variety of graphite is characterised by giving a very large yield of marsh-gas.

CO_2	45·42
CO	39·88
CH_4	4·43
H	8·31
N	2·00

Occluded gases in volumes of the graphite=53·13.

XIV. "Preliminary Communication on the Structure and Presence in Sphenodon and other Lizards of the Median Eye, described by von Graaf in *Anguis fragilis*." By W. Baldwin Spencer, B.A., Demonstrator of Comparative Anatomy in University of Oxford, Fellow of Lincoln College. Communicated by Prof. H. N. Moseley, F.R.S. Received June 10, 1886.

In 1872 Leydig* described a structure in *Lacerta agilis*, *L. muralis*, *L. vivipara*, and *Anguis fragilis*, to which he gave the name of "frontal organ."

In the embryo, owing to its being deeply pigmented, it forms a prominent feature on the roof of the original forebrain in connexion with the pineal gland; in the adult it lies immediately beneath the skin, and, according to him and subsequent observers, completely separated from the brain.

In *Anguis fragilis* the organ is seen microscopically to consist of long cells like those of a cylindrical epithelium, which are so arranged that together they form a shallow pit with a circular outline. The edge of the pit is directed downwards, and has a thick black girdle of pigment. It corresponds in position to that occupied by the parietal foramen in the adult.

Leydig regarded our knowledge of the organ as insufficient to allow of any statement being made with regard to its function.

Rabl-Rückhard,† in 1882, describing the development of the pineal gland in the trout, pointed out the resemblance between its development as a hollow outgrowth of the brain and that of the optic vesicles.

Granted such secondary developments from the epiblast and mesoblast as combine to produce the eye, and which are absent in the case of the pineal gland, though the distal extremity of the latter lies in a

* "Die in Deutschland lebenden Arten der Saurier," p. 72, taf. 12.

† "Zur Deutung und Entwickelung des Gehirns der Knochenfische." Arch. für Anat. u. Phys., Jahrg. 1882, p. 111.

favourable position immediately beneath the epiblast, and, he states, there is no difficulty in the way of the idea that an unpaired sense organ similar to the eye would be developed out of the pineal gland.

Ahlborn* also, in 1882, independently arrived at the conclusion that the epiphysis is to be regarded as the remains of an unpaired median eye, founding this conclusion upon general considerations, such as the agreement in origin of the eye vesicles and the epiphysis as hollow outgrowths of the brain, the connexion of the epiphysis with the eye region of the brain (especially the optic thalami), and the peripherally directed position of the structure in Selachian Ganoids and Petromyzon, and the completely peripheral position in Amphibia on the outside of the skull. He even goes so far as to suggest a comparison of this structure with the unpaired eye of Amphioxus and Tunicates.

More lately Henri de Graaf† has published an outline of his results in studying the development of the epiphysis in Amphibia, and its structure in the adult *Lacerta agilis* and *Anguis fragilis*.

He agrees with Strahl and Hoffmann in stating that the "frontal organ" of Leydig is the distal part of the epiphysis completely separated off from the proximal.

He describes in detail the structure of the organ in Anguis, where it develops, he says, into a structure very similar to a highly organised invertebrate eye, as that of Cephalopods, Pteropods, and Heteropods.

The following is a preliminary notice of results obtained recently by studying the structure of the organ in various forms of lizards, at the suggestion of Prof. Moseley, and by means of materials procured for the purpose with great kindness by him from various sources.‡

The forms investigated at present are the following, though only the more important results obtained from a few are given in th abstract :—

Hatteria punctata.
Lacerta ocellata.
Lacerta vivipara.
Iguana (2 sp.).
Calotes ophiomaca.
Calotes versicola.
Leiodera nitida.
Plica umbra.
Anolius (sp ?).
Grammatopleora barbata.
Chameleo vulgaris.
Stellio cordylina.
Varanus bengalensis.
Varanus giganteus.
Cyclodus gigas (?).
Seps chalcidica.

* "Ueber die Bedeutung der Zirbeldrüse." "Zeit. für Wiss. Zool.," vol. 40 (1884), p. 336.

† "Zur Anat. u. Entwick. der Epiphyse bei Amphibien u. Reptilien." Zool. Anzeig., Jahrg. 9 (1886), p. 191.

‡ I am especially indebted to Professor Günter, through whose kindness I have

(1.) *External Appearance.*

The organ is situated upon the dorsal surface in the median line, and at varying distances posterior to the level of the paired eyes; the presence or absence of an external indication of the organ can be by no means relied upon as indicating the existence or non-existence of the structure in a highly developed state. In many cases, as *Varanus Bengalensis*, the various species of *Calotes* and *Lacerta ocellata*, the organ is marked externally by the presence of a specially modified scale, usually considerably larger than the surrounding ones, and with a circular patch of pigment behind the whole resembling a cornea. Being transparent, and forming the anterior boundary of a capsule containing the organ, the appearance of a dark pupil surrounded by a light circle is produced. On the other hand, as in *Plica umbra* or Cyclodus (sp.), a more or less highly specialised scale may be present, but the organ beneath be not highly developed; or again, as in Hatteria, there may be no special scale, but only a general transparency in the median line immediately above the organ, which may nevertheless be in a highly developed state.

(2.) *Position of the Organ.*

The organ may lie at different levels imbedded more or less deeply in connective tissue beneath the skin, or even within the skull cavity, but is always placed external to the dura mater. It always has a definite relationship to the parietal foramen usually lying within this. In Calotes it is placed immediately beneath the specially modified scale; in most forms, such as Varanus, Seps, Anolius, Leiodera, &c., it lies within the foramen, and separated by specially modified connective tissue from the skin. In Hatteria it lies on the inner side of the airamen, which is filled up by a plug of connective tissue, and in *Lacerta ocellata* the bone around the foramen is modelled to fit closely to the outline of the organ and the connective tissue surrounding this.

(3.) *Structure of the Organ.*

It may be said at once that Leydig's "frontal organ" resembles in essential structure an *invertebrate eye*.

This resemblance has lately been clearly pointed out by Graaf, in the case of *Anguis fragilis*, and is found to hold good for many others. He in common with all previous observers regards the organ as the

been allowed to examine duplicate specimens of ten species from the British Museum; they are not all described in this communication, but will be dealt with more fully subsequently. By Professor C. Stewart's kindness also I have been able to examine duplicate specimens of Iguana and Varanus from the museum of the Royal College of Surgeons.

distal portion of the epiphysis, which becomes completely separated off from the proximal portion of the same, and lies completely surrounded by connective tissue in the parietal foramen. If in contact with a nerve, as frequently happens according to Graaf in Amphibia, then the nerve in question is a subcutaneous branch of the ramus supramaxillaris of the trigeminal.

It is difficult to imagine why a single medianly placed organ should be supplied in any way by a branch from one only of two paired lateral nerves.

The two most important facts established by the present series of observations are—

(1.) That Leydig's "frontal organ" exists as a structure comparable to an invertebrate eye, widely distributed amongst Lacertilians. It may, in reference to its position and structure, be perhaps best called the *pineal eye*.

(2.) That the eye is connected by a medianly placed nerve with the proximal portion of the epiphysis, and thus with the dorsal surface of the brain in the median line.

There can be further little doubt that this nerve is the remains of the part connecting the distal with the proximal part of the epiphysis, that it is in other words formed as the optic nerve from a hollow outgrowth of the brain, which subsequently becomes solid.

The structure of the eye in two or three typical cases is as follows:—

(*a*.) *Hatteria*.—In this form the organ is well developed, and being through Prof. Moseley's kindness enabled to procure a fresh specimen, it has been possible to determine the elements comprising the optic vesicle.

In all the eyes yet examined a lens is present. Von Graaf figures it in Anguis as separated from the hinder part of the vesicle, but this does not hold good for any of those examined during the course of this work. The lens, on the contrary, appears to be only the modified anterior portion of the optic vesicle with the hinder walls of which it is directly continuous. In Hatteria it is somewhat cone-shaped, with a broad base corresponding to the anterior surface of the vesicle; it is distinctly cellular, the nuclei being well marked, and the cells having a definite arrangement.

The walls of the vesicle posterior to the lens consist of the following elements:—(1.) A layer of rods bordering the vesicle internally, deeply imbedded in dark pigment, arranged as seen when the rods are separated so as to give the latter a clearly marked striated appearance. (2.) External to these is a layer composed of rounded nucleated elements, two, and in fact possibly three, rows deep. (3.) External to this what may be called a molecular layer, consisting of finely punctated material, through which seems to run a supporting structure;

processes from the structures on both sides of the layer seem to run into its substance. (4.) External to the molecular layer an outer part, in which three kinds of elements may be distinguished: (*a*) round nucleated cells, somewhat larger than those of the inner layer; (*b*) rod-like structures, somewhat conically shaped, with their broad ends external; (*c*) small nucleated spindle-shaped elements, placed between the latter at their bases. (5.) Though difficult to trace, a fine layer of nerve fibres appear to spread round the vesicle from the nerve which enters it at the surface nearest the epiphysis. The elements are connected serially, though processes from the rods may be seen passing at times directly into the molecular layer, or the rod elements externally, or even right through to the external surface. Such processes are accompanied by pigment, and may in some cases merely indicate supporting structures.

In Hatteria, as in other forms, a special bundle of rods lying in the optic axis is highly developed, being much lengthened out and running down into the nerve, their outer extremities being in connexion with a particular group of nucleated cells.

Von Graaf describes in Anguis a layer of small rod-like structures, similar apparently to those found in many invertebrate eyes, though he is not certain as to their nature. In Hatteria and other forms examined, the vesicle appears to have been filled during life by a fluid material, and this in coagulating adheres to the wall. The coagulation often apparently sets in from definite points, and these being the ends of rods, gives the appearance, under certain conditions of light, of refracted processes attached to these structures.

The *nerve* enters the vesicle posteriorly, certain fibres appear to enter into connexion with the cells connected with the specialised rods, the remainder spread out around the external surface of the vesicle, and here enter into connexion with the elements, that is, the rods bound the internal surface of the vesicle, and the nerve-fibres the external.

The nerve, whilst differing in appearance from an ordinary one, yet resembles more closely than anything else the developing optic nerve, being formed of long spindle-shaped elements, which recall the stage passed through when the at first round cellular elements of the optic stalk are gradually lengthening out. The nerve in both cases developes in a similar manner.

The whole eye lies in a special capsule of connective tissue into which enters and breaks up a blood-vessel, this vessel being present in connexion with the eye in all Lacertilia examined, even in those in which a nerve could not be distinctly traced.

(*b*.) *Lacerta ocellata*.—In this form the organ lies considerably below the surface, and so shut in by bone that it may be said to lie within the skull. The dura mater which surrounds it is deeply pigmented,

and the presence of the branched pigment cells renders the examination of its structure very difficult.

A well developed cellular lens is present, formed from the anterior part of the vesicle apparently. The retinal elements are imbedded in pigment, and, save the rods, are difficult to detect, though by careful examination two rows of round nucleated cells may be detected. The pigment obscures the nerve, which is nothing like so clearly marked as in Hatteria, due largely to the dura mater encasing the eye so closely that no capsule is formed.

The nerve enters posteriorly, and a slight differentiation of the rods at two points may be noticed, the nerve appearing to divide into two just before entering the eye; it passes down, lying in the dura mater to join the proximal part of the epiphysis, which is itself deeply pigmented.

The blood-vessel accompanying the nerve is well developed.

(*c.*) *Iguana.*—The structure agrees in the main with that of Hatteria, though, owing to the eye being not so well preserved as in the latter, the elements cannot be so clearly differentiated. The lens is cellular, and somewhat similarly shaped to that of Hatteria; the rods are as usual deeply pigmented, and external to them may be detected (1) a row of round nucleated cells; (2) a well-marked molecular layer, in which the nucleated cells are often embedded; and (3) an outermost layer of cone-shaped bodies, similar to those of Hatteria.

The rods in the optic axis are again lengthened out and prominent, running down into the nerve.

The eye lies in a capsule of connective tissue within the foramen, and into the same space passes also a hollow process from the epiphysis, into which the nerve enters.

In another Iguana examined the process appears not to be hollow, and the eye, instead of lying in a capsule, is closely invested by connective tissue.

In both cases the vesicle is filled with a coagulation, indicating the presence of a fluid material in life.

(*d.*) *Anolius* (sp. ?).—The eye lies close beneath the skin, and almost entirely fills up the parietal foramen, the remainder being occupied by vacuolated tissue, in which large nucleated cells are present at intervals, together with branching pigment cells.

The eye is elongated in the direction of the optic axis, and provided with a nerve running back through the vacuolate tissue and entering the proximal part of the epiphysis.

Pigment is largely developed, ensheathing all the elements of the retina; the rods may be traced into rounded elements; these again externally into cone-shaped elements. The rods in the optic axis are again modified and pro ninent, and their ends facing into the vesicle appear striated.

The lens is cellular, and has a slight development of pigment in some of its cells in the optic axis.

Special connective tissue fibres pass, as in some other forms, from the capsule to the edge of the lens.

(*e.*) *Leiodera nitida.*—This may be taken as the type of several forms, such as *Calotes ophiomaca* and *versicola* and *Seps chalcidica*, in which the eye is lengthened out in a direction at right angles to the optic axis. The lens is distinctly cellular, and continuous with the hinder walls of the vesicle. The retinal elements consist of (1) rods; (2) a layer of round nucleated cells; (3) a well marked clear space, corresponding in position to the molecular layer; and (4) an external layer of cone-shaped elements.

In these forms a nerve cannot be detected with certainty, though very possibly with freshly killed specimens its presence might be demonstrated.

In Leiodera the scale above the eye is beautifully modified, and a transparent dome-shaped cornea developed, sections showing that the pigment is absent from the scale in this region, though very abundantly developed elsewhere.

(*f.*) *Varanus Bengalensis and giganteus.*—The eye in these forms will be dealt with fully on a subsequent occasion; at present one point only will be mentioned. In two specimens examined (perhaps of different species of Varanus) the connexion with the proximal part of the epiphysis was of an importantly different nature; in one it was in the form *of a hollow process*, in the other of a *solid stalk*, much as in Hatteria.

There can be no doubt that the connecting parts in the two instances are equivalent to each other.

(*g.*) *Cyclodus gigas* (?).—This may be taken as the type of those forms, in which no structure comparable to an eye is at present found. The distal extremity of the epiphysis is swollen out, the cells of its walls, which are thrown into folds, become shaped like those of cylindrical epithelium, and amongst them pigment is deposited, but no true retina is formed, or any structure comparable to a lens.

The distal swollen part of the epiphysis is enveloped in pigment in the dura mater, some distance in front of the proximal part, with which it is connected by a hollow process. The whole structure lies on the inner side of the cranium, closely fitted to the bone, as in *Lacerta ocellata.*

The scale on the surface of the head is imperfectly modified to form a cornea, and has the appearance of degenerating.

XV. "Star Photography; the Effects of Long and Short Exposures on Star Magnitudes." By ISAAC ROBERTS, F.R.A.S. Communicated by the Rev. S. J. PERRY, F.R.S. Received May 21, 1886.

[Publication deferred.]

XVI. "An Instrument for the speedy Volumetric Determination of Carbonic Acid." By W. MARCET, M.D., F.R.S. Received June 9, 1886.

[Publication deferred.]

XVII. "On the Practical Measurements of Temperature; Experiments made at the Cavendish Laboratory, Cambridge." By H. L. CALLENDAR, B.A., Scholar of Trinity College, Cambridge. Communicated by J. J. THOMSON, F.R.S., Professor of Experimental Physics at the Cavendish Laboratory. Received June 9, 1886.

[Publication deferred.]

XVIII. "The Determination of Organic Matter in Air." By Professor T. CARNELLEY and WILLIAM MACKIE. Communicated by Sir H. E. ROSCOE, F.R.S. Received June 10, 1886.

[Publication deferred.]

XIX. "The Carbonic Acid, Organic Matter, and Micro-organisms in Air, more especially of Dwellings and Schools." By Professor T. CARNELLEY, J. S. HALDANE, and Dr. A. M. ANDERSON. Communicated by Sir H. E. ROSCOE, F.R.S. Received June 10, 1886.

[Publication deferred.]

XX. "Preliminary Report on the Pathology of Cholera Asiatica (as observed in Spain, 1885)." By C. S. ROY, F.R.S., J. GRAHAM BROWN, M.D., &c., and C. S. SHERRINGTON, M.B. Received June 10, 1886.

[Publication deferred.]

The Society adjourned over the Long Vacation to Thursday, November 18th.