneficial it might be to the public, and however easy of accomplishment, has no fascinations for me. Dr. Thomson's other observations*, therefore, not bearing upon the main question, I leave to sink by their own weight; and remain,

Sir,

Yours respectfully,

Royal Military Academy, Woolwich,
September 6, 1814.

OLINTHUS GREGORY.

XXX. *Memoir upon the compound and smooth or simple Eyes of Insects, and on the Manner in which these two Species of Eyes concur in Vision.* By M. MARCEL DE SERRES, Professor of the Sciences in the Imperial University.

[Continued from p. 118.]

THE tunic of the cornea is generally black in the *coleoptera*: it is the same in those which want the choroid and the mucous varnish. The colour of this tunic is on the contrary much more variable among the *orthoptera*, and sometimes one and the same

* Such, for example, as the reasons he assigns, why the first two volumes of "The Trigonometrical Survey," which were actually printed and published in The Philosophical Transactions, *were not admitted* into that work. O exquisite philosopher! to amuse and satisfy himself with accounting for the non-appearance of a phenomenon in a certain place, which did, notwithstanding, appear there *permanently*! Should I ever again be involved in controversy, may I have the good fortune to meet with such another *opponent*!

eye presents it of two different shades, as we see in the *locusta lilifolia*: lastly, in certain species the tunic of the cornea presents stripes variously coloured, and traced with the greatest regularity. These stripes are parallel in the *gryllus lineola*: some are of a blackish brown, and others of a yellowish gray, the clear colour of which dips into that of the rest of the eye. It must be remarked, that frequently these shades are effaced after death, on account of the alterability of the tunic of the cornea. There are even species in which the tunic of the cornea is as it were marbled; then it exhibits various shades in different parts of the eye.

As to the tunic of the smooth or simple eyes, it is seldom black in the *orthopterae*, and its colours are always uniform in the same eye; although they are much variegated, when we examine a great number of species. The most common colours are white, red, or pale green.

A great number of *hemipterae* also present the tunic of their cornea of colours pretty much variegated; but its brown or rather black tints are much more common than in the *orthopterae*. As we find among the latter, several *hemipterae* present the tunic of the cornea of their smooth eyes, either whitish or of the most agreeable red, as is observed in the common grasshopper. Lastly, it appears to me, that almost all the *hemipterae* which live in water have the tunic of their cornea completely black; perhaps it is the same with all the *coleopterae* which have the same way of living.

The *lepidopterae* furnished with the finest colours have also the tunic of the cornea of shades greatly variegated. Nevertheless, among all those which fly at sunset or during the night only, we observe that the tunic of their cornea is generally black. To conclude: the case is the same with several species of diurnal butterflies: for instance, the *papilio podalirius* has the tunic of the cornea completely black; and notwithstanding the sombre hue of this colour, the varnish of the choroid is very thick in this species. In the *papilio atalanta* the tunic of the cornea is of a clear brown; thus the black point resulting from the aperture through which the optic nerve passes, is seen on the outside of the eye. It must be observed, however, that as this circular aperture is formed in this species by vesicular tracheæ, and these tracheæ being a little separated from each other, the black point which is seen generally at the exterior of the eye, seems surrounded by other black points, which present a peculiar form, all having a smaller extent than the central point. In the *papilio cardui*, the tunic of the cornea is of a brilliant green, but much clearer in the lower part of the eye than in the upper, on account of the luminous rays less easily reaching them.

them. This tunic is thin, whereas the varnish of the choroid and the choroid itself are on the contrary thick. We also observe externally on the eye the central black point, and several others produced by the same cause with those of the eye of the *papilio atalanta*. Only these blackish points are more irregular in their form than those of the *papilio atalanta*.

The larvæ of the *lepidopteræ* have only smooth eyes situated generally on the sides of the head. They are variable in colour and number. Thus we observe eight in the silkworm, and six only in the caterpillar. The former are black, and the latter transparent. As to their internal structure, we shall speak of it elsewhere, inasmuch as it exhibits some differences from that of the other smooth eyes.

In the *neuropteræ*, the tunic of the cornea is also very much varied, and its colours vary much in various species. In the *libellula vulgaris*, the compound eyes exhibit all their upper portion of a reddish brown, and all the lower of a yellowish green. On carefully removing the cornea, it is easily seen that the difference in the two colours is owing to the diversity of colour in the tunic of the cornea. It seems even that this tunic is thicker in the brown part of the eye than in the green. We shall also remark that the upper facets of the cornea are greater than the lower; which is rather singular. If we remove the cornea, we distinctly perceive the optic nerves passing through the choroid and its varnish, membranes which are easily distinguished from their being of a deep black.

The circular trachea surrounds the retina, and its ramifications pierce with the optic nerves all the other membranes, dispersing themselves *ad infinitum* under the cornea. This disposition is so evident, that we may easily conceive how Swammerdam thought the cornea was formed by the meeting of these trachæ. In other respects the eye of this *libellula* presents nothing particular, with the exception of the enlargement or great extent of the retina.

I have also dissected the eyes of certain larvæ of *agrion* and *aeshma*, but have observed nothing very different. These larvæ seemed to want the circular trachea, the place of which is supplied by an infinity of other trachæ, which spread in a great number around the optic nerve, which is very broad and thick in these larvæ. I never observed that the eye had any particular conformation in the species which habitually frequent the water; and this remark is important, because the case is very different in the other animals. The form of the cornea also presents differences in the species in the aquatic insects, as well as in those which live habitually in the air.

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If the tunic of the cornea presents shades much varied in the *lepidopteræ* and *neuropteræ*, these shades are not less varied in the *hymenopteræ*, in which we sometimes see a gray, a green, a yellow, and even all the shades of black. Certain bees, and particularly the *violaceæ*, present this tunic of the most opaque black. Generally the *hymenopteræ* have their cornea very thick, and it is not difficult to remove it by thin slices. Sometimes this cornea is surrounded by hairs, and rarely do they issue from the cornea itself. In a great number of species, the circular trachea is totally wanting; but its place is always supplied by other and smaller tracheæ which surround the optic nerve, and in general these tracheæ are extremely multiplied.

What has been said with respect to the eyes of the *hymenopteræ* is applicable to those of the *dipteræ*, which have the tunic of the cornea with the most variegated shades. In a certain number of species these shades are very brilliant, and the *tabanus* as well as the *musca* hold a distinguished part in this respect.

Certain species of *syrrhus* present, at the exterior of the eye, two semi-circular stripes deeper than the general tint. These stripes are produced as usual by a deeper shade of the tunic of the cornea in this part of the eye: but what renders this disposition remarkable is, that there are numerous hairs precisely in this very part of the compound eye, and which originate from the cornea itself.

As to the eyes of the *apteræ*, they are in general of dark colours, and not very large. These insects seem therefore not to be much favoured in respect to the organ of sight, and probably their way of life does not require acute vision.

It is remarkable that the insects which live in water have in general their eyes dim and opaque externally, nearly like those which exist in dark places. Thus the nymphs of the *libellulæ* in passing to the condition of a perfect insect assume brilliant and transparent eyes, whereas previous to their last metamorphosis these eyes were dull and without lustre. This observation has not escaped the sagacity of Reaumur in his History of Insects.

In the descriptions which we have given of the situation and form of the compound and simple eyes of insects, it will be remarked that the former disposition is less subject to vary than the latter. This consideration might have arisen *a priori*, since no form can exhibit differences in any order of animals, without other variations following in the parts which surround those whose disposition changes. The only very remarkable example which we can mention of the variation in the position of the compound

compound eyes, is that of the *diopsis ichneumonea*. This insect exhibits its eyes situated nearly like those of the *mollusci*: thus they are placed at the extremity of a long pedicle, or a kind of contractile tentacular point, but which can at least follow all the motions of the head. We may say, on observing this singular organization, that this insect has its eyes at the extremity of a telescope; but as we have not seen it alive, nor dissected it, it would be difficult to decide how far this idea is correct.

As to the descriptions which we shall presently give of the relation which exists between the size of the bodies and that of the compound eyes, they prove that the *dipteræ*, the *hymenoptera*, *lepidoptera*, and *neuroptera* have very large eyes: it even seems that there are few animals equally favoured. As a great number of *coleoptera* and *hemiptera* have also very large eyes in comparison to their bodies, we may say that this size is very general in all insects. The two solitary examples of the *phasma* and *scolopendra* ought not to prevent us from concluding that, of all the animals, insects have the largest eyes in comparison with the size of their bodies.

§ II. *Of the simple or smooth Eyes.* The number of simple eyes is far from being as constant as that of the compound eyes. Certain species present two; others four, six, and eight; but in general we observe three. This number is even pretty constant in families which have at once compound and smooth eyes. We rarely see exceptions to this arrangement; and the *blatta*, as well as certain *acheta*, are perhaps the only kinds which, having compound eyes, have only two simple eyes situated on the upper part of the head. When there are three simple eyes, they are always arranged in the form of a triangle, so that there are two lateral, and one in the middle: their situation is also constantly on the summit of the head. Sometimes, however, the simple eyes are arranged two on the summit, and one in the middle of the front of the head. This arrangement holds in the *gryllus*, the *truxalis*, the *acrydium*, the *locusta*, and the *gryllotalpa*.

The *empusa*, which have upon the summit of the head a small triangular elongation, cannot on account of this organisation see objects with their eye in the middle.

The general form of the simple eyes is very variable: it seems, however, that in general that of the lateral eyes is elongated and elliptical, whilst that of the middle one is round: there are also many exceptions in this respect, since the *acheta* and the *gryllotalpa* present that in the middle of a very much elongated oval of which the greatest diameter is transversal.

The smooth or simple eye is formed of an external hard transparent membrane, convex externally, and concave internally. This membrane enveloping the eye necessarily determines its form:

form: it is not composed, like that of the compound eyes, of an infinite number of facets, but rather of a membrane of a single piece, and on which no divisions are perceptible. We may consider this first membrane as a cornea, on account of its transparency, a transparency which we observe even at the exterior of the eye, on account of the little colour of the varnish applied on the membranes situated under it.

After having removed the cornea, we find a viscous tunic more or less thick, and of which the colour also undergoes considerable variations. Thus this tunic or varnish presents the most opposite colours: it is almost always black in the *hymenoptera*, whereas it is whitish in the *orthoptera*. In the caterpillar, this varnish is frequently black, yellow, or red, and sometimes it is of the most beautiful brilliant green. This viscous tunic has been regarded by Swammerdam as a kind of uvea, although it seems very like the tunic which covers the cornea in compound eyes.

We ought not, however, to decide that the tunic of the cornea of the simple eyes is distinct from the varnish of the choroid. This appears probable notwithstanding, since in certain species the external colour of the simple eyes is not the same with that of the varnish with which the choroid is covered. Thus much is certain, that the cornea of the simple eyes is always coated internally with a kind of varnish, the colour of which appears at the exterior of the eye on account of the transparency of the cornea. This coating surrounds the optic nerve, which proceeds into the concavity of the cornea after having passed through the choroid and its varnish. Swammerdam very properly remarks, that the smooth eyes of insects receive nerves which are furnished to them by the cerebriiform ganglion lodged in the head. Lyonnet, whose researches announce so much sagacity, has also observed that the simple eyes of the willow caterpillar are composed of a cornea and a choroid traversed by the extremity of the optic nerve*.

The optic nerves of the simple eyes issue immediately from the brain, when these eyes are removed far enough from each other; but when, on the contrary, they are close together, as observed in the caterpillar and a great number of larvæ, the optic nerves are only divisions of a larger nerve which issues directly from the brain.

Lyonnet has described this arrangement accurately, and the figure which he gives of it, Plate XVIII. No. 6, is very correct. Then there exists a peculiar membrane in the form of a funnel, to which the six branches of the optic nerve are attached, and

* *Traité Anatomique de la Chenille du Saule, par Lyonnet, p. 570.*

this membrane ends at the place where the nerve itself divides into these six branches. We do not know positively, if this arrangement exists in the spiders: we only know that it does not hold in the scorpions. Besides, externally the eyes of the spiders and of the scorpions have the same structure and figure with the simple eyes of insects.

Immediately after the optic nerve and the tunic of the cornea, we observe a peculiar membrane which we shall consider as a kind of choroid. It exhibits, however, this difference from the choroid of the compound eyes, that it has no varnish so distinct; and finally, its breadth is always greater than the circumference of the cornea itself. This membrane, coloured frequently in red or black, is also sometimes colourless; and lastly, its whiteness is so dull that it is easy to distinguish it from the tracheæ. The thickness of this membrane is great enough to make it resist even a long maceration.

In the species in which the simple eyes are whitish, we see this membrane clothed with a coating of colours varying with the colours of the tunic which covers the choroid. This arrangement is even very perceptible at the exterior of the eye.

It would seem that this choroid is particularly very thick and white in such species as have their cornea concave and as if sunk. This arrangement must have taken place on account of the divergency undergone by the rays of light in arriving on a concave and transparent surface, their direction even being parallel, a divergency which is such that we may very well conceive that the eye would be too much affected by it, if a black membrane had also absorbed a certain number of luminous rays. A white membrane, sending back on the contrary all the rays which it receives, may augment the excitability of the optic nerve, and thus contribute to render the vision more distinct. Although this species of choroid presents in certain circumstances a very great whiteness, it is nevertheless always easy to distinguish it from the tracheæ, the only vessels with which it can be confounded. For, as little as we are in the habit of seeing the organs of insects, we can easily ascertain the tracheæ from their azure colour; and besides, by dissecting them in water (the most advantageous way of acting in these experiments) we see the tracheæ rise above the surface of the liquid; and from that moment we can no longer have the smallest doubt, for the tracheæ are the only organs which have so little specific gravity.

This choroid, the membranes of which are close and very thick, seems formed by a cellular texture of very close meshes, over which a heap of tracheæ are distributed. It is therefore underneath the cornea that the optic nerve is situated, which issuing from the anterior faces of the brain proceeds to the mid-

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dle of the eye. It does not appear that this optic nerve has any swelling at its base, or that a kind of retina is formed analogous to that of the compound eyes. In some species it appears to me that this nerve becomes broader towards its extremity, *i. e.* at the point where it corresponds to the cornea. I shall not, however, assert this positively, for it is possible that this dilatation may depend on the contraction produced by the section of the nerve. As I have not dissected these organs in the living subject, (which ought always to be done for the sake of precision,) I have not been able to verify, whether this dilatation depended on the sensibility of the nervous organ. However the case may be, the optic nerve before reaching the cornea traverses the muscles of the various parts of the head, sometimes enters a trachea, penetrates afterwards through the choroid and its varnish, and afterwards, when surrounded with the tunic of the cornea, corresponds to the internal surface of this membrane, on which it seems to lose itself.

As the cornea of the simple eyes is not, like that of the compound eyes, divided by numerous facets, it has not been necessary that the small nerves should give it a great number of small threads, but only that they should proceed to the point where the divergency of the rays of light should be the least considerable.

The small optic nerves which proceed to the simple eyes issue from the brain. As their position varies in regard to the other parts, they are sometimes the second, third, fourth, or fifth pair of nerves: this depends on their situation with respect to the various organs of the head, a situation which determines by what pair they are furnished. These nerves are directed always towards the simple eyes, being retained in their position either by pneumatic pouches, or by tracheæ, proceeding more or less obliquely according to their position with respect to the brain. They always terminate under the cornea, forming a kind of retina.

It results from this description, that the simple eyes are formed quite differently from the compound eyes. Thus the cornea of the former is all of one piece, whereas in the latter it is formed by the union of a great number of hexagonal facets. As to the tunic of the cornea, it does not exhibit any difference in the two kinds of eyes, except perhaps in point of thickness; but with respect to the varnish of the choroid, it is always less distinct in the simple than in the compound eyes. Finally, the choroid is not always black in the simple eyes, whereas it is uniformly in the compound. Sometimes this membrane, instead of being black and opaque, is of a peculiar whiteness and lustre. To conclude: this membrane and its tunic are placed in the same way with respect to the other parts in both kinds of eyes, and their

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uses are also similar. The large circular trachea, which we observe in the compound eyes when they present a choroid, does not seem to exist in the simple eyes. In fact, the tracheæ or pneumatic pouches which belong to them are used in supporting the optic nerve, and perhaps also in forming a part of the choroid in that sort of eye. At least the tracheæ of insects seem to perform the functions of the blood-vessels which are observed on the choroid of the red-blooded animals.

[To be continued.]

XXXI. *Some Particulars respecting Hail Storms in the West Indies in the Month of April 1814; and Experiments to ascertain the medicinal Powers of the Hura crepitans.*

To Mr. Tilloch.

Nevis, June 22, 1814.

SIR,—THOUGH I have already communicated to Sir Joseph Banks some particulars respecting the late hail storms in this island and Saint Christopher's, a slight notice of their uncommon phenomena may not be deemed altogether undeserving of a place in your Magazine.

The fall of hail intermingled with masses of ice took place in the island of Saint Christopher's at eleven o'clock in the forenoon of Wednesday the 13th of last April, at which time I was absent from that island on a visit to a friend here. The weather had been for some time previous excessively dry, and the heat in general very great; and even upon the morning of the day on which this phenomenon appeared, the atmosphere was at an early hour close, sultry, and oppressive. As the day advanced, black and dense clouds gathered from all sides, and thunder was heard at a distance; a small quantity of rain fell in the southern and western parts of this island (Nevis), but the thickest part of the storm skirting our northern shores proceeded along the Salt Pond Hills towards the valley of Basseterre (St. Kitts), where an abundance of rain fell. A short time before the hail fell, an unusual and, as some described it, even painful sensation of cold was observed, a loud clap of thunder was heard in the south-east, and the rattling of the hail upon the roofs of the houses attracted the attention of the inhabitants little acquainted with the nature of such appearances.

The fall of hail was by no means general throughout the island, confining itself to certain narrow limits little removed from the line of mountains which, after the manner of the Apennines, traverses the centre of the island from east to west. No hail fell at Basseterre; but at the estate called O'Gee, be-
longing