CHAPTER IV

THE NERVOUS SYSTEM

Spinal Cord

THE spinal cord extends the whole length of the vertebral canal and ends near the end of the tail as a thin, round thread. It varies in thickness and shape in cross section, being nearly always elliptical, but at places approaching a circle. Large, spindle-formed thickenings of about equal diameter are present in the cervical and lumbar regions.

A cauda equina is absent in the alligator, the nerves of the large tail leaving the cord like the intercostals.

On its ventral surface the cord has a deep perpendicular fissure, the fissura ventralis, that extends almost to the center; it extends even along the reduced region in the tail. A vascular membrane extends into this fissure.

A shallow but distinct furrow extends along the dorsal side of the cord, parallel to which, on either side, is a fine, linear furrow.

The first two spinal nerves have no dorsal roots.

Brain

The cervical cord passes insensibly into the medulla, the dorsal furrow becoming wider and more shallow as it merges into the fourth ventricle.

A dorsal view of the brain is shown in Figure 30, A. The most prominent structures here seen are the cerebral hemispheres, VH, whose combined transverse diameter is greater than their longitudinal. The tapering, cephalic end of each hemisphere forms an olfactory tract, I, which extends cephalad to form the olfactory bulb, B. ol. Lying between the caudal ends of the hemispheres is a small conical body, G.p., called by Bronn and others the pineal body. The writer has found (62), however, that this body is the paraphysis rather than the epiphysis. Caudad to the cerebrahemispheres and in contact with them are the optic lobes, MH; they have about the same shape and position as in the frog, but are much smaller in proportion to the size of the hemispheres. Immediately caudad to the optic lobes is the cerebellum, HH, somewhat elliptical in outline as seen from above.

Extending caudad from beneath the cerebellum is the medulla, NH, with its triangular fourth ventricle. The outlines of the medulla are somewhat obscured by the numerous roots of the eighth to eleventh cranial nerves, VIII–XI, which arise along its dorsal border. The medulla, as was

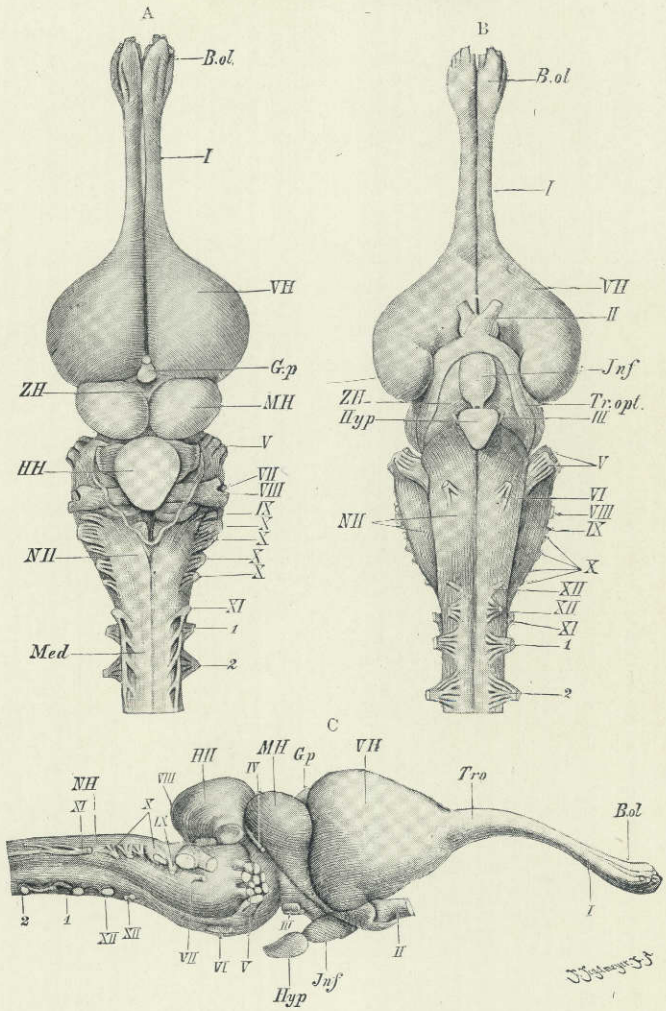

FIG. 30. BRAIN OF ALLIGATOR. (A, dorsal; B, ventral; and C, lateral view.) (From Wiedersheim, slightly altered.)

VH, cerebral hemispheres, each of which gives rise postero-laterally to a hippocampal lobe partially overlying the corresponding optic tract, *Tr.opt*; *ZH*, thalamencephalon; *MH*, optic lobes; *HH*, cerebellum; *NH*, medulla oblongata; *I–XII*, cranial nerves; 1, 2, first and second spinal nerves; *B.ol*, olfactory bulb; *Tro*, olfactory tract; *G.p*, parapHysis; *Jnf*, infundibulum; *Hyp*, hypophysis; *Med*, spinal cord.

said above, passes, as is usually the case, without any line of demarcation into the spinal cord, the obex filling in the apex of the fourth ventricle at the anterior end of the median dorsal fissure.

A lateral view of the brain is shown in Figure 30, C. The hemisphere, VH, is conical in outline, with a small projection from the posteroventral region; its continuation forwards as the olfactory tract, Tro., and bulb, B. ol., is plain. Beneath it and extending forwards are the prominent optic nerve, II, and tract. Caudad to the latter and projecting ventrad and caudad are the infundibulum, Inf., and hypophysis, Hyp.

Caudad to the cerebrum are seen the end of the paraphysis, G.p., the optic lobes, MH, and the cerebellum, HH. From the cerebral peduncles (ventrad to the optic lobes) arises the oculomotor nerve, III, and dorsocaudad to this, between the optic lobe and the cerebellum, arises the trochlear nerve, IV. From the middle zone (in a dorsoventral direction) of the medulla, ventrad to the cerebellum, arises the very large trigeminal nerve, V; while from its usual place, on the ventral surface of the medulla, the abducens nerve, VI, takes its origin by several roots. At some distance caudad from the trigeminal, from the dorsal surface of the medulla, as noted above, the very large acoustic nerve, VIII, arises; and immediately ventrad to this, on the side of the medulla, the facial nerve, VII, may be seen. Commencing just

caudad to the acoustic and extending along the upper border of the medulla and beginning of the spinal cord, are seen a dozen or more small nerve roots, which unite to form the glossopharyngeal, IX, vagus, X, and spinal accessory, XI, nerves. Ventral to the roots of the last, on the ventral surface of the medulla, arise the roots of the hypoglossal nerve, XII. A short distance caudad to this nerve are seen the first two spinal nerves, 1 and 2, which have, as noted above, no dorsal roots.

A ventral view of the brain is shown in Figure 30, B. The cerebral hemispheres, VH, have the same outline, of course, as in the dorsal view, but the rounded projection from the caudal end of each is here seen on each side of the infundibulum, Inf. The infundibulum is in close contact with the chiasma anteriorly, and lies close between the converging optic tracts, Tr. opt. From the chiasma the optic nerves, II, extend, in an anterolateral direction, almost at right angles to each other. The appearance of the olfactory tracts, I, is the same as in the dorsal view. Caudad to the infundibulum, from the cerebral peduncles, ZH, arise the rather small oculomotor nerves, III. Caudad to these, from near the ventral fissure, on the middle region of the medulla, arise the abducens nerves, VI, and from the ventral side of the posterior part of the medulla and of the anterior end of the cord arise the hypoglossal, XII, and the first two spinal nerves, 1 and 2. The ori-

gins of the other cranial nerves were described in connection with the lateral view of the brain, where they show more clearly. On each side of the cerebral peduncles is seen the ventrolateral edge of the corresponding optic lobe. The pyramidal tracts are seen, extending caudad from the region of the peduncles, as a swelling on each side of the median ventral fissure.

The Cranial Nerves (Crocodile)

The origin of each of the cranial nerves was described in connection with the lateral and ventral views of the brain. A full description of the distribution of these nerves would require more space than the limits of this book will allow, but a brief account will now be given.

I and II. The olfactory and optic nerves. These two large nerves go immediately to their respective sense organs, so that no further discussion of them need be here given.

III. The oculomotor nerve. The single stem divides into three branches: a median, going to the externus rectus muscle; a lateral, going to the inferior rectus muscle; and an intermedial, going to the inferior oblique muscle.

IV. The trochlear (pathetic) nerve leads to the superior oblique muscle.

V. The trigeminal nerve. The distribution of this nerve is very complicated. It has three

main divisions: (1) the ophthalmic branch, (2) the superior maxillary branch, and (3) the inferior maxillary branch. (1) The ophthalmic in turn divides into two branches: the smaller, frontal, going to the integument of the upper and lower eyelids; the larger, nasal, going chiefly to the nasal cavity but also sending some small branches to the upper and lower eyelids. (2) The superior maxillary branch separates into a number of divisions: (a) a branch that, in the neighborhood of the auditory capsule, fuses with the facial nerve; (b) a twig to the integument of the forehead and to the upper and lower eyelids; (c) a branch to the Harderian gland and the conjunctiva; (d) a branch to the neighborhood of the cheek, to the angle of the mouth, and to the palatine branch of the facial nerve; (e) a branch to the palate; (f) a branch to the integument of the upper jaw; (g) a branch to the teeth of the upper jaw. (3) The inferior maxillary branch divides into four branches: (a) this division supplies the skin of the cheek region; (b) a branch to the chewing muscles; (c) a branch that divides into two nerves—the first going to the skin of the lower jaw, the second dividing again into two nerves, both of which lead to the integument of the lower jaw; (d) the fourth division of the inferior maxillary, known as the inferior alveolar, itself divides into two twigs—(a′) the first twig divides into two parts, a larger and a smaller, both of which lead,

by different paths, to the inner skin of the mouth; (b′) the second twig divides into four parts—two leading to the mylohyoid muscle and to the integument at the corner of the mouth, one to the integumental glands at the corner of the mouth, and one to the floor of the mouth cavity.

VI. The abducens nerve leads to the retractor oculi muscle and to the muscle for the nictitating membrane.

VII. The facial nerve gives off three main branches: (1) the first divides again into three twigs—(a) connecting with a branch of the trigeminal nerve, (b) and (c) connecting with the trigeminal and also leading to the palate; (2) the second branch divides into two twigs that connect with the glossopharyngeal nerve; (3) the third branch divides into two parts, a muscular twig, and the chorda tympani.

VIII. The auditory or acoustic nerve leads, of course, to the sensory regions of the ear.

IX. The glossopharyngeal nerve divides into four main branches, as follows: (1) to the larynx, (2) to the œsophagus, (3) to the hyomaxillary and sterno-maxillary muscles, and (4) to the tongue. There are also certain communicating twigs with the facial and vagus nerves.

X. The vagus or pneumogastric nerve gives off four branches: (1) and (2) communicate with each other and supply the pharynx, larynx, œsoph-

agus, and trachea; (3) goes to the œsophagus; (4) goes to the heart, lungs, and stomach.

XI. The spinal accessory nerve. There seems to be some doubt as to the exact identity and distribution of this nerve, but Bronn says that, according to Fischer, it gives twigs to the lower head-muscles and then divides into fine branches in the atlanti-mastoideus muscle.

XII. The hypoglossal nerve, going to the region of the tongue, divides into three branches: (1) the median and smallest goes to the sterno-maxillary muscle; (2) the inner and larger goes to the same muscle and also to the coraco-hyoid and sterno-hyoid muscles; (3) the outer and largest divides into three twigs of which the first two lead to the hyomaxillary and sterno-maxillary muscles respectively, while the third divides into two twigs that lead to the hyoglossal and genioglossal muscles respectively.

The Spinal Nerves

As was noted above, the dorsal roots of the first two spinal nerves are lacking.

I, II, and III. The ventral branches of these three nerves supply the smaller, ventral neck muscles.

IV. The ventral branch of this nerve innervates with its chief divisions the ventral muscles, the sphincter colli, and the integument of the neck,

and sends a small branch to the levator scapulæ superficialis muscle.

V. The ventral branch of this nerve sends branches to the ventral muscles of the neck, to the levator scapulæ superficialis; a large branch goes to the sterno-mastoid; and the rest of the nerve distributes itself in the sphincter colli and the integument and ventral muscles of the neck.

VI. The sixth nerve distributes itself to the ventral musculature and to the integument of the neck, and sends a fairly strong branch to the levator scapulæ superficialis muscle and to the most anterior part of the collo-thoraci-supra-scapularis profundus muscle.

VII. The seventh nerve is the first to enter, by a small branch, into the brachial plexus (Figure 31). It also sends a branch to the ventral muscles and the integument of the neck, and three branches to various shoulder muscles.

VIII. The ventral branch of the eighth nerve (Figure 31) is the second largest nerve of the brachial plexus. It gives some twigs to the ventral muscles and then gives one or two nerves to the collo-thoraci-suprascapularis profundus and the serratus superficialis muscles. The rest of the nerve divides into an inferior and a superior branch which unite with the ninth nerve.

IX. The ninth and tenth nerves are the largest of the brachial plexus. The former, after giving off some twigs to the ventral musculature and to

the serratus superficialis and the hinder regions of the collo-thoraci-suprascapularis profundus muscles, unites with the tenth nerve just after giving off the small thoracicus inferior nerve to the costo-coracoideus muscle. After uniting with the tenth nerve the ninth nerve immediately divides into two branches that form loops with branches of the eighth nerve, the whole making a very complicated plexus.

X. The tenth nerve, as noted above, is one of the two largest nerves of the brachial plexus. After giving off a single nerve to the ventral musculature, this nerve unites with the eleventh nerve; it then gives a branch to the costo-coracoideus muscle and forms a loop with the ninth nerve. After giving off a couple of nerves it again divides into two equal branches which unite with similar branches of the eighth nerve.

XI. The eleventh nerve is next to the smallest of the plexus. Besides branches to the trunk musculature it gives a fine twig to the integument of the axilla and unites with the tenth nerve in the brachial plexus. This is the last nerve that enters into the brachial plexus.

The distribution of the nerves of the brachial plexus is as follows (Fig. 31): (a) supracoracoideus to the muscle of that name and to the integument of the breast; (b) thoraci inferiores nerves (10a)—a complex of nerves from the eighth, ninth, and tenth spinal stems—lead to the costo-coracoideus

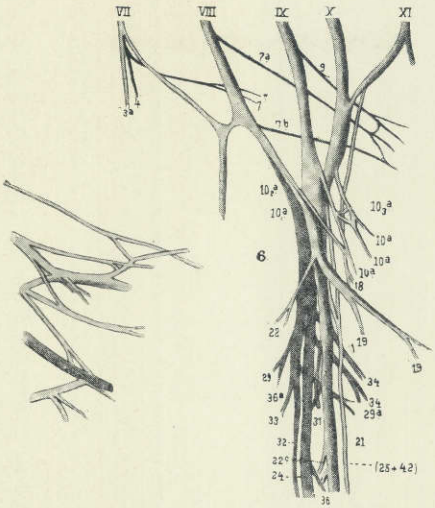

FIG. 31. BRACHIAL PLEXUS OF C. ACUTUS. (From Bronn, after Fürbringer.)

VII–XI. ventral branches of seventh to eleventh spinal nerves.

3*a*. thoracicus anterior VII.

4. thoracicus superior V.

7. thoracicus superior VI.

7*a*. proximally-leading thoracicus superior.

7*b*. distally-leading thoracicus superior VIII.

9. thoracicus superior IX.

10*a*, 10*a*$_1$, 10*a*$_2$, 10*a*$_3$. thoracicus inferior.

18. cutaneus pectoralis.

19. pectoralis.

21. brachialis longus inferior.

22. coraco-brachialis.

22*c*. branch for the distal belly of biceps muscle.

24. muscular branch for the humero-antebrachialis inferior.

(25+42). cutaneus brachii and antebrachii medialis.

29. subscapularis.

31. dorsalis scapulæ (posterior).

32. cutaneus brachii superior lateralis.

33. deltoides inferior.

34. brachialis longus superior.

36. anconæus.

36*a*. scapulo-humeralis profundus.

muscles and to the anterior part of the transversus abdominis muscle; (c) the pectoralis (19), a large nerve leading to the muscle of that name; (d) cutaneus pectoralis (18), fine branches from the XIth spinal nerve to the integument of the axilla and the neighboring parts of the breast; (e) coraco-brachialis (22) to the like named muscle; (f) cutaneus brachii et antebrachii medialis (25 + 42) to the medial side of the integument of the upper and fore arm; (g) brachialis longus inferior (21), a large nerve that supplies the biceps and humero-antebrachialis inferior muscles, and then divides into the medianus and ulnaris inferior nerves; (h) subscapularis (29) to the like named muscle; (i) scapulo-humeralis profundus (36a) to the like named muscle; (j) axillaris, a large stem that divides into two main twigs that lead to the skin of the lateral side of the upper arm, to the proximal part of the forearm, to the humero-radialis muscle, and to the deltoides coraco-sternalis muscle; (k) dorsalis scapulæ (posterior) (31) to the deltoideus scapularis muscle; (l) teres major (29b), one (alligator) or two (crocodile) middle-sized nerves to the teres major muscle; (m) latissimi dorsi (29b) to the like named muscle; (n) brachialis longus superior (radialis) (not shown in Figure 31) to the extensor side of forearm and the hand.

Of the spinal nerves between the brachial and crural plexuses Bronn gives no description for the Crocodilia. The most posterior nerve of the

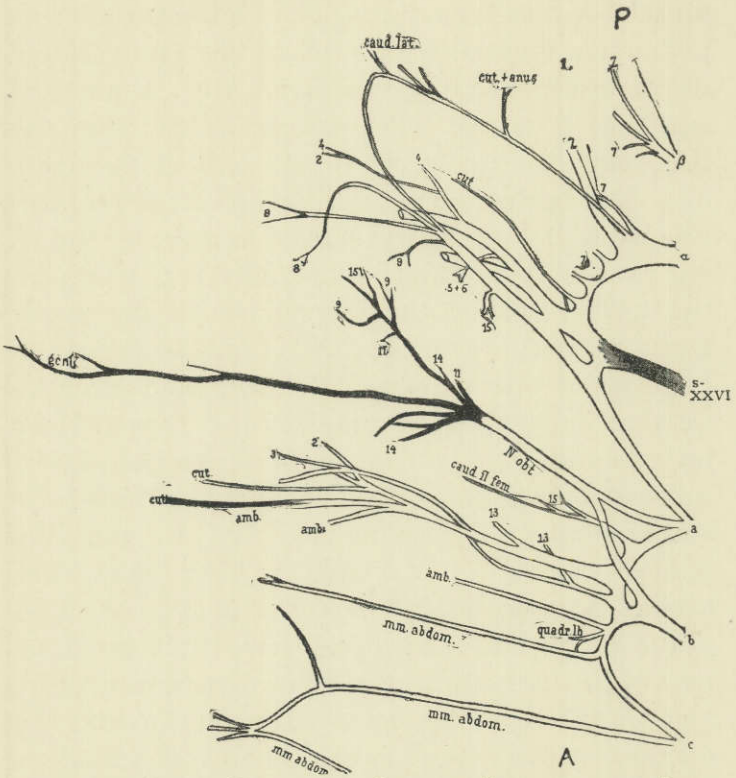

FIG. 32. CRURAL PLEXUS AND ISCHIADIC PLEXUS OF THE LEFT SIDE OF A. MISSISSIPPIENSIS. THE NERVE BRANCHES ARE SHOWN AS FAR AS THEIR ENTRANCE INTO THE MUSCLES. THE CRURAL PLEXUS IS MADE UP OF THE PRESACRAL STEMS *a*, *b*, *c*. THE OBTURATOR NERVE IS BUILT OF TWO BRANCHES FROM STEMS A & B. (FROM BRONN, AFTER GADOW.)

a, *b*, *c*. presacral nerves.
α & *β*. postsacral nerves.
s = *XXVI*. sacral nerve (26th spinal nerve).
2. to extensor ileo-tibialis muscle.
3. to femoro-tibialis muscle.
4. to ileo-fibularis muscle.
5. to ileo-femoralis muscle.
6. to caudi-ileo-femoralis muscle.
7. caudi-femoralis muscle.
8. to flexor tibialis externus muscle.
9. to flexor tibialis internus muscle.
11. to ischio-femoralis muscle.
13. pubo - ischio - femoralis internus.
14. pubo - ischio - femoralis externus muscle.
15. to pubo-ischio-femoralis posterior muscle.

former plexus is the eleventh and the most anterior nerve to take part in the latter is the twenty-third, so that there are eleven nerves that are doubtless distributed to the regions not supplied by the two plexuses.

The crural-ischial plexuses (Fig. 32) are made up of branches from five nerves, three presacral (a, b, and c), the sacral (s = xxvi), and one postsacral (α); the second postsacral shown in the figure apparently does not enter into the plexus.

The first and second presacrals terminate chiefly in the abdominal and thigh muscles, though the second sends a large branch to fuse with a branch from the third to form the large obturator nerve (N. obt.) that leads to the muscles of the thigh and knee.

The third presacral sends a branch back to fuse with the large sacral (s = xxvi), and these two, together with a branch from the first postsacral, form a complicated network that sends numerous branches to the muscles of the pelvic and femoral regions, to the skin, legs, and tail, as shown in Figure 32. The large muscles of the tail are innervated by the regular, metameric nerves of that region, and since there are usually thirty-nine caudal vertebræ, there are probably about that many pairs of caudal nerves, although the last few vertebræ and the muscles of that region are so small it may be that some of the nerves are lacking.

Special Sense Organs

It is not possible in a work of this size to give much space to the discussion of the anatomy of the special sense organs. A few of the main features will be given here, taken mainly from Bronn's *Thierreich*, but for details of structure the reader is referred to that larger work.

The Eye. As might be expected, the Crocodilia have the usual upper and lower eyelids and the nictitating membrane. Except along their thickened rims the lids are usually rather faintly pigmented, and near the thickened border numerous goblet cells are found.

The structure of the upper and lower *lids* is similar except that in the former a bony formation is present, as a support to that lid, even in very young animals. The arrangement of the muscles, which are of both smooth and striped fibers, and the histological structure cannot be described here.

The *nictitating membrane* is strongly developed in the Crocodilia. Its outer surface is marked by two fairly high folds that are conspicuously pigmented. The cartilage described in the nictitating membrane of Lacerta is wanting, according to Bronn, in the Crocodilia.

The glands of the eye are of three types: the lachrymal glands proper, the Harderian glands, and the conjunctival glands. The *lachrymal gland* is small in proportion to the size of the eye. It

is an elongated, almost band-like structure situated in the roof of the eye-socket, near its border; its long axis lies in an antero-posterior direction. It is so closely inclosed by and united with connective tissue that it is difficult to find.

The *Harderian gland* is much larger than the lachrymal gland proper and is easily found. It lies in the forward part of the eye-socket and is of a somewhat three-cornered shape. From its outer and forward base it sends a short, delicate duct to open between the nictitating membrane and the eyeball.

The *lachrymal canal* is well developed in the Crocodilia. Near the forward angle of the eye, on the inner side of the lower lid, are found from three to eight tear dots, lying in a row from behind forward. Each of these dots opens into a small elongated sac. This sac opens downwards and forwards into a common canal, which canal, at first narrow but soon widening, extends for a time parallel to the free border of the eyelid and then enters the opening in the hinder side of the lachrymal bone. Rathke found none of these tear dots on the upper eyelid so concluded that the lachrymal fluid could escape only through the lower lid. This canal, which might correspond to the lachrymal sac of higher forms, is rather narrow until it enters the lachrymal bone, then it becomes considerably wider and forms a sort of reservoir that Rathke calls the "*saccus naso-lachryma-*

lis." This reservoir is of irregular form and opens forwards into the base of the nasal cavity proper.

The third type of gland mentioned above, the *conjunctival*, is found on the lower eyelid where the conjunctiva passes from the lid to the eyeball. The gland is of a "scattered acinose" type.

The usual muscles of the eyeball are found in the Crocodilia. The four *rectus* and two *oblique* muscles have about the usual arrangement and are attached to the eyeball by very short aponeuroses. The *retractor oculi* muscle is only weakly developed. It consists of two separate bundles which, lying behind the optic nerve, arise from the forward bony wall of the socket and are inserted on the sclera very near the optic nerve.

The *eyeball* consists of the usual layers, including, as might be expected from the nocturnal habits of the Crocodilia, a typical *tapetum lucidum.*

In the *sclera*, instead of the bony ring common to the saurians, is found a well-developed cartilage covered with the fibrous layer of the sclera; the fibers of this layer are arranged into two more or less distinct layers.

While not worked out in detail the *cornea* consists of the usual five layers.

In the *iris* the musculature is less developed than in the birds; Bronn thinks this may be compensated for by the greater development of the "vascular structures."

The *pupil* is a vertical slit.

The *choroid* is very closely united on the outside with the sclera; on the inside it is less closely attached to the retina except at the ora serrata. It consists of an outer fibrous coat, an inner, unstratified pigmented epithelium derived embryologically from the pigmented layer of the retina, and the ground substance which is a network of irregular and very vascular cells.

As in probably all reptiles there is present in the Crocodilia a vascular pigmented fold of the choroid, the *pecten*, which projects into the middle of the cavity of the eyeball.

In the *retina* Bronn describes the following ten layers, which are those commonly given in other vertebrate retinas: (1) the inner limiting membrane, (2) optic fiber layer, (3) ganglion cell layer, (4) inner granular layer, (5) inner nuclear layer, (6) outer granular layer, (7) outer nuclear layer, (8) outer limiting membrane, (9) cone layer, (10) pigmented layer. The Crocodilia differ from probably all other reptiles in having rods as well as cones in the retina. The rods are more numerous except in the neighborhood of the fovea centralis where the cones predominate; in the fovea itself only cones are found.

The *lens* does not show any characteristics unusual enough to warrant special description.

The Ear. The ear is of special interest here because it is in the Crocodilia that are first found the three distinct regions of the ear that are seen

in the Aves and Mammalia: the external auditory meatus, the tympanic cavity, and the labyrinth. It is the presence of the meatus that lifts the Crocodilia above the other Reptilia.

Two strong folds of integument, one above and one below, completely cover the outer ear and allow it to open as a mere slit on the lateral surface of the head a little back of the corner of the eye. By lifting the upper valve one may perceive the lower half of the meatus and the bottom of the tympanic membrane. The upper valve is the larger and is sickle shaped; the lower is smaller and more three cornered. Both spring from the outer surface of the squamosal bone, from its posterior obtuse angle to its anterior union with the postfrontal. The lower fold is raised highest behind the corner of the eye and is lost in the middle of the rima auditoria; by this Hasse indicates the position of the outer opening of the external auditory meatus. The form of the *meatus* may be compared to a wedge whose base is directed dorso-medio-caudad and whose edge points in a ventro-latero-cephalic direction; its side walls are either soft or bony; its outer end is covered by the folds; at its inner end is the tympanic membrane or drum.

The *drum* is a round, soft, elastic membrane in which a radial arrangement of its constituent fibers may be seen. It is funnel shaped from without and above, and the fibers radiate from the apex to which the columella is attached. The membrane

is stretched taut and while it does not, as in the higher vertebrates, lie in a bony groove, it possesses around its periphery a strong thickening of circular fibers, the *annulus tympanicus*, by means of which it is closely united with the lining membrane of the outer ear passage. The drum is attached chiefly to the quadrate but in part to the squamosal bone.

The *middle ear* is divided into an outer part, the *tympanic cavity proper*, and a part next to the labyrinth, the *recessus cavi tympani*. Within the tympanic cavity, besides blood-vessels and nerves, is found the *columella* with its appendage (found in all Reptilia), the *recessus scalæ tympani*. The tympanic cavity is formed mainly by the quadrate, though the exoccipital and squamosal bones take some part. In outline it might be compared to a truncated, four-sided pyramid, with its base below, its truncated apex above, and with an anterior, a posterior, a mesial, and a lateral side.

From the floor of each tympanic cavity a *Eustachian tube* leads towards the throat. These tubes unite and connect with the throat by a single small opening just behind the posterior nares, as shown in the figures of the skull.

The *semicircular canals* with their *ampullæ* lie in the usual positions as seen in other vertebrates: the anterior vertical, posterior vertical, and horizontal. The details in structure of the inner ear cannot be given here. The nervous epithelium is said to have the same characteristics as in other vertebrates.