tion of this substance the name "Urochrome," assigned to it by Thudichum, appears eminently suitable.

The only points hitherto brought out which afford any clue to the chemical relationships of this pigment are the resemblance of the products of its decomposition to the humous substances described by Udránszky,* and the fact that it yields, when heated with nitric acid, a colour reaction which is indistinguishable from the xanthoproteic reaction, suggesting a relationship to the members of the aromatic series.

Udránszky classes Thudichum's uromelanine and the other products of the decomposition of urochrome as humous substances, and suggests as a possibility that the conversion of carbohydrates into such substances begins even within the body, and so may contribute to the yellow coloration of urine.

Certainly uromelanine has, as might be expected, certain obvious resemblances to the products which Udránszky obtained by the action of acids upon urine, and Thudichum long ago described how it might be prepared directly from urine by similar means. On the other hand, even if it be granted that the yellow pigment does yield humous substances on decomposition, any argument based upon this may well be regarded as open to the objection of explaining *ignotum per ignotius*.

IV. "Some Points in the Histology of the Nervous System of the Embryonic Lobster." By Edgar J. Allen, B.Sc. (London). Communicated by Professor W. F. R. Weldon, F.R.S. Received February 10, 1894.

The following observations have been made on late embryos of the common lobster (*Homarus vulgaris*) by means of Ehrlich's methylene blue method, as modified by Biedermann† and Apáthy.‡ The results to be recorded in the present communication apply chiefly to the thoracic ganglia, which in the embryo are fused into one mass.

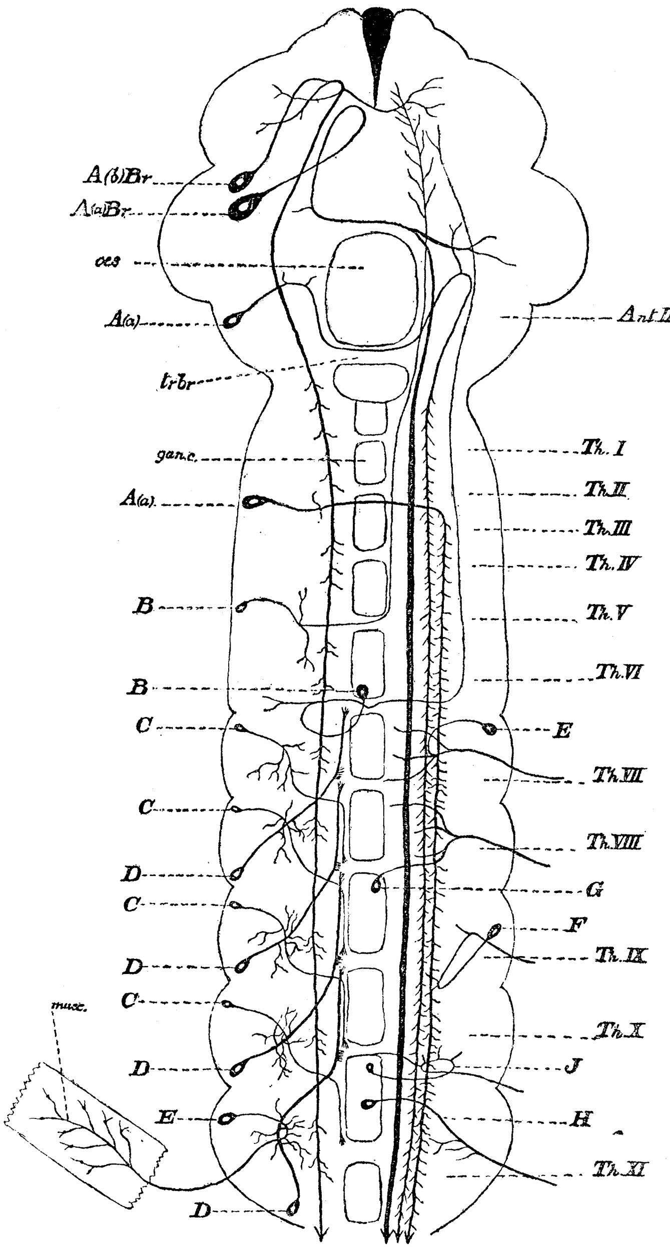
The nerve elements, which have stained, may be divided into three main groups:—

I. Elements of which both the cell and the fibre lie entirely in the ganglionic chain, and which must be supposed to serve the purpose of co-ordinating the action of its various parts.

* 'Zeitschrift. f. Physiol. Chemie,' vol. 11, 1887, p. 537, and vol. 12, 1888, p. 33.

† Biedermann, "Ueber den Ursprung und die Endigungsweise der Nerven in den Ganglien wirbelloser Thiere," 'Jena. Zeitschr.,' vol. 25, 1891.

‡ Apáthy, "Erfahrung in der Behandlung des Nervensystems für histologische Zwecke," I, Methylenblau. 'Zeitschr. Wiss. Mikr.,' vol. 9, 189



œs., œsophagus; *tr. br.*, transverse bridge behind œsophagus; *gan. c.*, central mass of ganglion cells; *musc.*, nerve ending on muscle; *Ant. II*, ganglion of Antenna II; *Th. I—XI*, thoracic ganglia; I—VI form anterior thoracic ganglion of adul ; *A—J*, individual nerve elements. For description of each, see text.

II. Elements which consist of a ganglion cell in the cord and a fibre which runs out at a lateral nerve root. Some, at least, of these elements, possibly all, are connected with muscles, and are motor elements.

III. Elements which consist of a cell lying *outside* the central ganglionic chain, and a fibre running from it to a ganglion. These must be regarded as sensory elements.

I. Elements of the first group, co-ordinating elements, are of four kinds.

A. Elements made up of a cell in the brain or one of the ganglia, and a fibre which runs posteriorly to the end of the cord, giving off collateral branches to the neuropile in each ganglion through which it passes. For reasons to be explained, these elements must be regarded as placed temporarily in the groups of co-ordinating elements. It may be necessary to place them in a new group by themselves.

Two kinds of A elements may be distinguished :—

(*a.*) Those which decussate with the corresponding element of the opposite side.

(*b.*) Those which pass down on the same side of the cord as that on which the cell lies.

The elements A (*a*) inserted in the ganglion of Antenna II and Thorax II (fig. 1) may be taken as typical of the fibres which decussate. The cell lies in the lateral mass of ganglion cells, and the fibre gives off lateral branches to the neuropile before crossing to the other side. After the decussation has taken place the fibre turns backwards, and runs down the ganglionic chain, giving off collateral branches to the neuropile of each ganglion through which it passes. The fibre A (*a*) Thorax II, together with a corresponding fibre in Thorax I, have been traced as far as the last abdominal ganglion, but no definite ending has been made out. A (*a*), Antenna II, was only actually traced to Abdomen 5, but it showed no sign of ending in that ganglion, and probably continues to Abdomen 6. It will be observed that the decussation of A (*a*), Antenna II, takes place through the transverse bridge, *behind* the œsophagus. Similar elements have stained in Thorax III and Thorax V.*

The element A(*a*)Br (fig. 1) may be best considered here. It consists of a large cell on the ventral surface of the brain, from which a moderately thick fibre runs at first forwards and upwards to the dorsal surface. After turning outwards, the fibre runs backwards to a point immediately in front of the œsophagus, where it passes across

* In the present communication the thoracic ganglia are numbered consecutively I—XI. Of these I—VI form the anterior thoracic ganglion of the adult, whilst VII—XI form the five posterior ganglia.

to the other side, and then runs down the cord. On entering the thoracic ganglia, the fibre becomes very broad, and maintains a diameter many times that of any other fibre in the ganglionic cord. A single pair of elements of this kind exists, and it is easy to trace the fibres from the brain through the whole length of the ganglionic cord to the 6th abdominal ganglion. In the latter ganglion the fibre divides into several branches, but I have never obtained complete staining of these. The giant-fibres of the adult, with which these agree, are stated by Retzius* to divide in the last abdominal ganglion, and send branches through several of the nerve roots, which leave that ganglion.

In the brain this fibre gives off a few branches to the neuropile (fig. 1), but on its course down the cord, no collateral branches have ever stained, and I believe that none exist. The giant fibres differ in this respect from the other fibres of the class (A) which is now being considered.

Of the elements whose fibres do not decussate, A(*b*)Br. (fig. 1), may be taken as a type. The element starts with a cell of moderate size on the ventral surface of the brain, immediately anterior to the large cell of the giant fibre (A(*a*)Br). The fibre passes first forwards and upwards, giving off numerous branches to the anterior lobes of the brain on both sides, and then backwards through the brain, and down the ganglionic cord of the same side to the last abdominal ganglion. It gives off collateral branches to the neuropile of the ganglia through which it passes.

Similar elements have stained in Thorax III and Thorax IV.

B. Each element consists of a fibre starting from a cell in one of the thoracic ganglia, and running forwards to the brain. B Thorax V and B Thorax VI (fig. 1) are types of elements of this kind.

The cell of B Thorax V, lies in the lateral mass of ganglion cells. Soon after entering the neuropile the fibre gives off two branches, one running forwards and breaking up in the hinder portion of the ganglion immediately anterior, whilst the other runs backwards and breaks up in that immediately posterior. The main fibre turns inwards, crosses its fellow of the opposite side, and then bends forwards, running close to the median ganglionic cells, until it enters the brain. In the brain the fibre continues to run forwards, giving off many branches, and ends at about the level of the nauplius eye. The fibre has not been observed to give off collateral branches during its course through the thorax. Precisely similar elements occur in Thorax VIII, and somewhat similar ones in Thorax II.

In B., Thorax VI (fig. 1), the cell lies in the median mass of ganglion cells, and the fibre, on its course towards the brain, runs

* Retzius, "Zur Kentniss des Nervensystems der Crustaceen," 'Biol. Untersuch.' Neue Folge I, 1890.

along the outer border of the neuropile. It ends in the brain, at a point nearly as far forwards as the termination of B Thorax V, but somewhat lateral to it. In this fibre also no collaterals have been observed in ganglia other than that in which the element originates. A similar element occurs in Thorax I.

C. Elements of this kind are inserted in ganglia Thorax VII—X in fig. 1. Each consists of a small cell in the anterior portion of the lateral mass of ganglion cells. The fibre, after taking a Z-shaped course through the neuropile, to which it gives off numerous arborescent branches, turns backwards, and after running between a fibre of Series D and the central mass of ganglion cells, ends in a tuft of fine branches at the posterior end of the ganglion next behind that in which the cell is situated.

D. These elements appear to be intimately associated with those of Group C, and both groups generally stain in the same preparations.

The cells of elements D lie in the posterior portion of the lateral ganglionic mass. The fibre of each element passes forwards and inwards through the neuropile, giving off numerous arborescent branches to the latter. On entering the next ganglion in front, the fibre has reached the outer border of the median ganglionic mass, and after giving off a little tuft of branches in front of the tuft in which one of the C elements ends, it pursues a direct anterior course, ending in a tuft of branches in the ganglion next but one to that in which it started. This terminal tuft lies opposite the terminal tuft of one of the C elements, and behind the lateral tuft of the D element of the next ganglion. The three tufts lie at exactly the same level in the cord, being all in the focus of the microscope at the same time.

II. Elements consisting of a cell in the ganglionic cord, giving off a fibre, which, after sending arborescent branches to the neuropile, passes out from the cord by one of the nerve roots. Many of these elements, not improbably all, are motor, and in some cases the fibre has been traced through its whole course from the cell, until it breaks up on the muscle. (Fig 1, E. Thorax XI.)

Typical elements of this class are inserted in fig. 1 (Thorax VII—XI, E—J). Each of these ganglia contains one or more elements of the various kinds. E and F have the cell situated in the lateral mass of ganglion cells, and the fibre passes out through the anterior root of the ganglion and goes to one of the limbs. In G and H the cell lies in the central mass, but the fibre passes through the same anterior root as E and F to a limb. The element J, on the other hand, passes through the posterior root and goes to the muscles of the body wall. It arises in a very small cell in the median mass, and the fibre runs for some distance outwards. It then turns and takes a circular course through the neuropile, forming a complete loop, after which it passes outwards and enters the posterior nerve root. From the anterior part of the

inner side of the loop a straight arm passes inwards and meets a similar arm from the opposite side. A direct fusion of the two arms has, however, never been observed.

III. Sensory elements, in which the cell lies outside the ganglionic cord.

These have been demonstrated by me up to the present only in the abdomen of lobster embryos. The cells are similar to those described by Lenhossék* and Retzius† in the earthworm, and by Retzius‡, in polychaetes and molluscs. They are spindle-shaped and lie in the ectoderm (or immediately beneath it) of the dorsal surface of the abdomen. The distal end of the spindle either runs out as a fine fibre which ends freely, or the end of the fibre broadens out, forming a T-shaped figure on the end of the spindle. The fibre arising from the proximal end of the cell passes forwards and downwards to the nerve cord, where, after entering one of the ganglia, it bifurcates, giving rise to a Y-shaped figure. One of the branches runs forwards, the other backwards along the ganglionic cord. They have been seen to pass through two ganglia, but as to where they end I am not at present in a position to make a definite statement.

Theoretical.

I shall now endeavour to draw attention to some points of interest connected with the observations described above. With regard to the elements C and D, it might be maintained that they represent a purely embryonic arrangement, which has not yet reached the active state. This, however, appears to me improbable from the fact that the two systems remain in practically the same state from very early embryos, in which the eye-pigment has just begun to deposit, to the oldest larvæ (about one week) which I have been able to examine; and also from the fact that they take up methylene blue in a way which, according to present experience, only active nerve tissue does. Assuming then that the system is in the active state, it is important to notice the position of the three tufts of fibres, which stand opposite to each other, where elements C and D end. Although my observations agree entirely with those of Retzius, Kölliker, and the majority of recent investigators, in the fact that direct anastomosis of the portion of the element which stains with methylene blue has never been observed, it seems impossible to understand the meaning of this arrangement on any other supposi-

* Lenhossék, "Ursprung, Verlauf, und Endigung der sensibeln Nervenfasern bei Lumbricus," 'Arch. Mikr. Anat.,' vol. 39, 1892.

† Retzius, "Das Nervensystem der Lumbricinen," 'Biol. Untersuch.' Neue Folge III, 1892.

‡ Ditto, Neue Folge IV, 1892.

tion than that here the nervous stimulus passes from one element to the other. It appears to me to be at least worth while to throw out the suggestion that the nervous energy resembles a static electrical charge, in the fact that the discharge takes place most readily through points. Wherever nerve endings have been demonstrated, the breaking up into finer and finer branches, which end freely, has been shown to take place.

On the view suggested, each nerve element resembles an electrical condenser capable of charging itself, and being suddenly discharged by an appropriate stimulus. It is interesting to note what would happen upon some such theory as this, supposing one of the elements D to be stimulated in any way. Imagine, for instance, the element D Thorax IX to be caused to discharge, either by an impulse from a sensory nerve, or from the brain. The main discharge would, we must suppose, pass into one of the motor elements such as E, by means of the fine branches which both send to the neuropile, and the muscle innervated by that particular fibre would be stimulated. A portion of the charge would, however, pass to the lateral and terminal tufts of D Thorax IX, and we may suppose that in this way D Thorax VIII and D Thorax X are made to discharge, as well as C Thorax VI. If we suppose the C elements to influence some other motor element in the neuropile, say F, then it will be seen by following out the result in the figure, that all the E and F elements upon one side of the thorax would be stimulated by the single stimulus to D Thorax IX.

With regard to elements of the class A, which start from a cell in one of the anterior ganglia and send a fibre down the cord, the fact that they give off collateral branches to the neuropile of each ganglion would seem to indicate that they in some way control an element, which also sends branches into that particular ganglion, and the suggestion would be that by their means a series of elements are stimulated all along the body by an impulse from the brain. On the other hand, by means of elements B, a particular ganglion would be placed in direct communication with the brain. This communication would be independent or correlated with a stimulus to (or from) all the ganglia through which the fibre passes, according to whether the absence of collaterals is the true condition of the element, or is due merely to imperfect staining.

A similar consideration will apply to the giant fibres (A(a)Br). It has been already stated that no collaterals have ever been observed on these fibres. According to Retzius branches go directly from their ends to the nerves of the last abdominal ganglion, and it, therefore, seems probable that they serve the purpose of putting some organ into direct communication with the brain. The most obvious suggestion would be that it is by their means that the muscles of the tail-fin, the steering apparatus of the animal, are controlled by the brain. There

is, of course, the possibility that the other fibres, which have been followed all along the cord to the last abdominal ganglion, also send branches through the nerve roots of this ganglion and serve a similar purpose. The presence of collateral branches upon them seems to me to be opposed to this view. The problems, however, suggested by the foregoing remarks can only be finally solved by means of physiological research.

My observations were made in the laboratory of the Marine Biological Association at Plymouth, with the assistance of a grant made by the Government Grant Committee. I hope shortly to publish a more detailed account with fuller illustrations.

V. "The Refractive Character of the Eyes of Horses." By Veterinary-Captain F. SMITH, F.R.C.V.S., F.I.C., Army Veterinary Department. Communicated by Professor McKENDRICK, F.R.S. Received March 7, 1894.

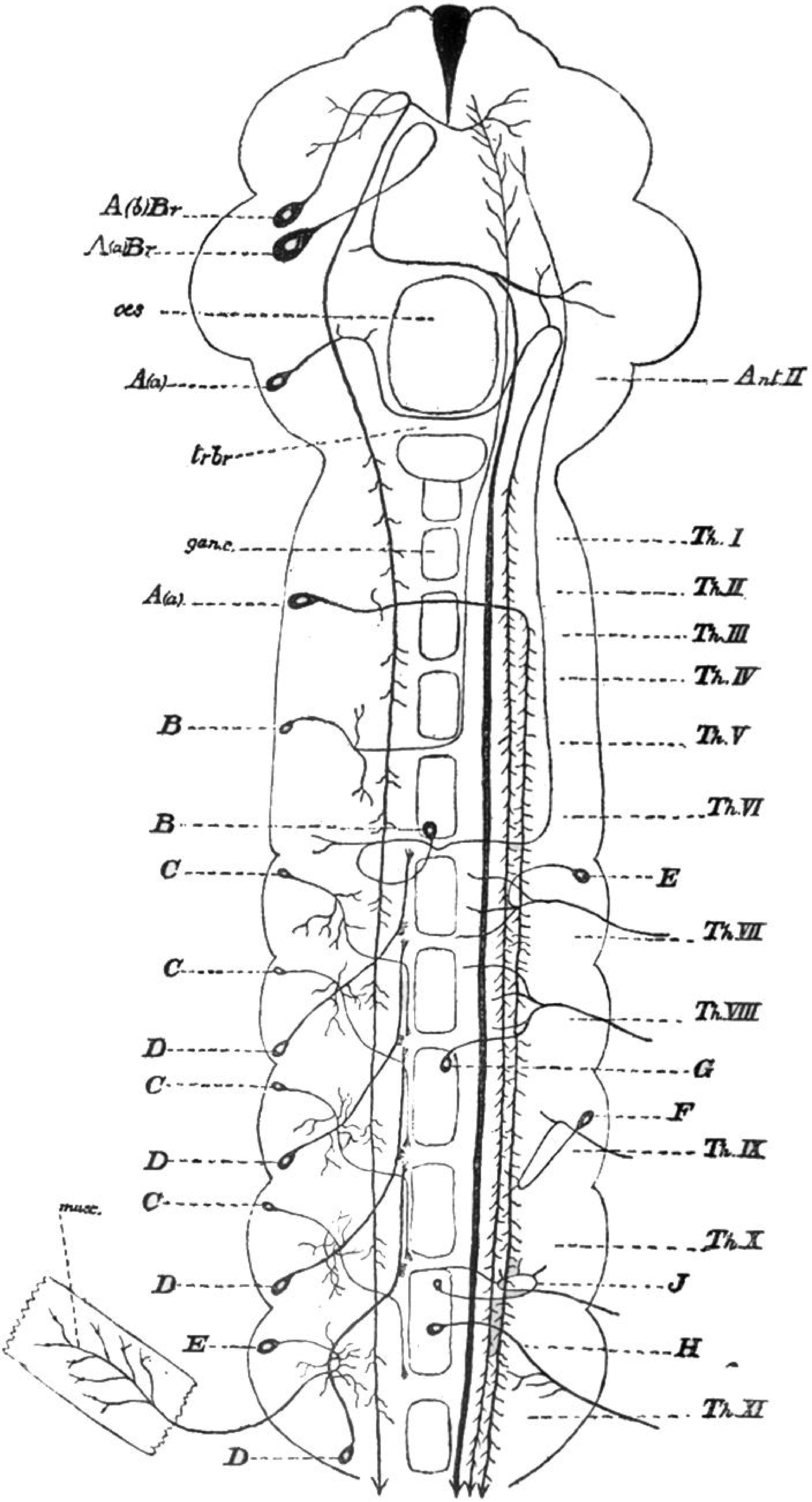
The eyes of the horse are of great physiological interest, for there are certain features in connection with them not found in other animals.

While equine vision is principally monocular, it is quite undoubted that the horse can see objects situated to the right and left of his body at one and the same time; it is also equally certain that by directing both eyes forward, and producing a powerful internal squint, vision may be rendered binocular for objects situated directly to the front.

The corresponding points in the retina of the human eye, do not hold good in the case of animals which have their eyes situated laterally in the head and at some distance apart.

The pupil of the horse is a horizontal slit, which in full sunlight becomes so contracted that, with the presence of the corpora nigra, it is difficult to understand how sufficient light finds its way to the retina. A monocular retinal image in full sunlight must be a broken or imperfect one, for, filling up the centre of the horizontal pupil, are some large, black, soot-like bodies, the corpora nigra just referred to. These are attached principally to the superior pupillary margin of the iris, and completely block out the centre of the pupil when the latter is closely contracted. The horse is, I believe, the only animal possessing corpora nigra, and the function of these bodies is quite obscure.

It is essential that the horizontal pupil should always be kept horizontally placed, no matter what position the head may occupy; every upward and downward movement of the head necessitates a rotation of the eyeballs to ensure the pupils remaining horizontal,



œs., œsophagus; *tr. br.*, transverse bridge behind œsophagus; *gan. c.*, central mass of ganglion cells; *musc.*, nerve ending on muscle; *Ant. II*, ganglion of Antenna II; *Th. I—XI*, thoracic ganglia; I—VI form anterior thoracic ganglion of adul ; *A—J*, individual nerve elements. For description of each, see text.