DESCRIPTIVE AND ILLUSTRATED CATALOGUE

OF

THE PHYSIOLOGICAL SERIES

OF

COMPARATIVE ANATOMY

CONTAINED IN

THE MUSEUM

OF

THE ROYAL COLLEGE OF SURGEONS OF ENGLAND

VOL. III.

SECOND EDITION.

LONDON:
PRINTED FOR THE COLLEGE;
AND SOLD BY
TAYLOR AND FRANCIS, RED LION COURT, FLEET STREET.
MDCCCCVII.

ALERE FLAMMAM.

PRINTED BY TAYLOR AND FRANCIS,
RED LION COURT, FLEET STREET.

PREFACE

TO THE

THIRD VOLUME.

THE third volume of the Catalogue of the Physiological Series comprises descriptions of the remainder of the specimens in Section D [the Nerves of Vertebrates], and also of those in Section E [the Organs of Special Sense]. The latter are arranged in order of increasing complexity, namely, Touch, Taste, Smell, Hearing, and Seeing. These are followed by undoubted sense-organs which as yet have not had their function certainly ascertained.

Section E has presented special difficulties as many of the preparations of sense-organs were very delicate and had become so injured as to require replacement; it was also necessary to add largely to the section, which probably will even yet long require numerous additions.

This volume of the Catalogue should be justly considered as the work of the Anatomical Assistant in the Museum, Mr. R. H. Burne, who has carried out my wishes to my fullest satisfaction. Professor C. S. Sherrington, F.R.S., has most kindly read the proof-sheets and furnished me with many valuable suggestions.

C. STEWART,
Conservator.

1 June, 1907.

CONTENTS.

VOL. III.

D.

NERVOUS SYSTEM (*continued*).

VERTEBRATA.

NERVES.

E.

ORGANS OF SPECIAL SENSE.

TACTILE ORGANS.

GUSTATORY ORGANS.

VERTEBRATA.

OLFACTORY ORGANS.

INVERTEBRATA.

VERTEBRATA.

Olfactory Chamber.

MAMMALIA.

Middle and Internal Ear.

DESCRIPTIVE CATALOGUE

OF THE

PHYSIOLOGICAL SERIES.

D
(*continued*).

NERVOUS SYSTEM.

NERVES.

John Hunter, Animal Œconomy: A description of the nerves which supply the organ of smelling, Works of Hunter, Palmer, vol. iv. 1837, p. 187.

Croonian lecture on Muscular Motion, No. 1, 1776, *ibid.* vol. iv. p. 212.

Lectures on the Principles of Surgery, *ibid.* vol. i. p. 260.

Essays and Observations, edit. R. Owen, vol. i, p. 163.

Cranial Nerves.

Cole, Liverpool Mar. Biol. Committee Memoirs, viii. (*Pleuronectes*) p. 110.

Merritt, Jour. Anat. & Physiol. vol. xxxix. 1905, p. 199.

The cranial nerves take their origin from the brain and supply the muscles, skin, and sense-organs of the head, the mucous membrane of the mouth and pharynx, parts of the viscera and, in low aquatic Vertebrates, special sense organs distributed over the surface of the trunk.

For convenience sake they are grouped according to their superficial origin from the brain into ten pairs in lower Vertebrates, or twelve pairs in the higher, although this arrangement in the case of the majority has no correspondence with their true centres of origin. The individual nerves of this series, with the exception of the olfactory and optic, are not, in fact, morphological unities, but each is composed of several kinds of fibres, that differ in histological features, arise from distinct centres in the brain, and have each a peculiar distribution and function. In all, five of these "components" have been recognized:—(1) General cutaneous sensory, distributed by the trigeminus (V.) and to a less degree by the glossopharyngeal (IX.) and vagus (X.) to the skin, but not to specialised sense organs. These fibres are similar to the sensory fibres of the dorsal roots of the spinal nerves and like them are in connection with special ganglia—the Gasserian and jugular. (2) Special cutaneous sensory (acoustic and equilibrating). This in lower Vertebrates composes not only the auditory nerve (VIII.), but also branches of the facial (VII.) and vagus that innervate the sense organs of the lateral line (vestibulo-lateralis system). (3) Somatic motor, confined to the nerves of the eye-muscles (III., IV., VI.) and to the motor nerve of the tongue—the hypoglossal (XII.). (4) Visceral sensory: distributed to the taste-buds and the mucous membrane of the mouth and pharynx, and in Fishes to special sense organs of the skin other than those of the lateral line. This component (communis system) is found mainly in the facial (forming the chorda tympani and palatine branches), in the glosso-pharyngeal (IX.) for the innervation of taste-buds, and in the vagus. Its centres in the brain are often conspicuous superficially as the facial lobe and the sensory lobe of the vagus (Brain, Nos. D. 68, D. 85, D. 107). (5) Visceral motor, present in the trigeminus for the supply of the muscles of mastication, and in the facial, glosso-pharyngeal, and vagus.

From the trigeminus backwards the cranial nerves, and more particularly the hinder members of the series, show signs of their primitive relation to visceral arches in the separation of the nerve-trunk into three branches—præ- and post-branchial and visceral. With the loss of the gills, the vagus, which is essentially a compound of several independent branchial nerves, loses its branchial character, becomes more and more condensed and extends its range further down the trunk; at the same time its posterior part which even in Fishes innervates the trapezius separates off and, in combination with a root from the spinal cord, forms the spinal accessory (XI.). Meanwhile, the hypoglossus, which is a derivative of several spinal nerves, and in lower forms belongs clearly to the spinal series, becomes included within the cranium. The facial—the nerve of the hyoid arch—also shows signs of considerable evolutionary change. With the loss of aquatic life, it loses its lateral-line branches and becomes greatly diminished, particularly in Reptiles and Birds; in Mammals it receives a new importance owing to the relatively great development of the cutaneous muscles of the hyoid region. The trigeminal (the general sensory nerve of the face) gradually increases in importance in the ascending series, particularly as regards the branches of its maxillary division distributed to the muzzle.

PISCES.

HOLOCEPHALI *.

D. 809. Head of a Sea Cat (*Chimæra monstrosa*) with the brain and cranial nerves exposed on the left side. The optic nerve has been cut short. The oculo-motor (III.) and trochlear (IV.) nerves have respectively the distribution to the ocular muscles usual in Vertebrates: to the inferior oblique, inferior, superior, and internal recti, and to the superior oblique. The sixth nerve is not shown. The trigemino-facial (V., VII.) complex, which in all low aquatic Vertebrates is accompanied by a number of the nerves that supply the organs of the lateral line, and in Fishes is further confused by the blending of its roots, occurs in *Chimæra* in a relatively simple condition. In this specimen the roots of the buccal and hyomandibular branches of the lateral-line system have been cut to expose the underlying roots of the trigeminal. The roots of the lateral-line branches are better shown in D. 85. The nerves marked VII. belong for the most part to the lateral-line system, and comprise (*a*) the superficialis ophthalmicus VII.—a large trunk running along the dorsal border of the orbit and supplying the supra-orbital canal, (*b*) the buccal branch of VII., for the innervation of the infra-orbital canal, and (*c*)

* Placed before the Elasmobranchs owing to the greater simplicity of the cranial nerves.

the hyomandibular division for the hyomandibular canal. This latter nerve is closely bound up for the first half of its course with the true facial. The first (ophthalmic) division of the trigeminal (V.) consists of two parts: a minute ophthalmicus superficialis that runs upwards without joining the ophthalmicus superficialis VII. to the skin covering the top of the head, and a relatively large ophthalmicus profundus, that runs horizontally forward through the orbit and joins the ophthalmicus superficialis VII. to be ultimately distributed to the snout. The maxillary and mandibular divisions of the trigeminal are united for the first part of their course, but can be seen diverging towards the lower part of the orbit under cover of the buccal lateral-line nerve. The facial (VII.) shows the essential characters of a branchial nerve, in having three chief branches—a post-branchial, accompanying the hyomandibular lateral-line nerve to the operculum, a smaller præ-branchial passing to the inner aspect of the mandible (this possibly represents the chorda tympani of the higher Vertebrates), and a visceral distributed to the palate. The glosso-pharyngeal (IX.) and the first three trunks of the vagus supply the gills and each gives off præ- and post-branchial and visceral branches. The last (fourth) trunk of the vagus innervates the œsophagus and stomach. The several roots of the vagus retain their individuality far more completely than in any other Vertebrate. Crossing the roots of IX. and X. from before backwards is a powerful nerve (lateralis vagi) belonging to the lateral-line system; it arises in the brain in common with the other branches of this system and with the acoustic nerve, and supplies the organs of the lateral line upon the trunk.

Cole, Trans. R. Soc. Edinburgh, vol. xxxviii. 1897, p. 631.

ELASMOBRANCHII.

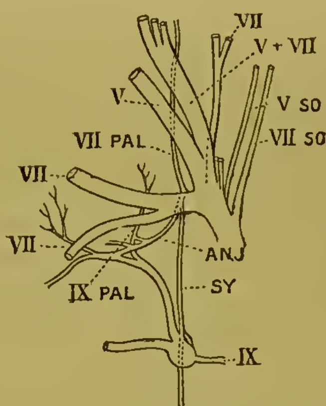
Ewart, Proc. R. Soc. vol. xlv. 1889, p. 524.

D. 810. Head of a Tope (*Galeus communis*) with the brain, and the cranial nerves of the left side, exposed. The nerves have the same general arrangement as in *Chimæra*. The union of the roots of the cephalic lateral line nerves with those of the trigeminus and facial is however more intimate, and the relative importance of the two ophthalmic branches of the trigeminus is reversed, the ophthalmicus superficialis V. being in this case a nerve of considerable size which soon after its exit from the skull blends with the ophthalmic lateral-line branch of VII., whereas the ophthalmicus profundus V. is quite small. Black paper has been inserted between the buccal lateral-line branch of VII. and the maxillary and mandibular divisions of the trigeminus, and nearer the brain, between it and the true facial. The post-spiracular branch of the facial is strongly developed and consists of a union of fibres of the true facial with the hyomandibular branch of the lateral-line system. The præ-spiracular branch is minute, but the visceral (palatine) is well developed. The glosso-pharyngeal is in a very generalised condition, with præ- and post-branchial, visceral, and dorsal branches. The lateralis vagi and the several divisions of the vagus are more intimately blended in their passage through the skull wall, than in *Chimæra*. The pigmentation of the neurilemma of the superficial ophthalmic and fourth nerves is worthy of remark.

TELEOSTEA.

D. 811. The head of a Cod (*Gadus morrhua*) with the brain and the cranial nerves shown from the left side. The blending of the roots of the trigeminus, facial, and cephalic lateral-line branches is even more complete than in the previous specimen. Nerve trunks essentially similar to those seen in *Chimæra* and *Galeus*, but differing much from them in details and in relative importance, spring from the common mass formed by the roots and ganglia of this nerve complex. The ophthalmicus superficialis V. is completely separate from the superficial ophthalmic lateral-line branch of VII. There is no ophthalmicus profundus V. The lateral-line branches in general, and particularly the buccal, are less developed than in *Galeus*; but, on the other hand, the maxillary and mandibular branches of the trigeminus are remarkably large: from the latter a strong branchlet supplies the barbel on the chin. The true facial is accompanied by nerves belonging to the lateral-line system; it is itself divisible into palatine, præ-spiraeular, and post-spiracular (hyoid) branches. The glosso-pharyngeal, on its exit from the skull, divides into two trunks; the anterior of these gives origin to palatine and præ-branchial branehes. From the palatine branch a slender filament passes towards the combined roots of v. and vii. and enters them in eon-junction with the eephalie sympathetie eord at the point of emergenee of the palatine branch of the faeial; this is the first appearanee of the anastomosis of Jaeobson.

Fig. 1.



Roots of V, VII, IX cranial nerves of *Gadus morrhua,* showing the anastomosis of Jacobson.

V, VII, IX. The several cranial nerves. AN.J. Anastomosis of Jacobson. PAL. Palatine branches. SY. Sympathetic cord. SO. Superficial ophthalmic branches.

The lateralis vagi and vagus nerves leave the skull as a common bundle and at onee separate into lateral line, branehial, and gastric branehes. An interesting nerve (ramus aceessorius lateralis) arises by two roots from the dorsal parts of the trigemino-faeial eomplex and vagus. Its ehief root, which is derived from the faeial, runs directly upwards towards the skull roof and after receiving the smaller, vagus, root passes backwards along the sides of the body for the innervation of special sense-organs situated chiefly upon the fins. Blue paper has been plaeed beneath the cranial portion of the sympathetic cord, whieh enters into connection with the ganglia of the trigemino-facial complex, and of the glosso-pharyngeal, vagus, and first spinal (hypo-glossal) nerves. The chief cranial nerves are distinguished by numbers. O. C. 1380 B *a*.

Cole, Trans. Linn. Soc., vol. vii. 1896–1900, p. 115.

D. 812. A Whiting (*Gadus merlangus*) with part of the skin of the trunk removed to expose a system of cranial nerve branches (ramus accessorius lateralis and lateralis vagi) that supplies special sense organs upon the body and fins. The organs are of two kinds—end buds similar in structure to the taste buds that occur in the mouth cavity and pharynx and upon the lips. These are innervated by the ramus accessorius (marked by black paper). The other organs form the trunk part of the lateral-line system. The nerve-fibres that supply them belong to the somatic sensory component and arise in common with the auditory nerve in the acoustic centre, but leave the brain in connection with the vagus. In the specimen they are marked by blue paper.

Merritt, Jour. Anat. and Physiol., vol. xxxix. 1905, p. 210.

D. 813. The head and anterior part of the trunk of an Eel (*Anguilla longirostris*) in which the commencement of the lateralis branch of the vagus is shown on the right side. O. C. 1385. *Hunterian.*

AMPHIBIA.

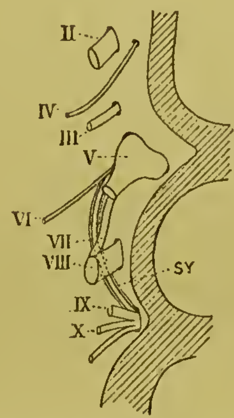
Strong, Jour. Morph., vol. x. 1895, p. 101.

D. 814. The head of a Bull-Frog (*Rana catesbiana*), with the brain and the cranial nerves of the left side, exposed. The right half of the brain has been removed to show the nerve-roots of that side and the cranial portion of the sympathetic system. In comparison with Fishes and aquatic Amphibia, the facial and vagus nerves have undergone reduction in size and importance owing to the loss of the gills and of the organs of the lateral line. The trigeminal is the largest of the cranial nerves. Two trunks arise from its Gasserian ganglion—a superficial ophthalmic, that passes forward beneath the roof of the orbit and is distributed to the nasal chambers and to the surface of the snout; and a large conjoint maxillo-mandibular trunk that shortly divides into maxillary and mandibular branches.

The facial is a relatively small nerve. It emerges from the brain in close contact with the auditory nerve by a single root and leaves the skull beneath the Gasserian ganglion. Outside the skull it divides into palatine and hyomandibular branches. The former runs forward along the floor of the orbit and near its anterior border is connected by a transverse anastomosis (marked by black paper) to the ramus maxillaris trigemini. The hyomandibular trunk passes behind the columella auris, and is joined by the præ-branchial branch of the glosso-pharyngeal. The compound nerve that results from this union redivides behind the outer end of the squamosal into three branches—an external mandibular (shown by Strong to be composed in the Tadpole of glosso-pharyngeal and lateral-line fibres) distributed to the skin around the angle of the mouth ; an internal mandibular (the præ-branchial division of the facial which possibly represents the chorda tympani of mammals) that runs parallel to the ramus mandibularis trigemini along the inner surface of the lower jaw ; and a hyoid branch (the post-branchial division of the facial) composed, according to Strong, of fibres derived partly from the glosso-pharyngeal and partly from the facial. The lateral-line branches associated with the facial in Fishes are absent. The glosso-pharyngeal emerges from the skull in company with the vagus. Besides the above-mentioned præ-branchial branch, it has also a visceral (pharyngeal) and a post-branchial. The latter runs along the floor of the mouth to the tongue. There is no anastomosis of Jacobson. The vagus arises by two roots. Outside the skull it forms a single trunk, that later divides into laryngeal, cardiac, pulmonary, and gastric branches; there is no lateralis vagi. The first spinal nerve (hypoglossal) supplies the muscles of the neck, hyoid region, floor of the mouth and tongue.

In this specimen the anterior part of the sympathetic system is also shown. Behind the skull it lies outside the vertebral column, enlarging opposite the first vertebra and beneath the second spinal nerve to form large pigmented ganglia. Anteriorly it enters the skull alongside the vagus,

Fig. 2.



Roots of the cranial nerves and intracranial sympathetic cords of *Rana catesbiana*, enlarged.

II, III, IV, V, VI, VII, VIII, IX, X. The cranial nerves.
SY. Sympathetic cord.

and can be seen (on the right side) as a delicate double strand passing forwards behind the roots of the auditory and facial nerves to join the Gasserian ganglion.

Ecker's Anat. des Frosches, 2e Aufl., Gaupp, Abt. 2, p. 128.

AVES.

D. 815. The head of a Swan (*Cygnus olor*) dissected from the left side to show some of the chief trunks of the cranial nerves. The most notable feature is the great size of the branches of the trigeminus. At the posterior part of the skull can be seen the glosso-pharyngeal, vagus, and hypoglossal.

MAMMALIA.

D. 816. Head and fore-part of the trunk of a Rabbit (*Lepus cuniculus*) showing the cranial nerves of the left side. The nerves of the eye muscles differ in no essential from those of lower Vertebrates. The trigeminal is divisible into three main trunks—(*a*) the ophthalmic, separated into several branches, for the innervation of the skin of the forehead and the eyelids ; (*b*) the maxillary, a strong nerve bundle that crosses the floor of the orbit, passes internal to the alveoli of the upper molars and traverses the maxilla through the infra-orbital foramen to reach its final distribution in the skin of the muzzle. It supplies the upper teeth and the vibrissæ and skin of the upper lip; and (*c*) the mandibular, which leaves the skull by the foramen lacerum medium some way behind the point of exit of the other two trunks and close in front of the auditory bulla. Within the foramen it divides into two branches—an anterior branch or rather bundle of nerves that enters the orbit and supplies the muscles of mastication and the buccinator, and a large posterior division. This latter, after a course of about 6 mm., subdivides into mandibular, lingual, and mylohyoid branches. The lingual is shortly joined by the chorda tympani (the præ-spiracular branch of the facial) and passes external to the hypoglossus to the lateral parts and tip of the tongue for the innervation of the mucous membrane. The mandibular trunk enters the lower jaw to supply the teeth. In the specimen the jaw has been removed as far forward as the mental foramen, through which the nerve regains the external surface for its ultimate distribution to the chin. The facial in comparison with that of lower land Vertebrates is relatively large, owing to the increased importance of the skin-muscles of the face. It emerges from the skull behind the auditory meatus through the stylomastoid foramen. Its proximal part only is shown. Close to its exit from the skull it gives off an anterior branch—the chorda tympani—which passes through the tympanic chamber and as just mentioned joins the lingual branch of the trigeminal. The glosso-pharyngeal is small ; its chief distribution is to the mucous membrane of the pharynx and the taste-organs of the circumvallate and foliate papillæ of the tongue. The vagus is represented by a single trunk, which 10 mm. below its exit from the skull enters a large ganglion (g. nodosum). Further down it gives off the superior laryngeal nerve and an extremely delicate filament (depressor cordis) that runs down the neck to the heart to exert upon it an inhibiting influence in opposition to the cardiac branches of the sympathetic system. On a level with the aortic arch, the main trunk of the vagus gives off another (recurrent) laryngeal nerve, that passes inwards through the arch of the aorta close behind the vestigeal ductus arteriosus, and supplies the trachea and larynx. The further distribution of the vagus to the lungs and stomach is not shown. The spinal accessory nerve leaves the skull close behind the vagus; it runs backwards, joins the fourth spinal nerve and is distributed mainly to the trapezius. The hypoglossal is strongly developed; it crosses the vagus just proximal to the ganglion nodosum, and gives off a small descending branch (Ramus descendens noni of Human Anatomy), which after forming connections with two of the spinal nerves innervates the sterno-hyoid muscles. The main trunk of the nerve runs forward above the hyoid and external to the hyo-glossus, to the base and sides of the tongue. It supplies the tongue muscles. In this specimen the cervical and anterior part of the thoracic portions of the sympathetic system are also shown.

W. Krause, Anat. des Kaninchens, 1868, p. 224.

Spinal Nerves.

The spinal nerves, like the cranial, are made up of several components. These are somatic sensory and motor for the innervation of the skin and the muscles of the body-walls and limbs, and visceral sensory and motor. The latter form the rami communicantes with the sympathetic system; the motor set enter *viâ* the sympathetic vertebral ganglia into various spinal nerves as vaso-motor and pilo-motor (to hairs) fibres. The two roots of a spinal nerve probably represent what at one time were two independent nerves, and in existing Vertebrates they actually vary much in the extent to which they are separate—the union tending to be more and more close the higher the position of the animal in the vertebrate scale.

Gaskell, Jour. Physiol., vol. vii. 1886, p. 1.

PISCES.

D. 817. Portion of the trunk of a Tope (*Galeus communis*), showing the origin and chief branches of three spinal nerves. The proximal parts of two isolated spinal nerves are mounted above. The dorsal and ventral roots of each nerve are given off from the spinal cord at different levels—the ventral root in front of the dorsal. Immediately upon emerging from the neural canal, the ventral (motor) root sends out a dorsal branch that unites with a similar branch from the dorsal (sensory) root to form a mixed nerve for the innervation of the muscles and skin of the back. The ganglion of the dorsal root lies just outside the vertebral column. It gives off a small outwardly directed branch which is later joined by a twig from the dorsal branch of the ventral root. The dorsal and ventral roots unite at some distance from the vertebral column and give off a few minor branches that accompany the ribs. The combined trunk perforates the intercostal membrane and proceeds outside the peritoneum to the ventral surface of the body.

REPTILIA.

D. 818. Part of the trunk of a Python (*Python sebæ*), showing the distribution of several of the spinal nerves, and (upon the anterior surface of the specimen) the roots of one pair of nerves, the position of the spinal ganglia, and the mode of origin of the chief branches.

Each spinal ganglion lies in the space between the zygapophyses of successive vertebræ, at the point of union of the dorsal and ventral roots of the spinal nerve. From its distal parts dorsal and ventral nerve-trunks are given off. The former passes upwards amongst the muscles of the back. The ventral trunk runs downwards between the ribs and emerges upon the inner surface of the body-wall between the costo-vertebralis inferior muscles. It shortly divides into dorsal and ventral branches. The dorsal branch innervates the latero-ventral muscles external to the ribs. The ventral branch is finally distributed to the muscles of the ventral shields.

MAMMALIA.

UNGULATA.

D. 819. Part of the cervical region of the spinal cord of a Colt (*Equus caballus*), showing the origins of the second to the fifth spinal nerves. On the right side the rootlets of the dorsal roots have been cut away to show the corresponding ventral rootlets and the spinal root of the accessorius. The latter arises from the spinal cord at a slightly lower level than the hinder end of this specimen, and runs towards the head between the dorsal and ventral rootlets of the spinal nerves receiving in its course reinforcing filaments.

The rootlets of the dorsal and ventral roots enter and emerge from the cord at the dorso- and ventro-lateral furrows respectively, and those belonging to each metamere converge to form the dorsal and ventral roots. The dorsal root just before it unites with the ventral to form the mixed spinal nerve bears a large ganglion.

PRIMATES.

D. 820. Proximal part of a Human spinal nerve, showing the roots internal to the investments of the spinal cord, the reflexion of the dura mater upon their surface as they leave the neural canal, and the swelling at their point of coalescence due to the ganglion on the dorsal root. At a spot proximal to the ganglion the two roots have been forcibly separated by the insertion of a bristle between them. O. C. 1378 H.

D. 821. Portions of two Human intercostal nerves unravelled at their lower ends to show their component bundles.
O. C. 1379. *Hunterian.*

Limb Plexuses.

Sherrington, Jour. Physiol., vol. xiii. 1892, p. 621 ; also Phil. Trans., vol. 190 B, 1898, p. 93.

von Ihering, Peripherische Nervensystem der Wirbelthiere, 1878.

The ventral branches of those spinal nerves that supply the limbs are united by their perineural investment to form plexuses, situated between their exit from the neural canal and their entry into the limb. Although, no doubt, mechanical causes, such as the crowding that takes place as the nerves converge to enter the limb, or that due to the backward extension of the gill-arches in Fishes, have had much to do with the formation of these plexuses, the constancy of their occurrence and the intricate interchange of nerve-fibres that takes place within them, indicate that they probably have some important physiological meaning. What this meaning is, has been a matter of much discussion. However, there is probably some truth in the suggestion of Panizza that the plexuses have for one of their uses the protection of the muscles from excessive fatigue ; for as the nerve to each muscle is composed of fibres arising in different parts of the cord, the entire muscle need not be called into play during any one coordinate movement, and thus while one part of the muscle is in action, the rest is in repose, and the liability to over-fatigue of the whole is much lessened. But to whatever extent this may be the function of the plexuses, it seems certain from Professor Sherrington's experiments that "by [their] instrumentality nerve-fibres passing through a number of spinal roots from an extended line of origin in the cord are sorted and collected in such a way that all those destined for one particular muscular organ . . . . finally exist gathered together in one and the same nerve trunk" (Jour. Physiol., vol. xiii. p. 712). The arrangement affords anatomical evidence that the group of motor cells to such muscles extends longitudinally through not one but several segments of the spinal cord.

A very constant feature in the arrangement of the plexuses is the separation of their individual roots into dorsal and ventral divisions, and the distribution of the nerves derived from the combination of the members of each series of these divisions, to the muscles and skin of the dorsal and ventral surfaces of the limb respectively. This constancy is to be referred to the mode of development of the limbs : to the early separation of the originally unbranched limb nerves into dorsal and ventral branches, following the separation of the muscle-sheath of the limb-bud into dorsal and ventral sheets. The further subdivision of these dorsal and ventral sheets into muscle groups of increasing complexity and the direct relationship that exists between the individual muscles of lower forms and complex series of muscles in those higher in the scale, is reflected by the approximate similarity in the various classes in the distribution of the chief nerves given off from the plexus.

Brachial Plexus.

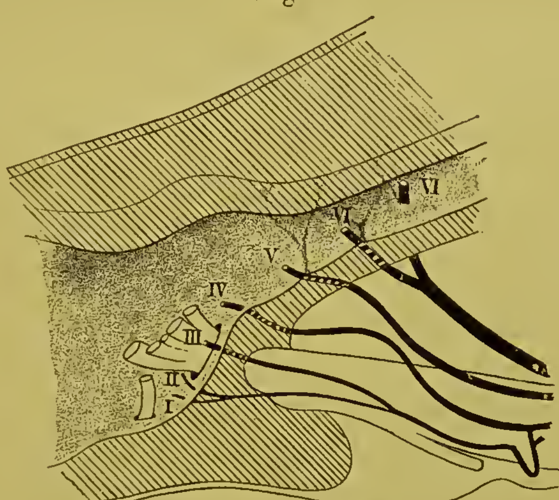
PISCES.

ELASMOBRANCHII.

Braus, Jena. Zeits., Bd. xxxi. 1898, p. 239.

D. 822. The fore-part of the trunk, including the posterior half of the skull, of a Tope (*Galeus communis*), showing the cervical and brachial plexuses and the spino-occipital nerves.

Fig. 3.



The spino-occipital nerves of *Galeus communis*.
I, II, III, IV, V, VI. Roots of the first six spinal nerves.

The first four spinal nerves (spino-occipital) arise from the medulla within the cranial cavity, and with the fifth, which lies between the skull and the vertebral column, are more or less vestigeal, being small and without dorsal roots. They increase regularly in size from the first, which leaves the skull in front of and below the root of the vagus and is so small as to be almost invisible. The sixth and succeeding nerves are formed by the union of dorsal and ventral roots in the ordinary way. The ten anterior spinal nerves (including the spino-occipital) join together between their exit from the cranio-spinal cavity and the posterior limit of the branchial apparatus, to form a single trunk (cervical plexus) that innervates the hypo-glossal region, and also gives off a large branch that traverses the pectoral arch to its outer side for the innervation of the fin. The four succeeding spinal nerves unite on a level with the lateral vein to form a brachial plexus, from which branches are given off to the ventral trunk muscles and to both dorsal and ventral surfaces of the fin. Posterior to this, each spinal nerve remains distinct although seven of them take part in the innervation of both surfaces of the limb.

Black paper has been placed beneath the spino-occipital nerves after their exit from the skull, a red glass rod is inserted into the subclavian artery, and the branches of the brachial spinal nerves to the body-wall have been cut short and lifted to distinguish them from the branches distributed to the fin. The lateralis vagi has been exposed.

TELEOSTEA.

D. 823. The right pectoral fin and part of the skull and vertebral column of a Gurnard (*Trigla hirundo*), showing the brachial plexus and the distribution of nerves to the fin. An isolated specimen of the roots of the last two cranial and the first five spinal nerves is also shown, in which the boundary between the cranium and spine is marked by a red line. The first and second spinal nerves are fused together; they have two dorsal roots, that arise respectively in the two anterior enlargements of the spinal cord (*cf.* D. 755), and three ventral roots. The first nerve supplies the swim-bladder and the muscles of the throat, and unites by a strong branch with the second and third nerves to innervate both surfaees of the fin. The fourth spinal nerve has one immense dorsal root derived from the fonrth and fifth enlargements of the cord, and a single small ventral root. It breaks up into five strong sensory branches for the supply of the free tactile fin-rays—one to the first and two to each of the others, and also gives rise to motor branches for the inner superficial muscle-sheet of the fin and for the muscles of the tactile fin-rays.

REPTILIA.

Fürbringer, Jena. Zeits., Bd. xxxiv. 1900, p. 364.

D. 824. Right fore-limb and part of the trunk of a Monitor Lizard (*Varanus varius*), showing the brachial plexus and the distribution of the chief nerves given off from it. The four roots of the plexus (of which the middle two are by far the strongest) are derived from the seventh to the tenth spinal nerves. At the point of union of the two anterior roots a bundle of dorsal nerves (analogous to the supra- and subscapular of Mammals) is given off to the subcoracoscapularis and supracoracoideus. The second root prior to its union with the first divides into dorsal and ventral divisions. The former joins a similar dorsal division of the combined posterior roots of the plexus to form a nerve trunk with a distribution approximately similar in the upper arm to that of the circumflex and musculo-spiral of Mammals, but restricted in the forearm to the head of the extensor communis and the skin for a short distance below the elbow. Nerves for the latissimus dorsi arise from the proximal parts of the dorsal divisions of the plexus. The ventral division of the second root unites with that of the combined third and fourth roots to form the chief nerve of the limb—the brachialis longus inferior. Between the axilla and the elbow this nerve gives off branches to the pectoralis, to the flexors of the elbow, to the humero-radialis (supinator), and to the skin on the inner side of the elbow. In the bend of the elbow it divides into trunks analogous to the median and ulnar of Mammals. These supply the flexors of the forearm and hand, and, by branches of the median trunk that pass through the interosseous membrane, the humero-metacarpalis medialis (ext. comm. digit.), the epicondylo-metacarpalis ulnaris (ext. carp. uln.), the back of the hand and the skin on the extensor surface of the distal end of the fore-arm: parts that should be supplied by nerves derived from the dorsal division of the roots.

D. 825. The brachial plexus and nerves of the left fore-limb of the same individual, isolated. The distribution of the several nerves is indicated by figures as follows:—(1) Supracoracoideus. (2) Subcoracoscapularis. (3) Skin of fore-arm, humero-radialis, and humero-carpalis. (4) Dorso-scapularis, scapular head of anconeus, and skin of shoulder. (5) Latissimus dorsi. (6) Subscapular part of subcoraco-scapularis. (7) Anconeus and head of extensor communis. (8) Coraco-brachialis longus. (9), (10) Coraco-ante-brachialis (biceps) and humero-antebrachialis inferior (brachialis internus). (11) Coraco-brachialis longus, and skin on inner side of elbow. (12) Coraco-brachialis brevis. (13) Pectoralis. (15) Pronator teres, humero-radialis carpalis. (16) To radial surface of thumb. (17) Pronator quadratus, and back of the hand. (18) Palm of hand. (19) Extensors, and skin of fore-arm. (20), (21), (22) Flexor profundus. (23) Flexor carpi ulnaris. (24) Palm of hand. C, indicates cutaneous branches.

D. 826. Left brachial plexus of a Chameleon (*Chamæleon vulgaris*), isolated, together with the right half of the head and shoulders of the same individual with the plexus in position. The plexus lies relatively far forward, including the third to the sixth spinal nerves. The two middle roots are the strongest.

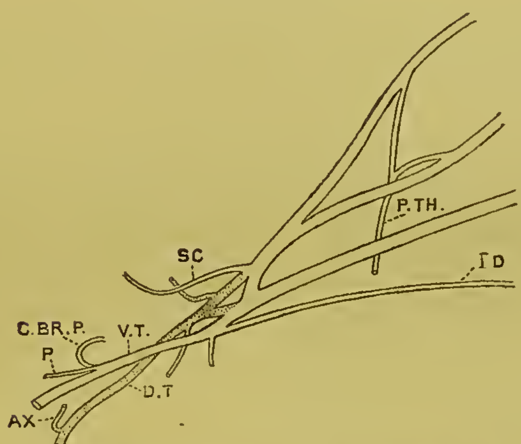
AVES.

Fürbringer, Morph. Jahrb., Bd. v. 1879, p. 324.

D. 827. The right wing and part of the trunk of a Ki-Wi (*Apteryx oweni*) showing the brachial plexus. The plexus is formed by the last three cervical nerves but one; the three components being fairly equal in size. Before joining to form the plexus, each bifurcates into dorsal and ventral divisions. The ventral divisions unite to form a cord that supplies the pectoralis and biceps. The dorsal divisions of the two anterior roots unite and give rise to the axillaris (analogous to the circumflex of Mammals) for the innervation of the deltoid and outer aspect of the shoulder. The main cord due to their union then joins the dorsal division of the third root to form a trunk (musculo-spiral of Mammals) for the supply of the extensors of the upper- and fore-arm. The nerves are very feeble beyond the elbow.

D. 828. Right wing and part of the vertebral column of a Heron (*Ardea cinerea*) showing the brachial plexus and the nerve-supply of the limb. The plexus lies at some distance from the vertebral column. It is formed by the last three

Fig. 4.



Brachial Plexus of *Ardea cinerea*.

AX. Axillaris. C.BR.P. Coraco-brachialis posterior. I.D. First dorsal nerve. D.T. Dorsal trunk. P. Branch to pectoralis. P.TH. Posterior thoracic. SC. Branch to surpra-coracoideus. V.T. Ventral trunk.

cervical and the first thoracic nerves, the two middle roots being the strongest. The two anterior roots, before joining, give rise to the posterior thoracic nerve for the serratus. At their point of union a large nerve is given off for the supra-coracoideus and just beyond this the combined roots divide into ventral and dorsal divisions that respectively unite with the third root and with its dorsal division. Two chief nerve trunks arise from the plexus—a ventral trunk, corresponding to the musculo-cutaneous and median of Mammals, which, after giving off branches to the pectoralis and coraco-brachialis posterior, passes down the inner surface of the arm, innervates the biceps, and in the hollow of the elbow bifurcates to form median and ulnar branches. The median supplies the pronators and flexors of the fore-arm (except the flexor carpi ulnaris which receives its nerves from the ulnar branch). The other chief trunk represents the musculo-spiral of Mammals. Before innervating the triceps, it gives off the axillaris to the deltoid and the shoulder-joint. In the middle of the upper arm it passes to the outer surface of the limb and is ultimately distributed to the extensors of the fore-arm and to the skin on its extensor surface.

MAMMALIA.

Paterson, Jour. Anat. & Physiol., vol. xxi. 1887, p. 611.

MONOTREMATA.

D. 829. Right fore-limb and part of the vertebral column of a Duck-billed Platypus (*Ornithorhynchus anatinus*), showing the brachial plexus and the innervation of the limb. The plexus involves seven spinal nerves—the last five cervical and the first two thoracic; the first and last roots are, however, quite insignificant. From the point of union of the first and second roots a nerve is given off to the supra-coracoideus (*cf.* Heron, *Varanus*, D. 828 & D. 824). Sub-scapular branches spring from the union of the second and third roots, and, by the combination of the dorsal divisions of the second, third, and fourth roots, a large trunk is formed that agrees in its distribution to the circumflex and radial nerves of other Mammals. The musculo-cutaneous is formed by the union of the ventral divisions of the third and fourth roots. It at once gives off several branches to the flexors of the elbow and passes on to join the main trunk of the median. The fifth and combined sixth and seventh roots of the plexus unite and also receive dorsal and ventral contingents from the fourth. The resulting trunk, after giving origin to a large anterior thoracic nerve for the supply of the pectoralis and skin muscles, divides into internal cutaneous, ulnar, and median branches. A large nerve is also given off from its dorsal surface between the ulnar and median branches, which supplies the extensor antebrachii, coils round the outer surface of the humerus and is distributed finally to the extensors of the fore-arm, thus agreeing in its area of innervation with the musculo-spiral and posterior interosseus of Man. This apparent origin of what should be a dorsal nerve from a ventral trunk is deceptive, as the stem from which it originates is derived clearly from both dorsal and ventral divisions of the plexus.

Westling, Bihang Kgl. Sven. Akad. Handlingar, Bd. ix. 1884–5, p. 27.

D. 830. Distal part of the right fore-limb of a Duck-billed Platypus (*Ornithorhynchus anatinus*), showing the distribution of the median, ulnar, and musculo-spiral nerves in the fore-arm. The cut ends of these nerves have been separated and arranged in a line just above the elbow. The extensor carpi radialis receives its chief nerve-supply from the radial extension of the circumflex. All the other extensors of the fore-arm are innervated by the musculo-spiral. The branches of the radialis have been cut short.

D. 831. Right fore-limb and part of the vertebral column of a Spiny Anteater (*Tachyglossus* [*Echidna*] *aculeatus*), showing the brachial plexus and the innervation of the limb. The formation of the plexus and the course and

Fig. 5. Fig. 6.

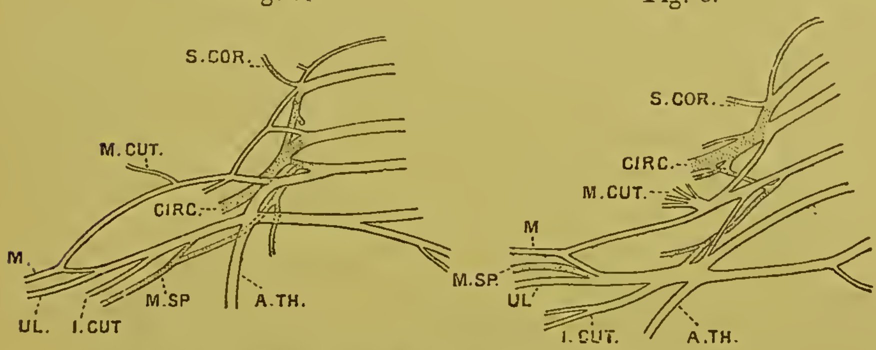


Fig. 5.—Brachial plexus of *Tachyglossus aculeatus*.
Fig. 6.—Brachial plexus of *Ornithorhynchus anatinus*.

A.TH. Anterior thoracic. CIRC. Circumflex. I.CUT. Internal cutaneous M. Median. M.CUT. Musculo-cutaneous. M.SP. Musculo-spiral. S.COR. Supra-coracoid. UL. Ulnar. Dorsal nerve-trunks dotted.

distribution of the nerves are essentially the same as in *Ornithorhynchus*, but the musculo-spiral which in *Ornithorhynchus*, as mentioned in the description of D. 829, appears to be a branch of the common trunk of the median, internal cutaneous and ulnar nerves, and thus to be a nerve of the ventral series, is here formed clearly by the union of the dorsal divisions of the fourth and of the combined fifth sixth and seventh roots of the plexus. The last mentioned dorsal division is, however, combined for some considerable distance with the common trunk of the median, internal cutaneous, and ulnar nerves.

MARSUPIALIA.

D. 832. The left fore-limb and part of the trunk of a Wallaby (*Petrogale penicillata*), showing the brachial plexus and the nerve-supply of the limb. The plexus is formed by the last four cervical and the first thoracic spinal nerves. The first two roots unite and the resulting trunk splits into dorsal and ventral divisions. The dorsal division gives off supra- and sub-scapular nerves and unites with the dorsal divisions of the third and fourth roots to form a plexus from which arise the circumflex, musculo-spiral and subscapular nerves. The ventral division in a similar way forms a plexus with the ventral divisions of the third fourth and fifth roots, which gives origin to the anterior thoracic, musculo-cutaneous, median, ulnar, and internal cutaneous nerves. The arrangement of the nerves within the limb is essentially the same as in Man, but the innervation area of the radial nerve is mainly supplied by a branch of the median (indicated by a green rod) given off in the hollow of the elbow.

Parsons, Proc. Zool. Soc., 1896, p. 708.

EDENTATA *.

D. 833. Right fore-limb and part of the vertebral column of a Sloth (*Bradypus tridactylus*), showing the brachial plexus and the innervation of the limb. The plexus is very large, being formed by seven roots derived from the last four cervical and first three thoracic nerves. The first two roots unite and give off the suprascapular nerve. They then join the third and fourth roots and the resulting trunk divides into a dorsal and a ventral division. In a similar way dorsal and ventral divisions are formed from the coalescence

* The brachial nerves of *Myrmecophaga* are shown in C. 145.

of the last three roots of the plexus. The two ventral divisions unite and give origin to the musculo-cutaneous, median, ulnar, and internal cutaneous nerves, and from a similar union of the dorsal divisions arise, as usual, subscapular, circumflex, and musculo-spiral nerves. The musculo-cutaneous is given off from the trunk of the median half way down the humerus and below the origin of the ulnar and internal cutaneous.

D. 834. The brachial plexus of a Two-toed Sloth (*Cholœpus didactylus*). The plexus is not so extensive as in *Bradypus*. It includes five roots derived from the last four cervical and the first thoracic nerves. Allowing for the smaller number of roots the chief nerves of the limb take their origin from the plexus in a manner similar to those of the Three-toed Sloth.

UNGULATA.

D. 835. Part of the vertebral column of a Cape Hyrax (*Procavia capensis*), showing the roots of the brachial plexus. These are derived from the last four cervical and the first thoracic spinal nerves. The anterior root is slender, but the rest, in correspondence with the great muscularity of the limb (*cf.* C. 147 *a*) are peculiarly stout.

George, Ann. des Sci. Nat., ser. 6, T. i. 1874, p. 156.

D. 836. Left fore-limb of a Goat (*Capra hircus*) with part of the vertebral column, showing the brachial plexus and the nerve-supply of the limb. The plexus is formed by the last three cervical and the first thoracic spinal nerves. The second root at its point of separation into dorsal and ventral divisions is joined by the relatively insignificant first root and gives origin to a large suprascapular nerve. The dorsal divisions of the last three roots, after giving off short and long subscapular nerves, unite to form a cord that soon branches into musculo-spiral and circumflex nerves for the innervation of the extensor surface of the limb in the usual way. The ventral division of the second root joins a compound ventral division derived from the two hinder roots, and in conjunction with it gives rise to the musculo-cutaneous, median, ulnar, and internal cutaneous nerves for the supply of the flexor surface of the limb. The musculo-cutaneous perforates and innervates the coraco-brachialis and enters the biceps. The brachialis internus receives its nerve-supply from the median. It should be noticed that the roots of the dorsal (extensor) plexus are considerably stouter than those of the ventral (flexor) plexus.

RODENTIA.

D. 837. Right fore-limb and part of the vertebral column of a Hare (*Lepus europæus*), showing the brachial plexus and the distribution of nerves to the limb. The plexus is formed by the last three cervical and the first thoracic nerves. The first root gives off the suprascapularis and separates into dorsal and ventral divisions which unite with the corresponding divisions of the second root to give origin respectively to the subscapularis and circumflex, and to the musculo-cutaneous nerves. The musculo-cutaneous sends a branch to the pectoralis and is united by a slender anastomosis to the main trunk of the median nerve through which its fibres are transmitted to the biceps and brachialis internus. The other nerves of the ventral series are formed by the union of the ventral divisions of the last two roots. The dorsal divisions of these roots unite together and with part of the dorsal division of the second to give rise to the musculo-spiral nerve.

Krause, Anat. des Kaninchens, 1868, p. 245.

INSECTIVORA.

D. 838. Right fore-limb and part of the trunk of a Hedgehog (*Erinaceus europæus*), showing the brachial plexus and the distribution of nerves in the limb. The plexus receives roots from the last four cervical and first two thoracic spinal nerves. The first and second, and fourth, fifth and sixth roots respectively unite before dividing into dorsal and ventral divisions. The suprascapular nerve arises at the union of the first and second roots. The three dorsal divisions of the conjoint first and second, of the third, and of the conjoint fourth, fifth and sixth roots, form a plexus from which arise circumflex, musculo-spiral, and subscapular nerves. The three corresponding ventral divisions also form a plexus which gives origin to the musculo-cutaneous, median, ulnar and conjoint anterior thoracic and internal cutaneous nerves. The latter is very strongly developed and innervates the cutaneous muscles of the trunk and the pectoralis (*cf.* Monotremes). The musculo-cutaneous nerve is united to the median by an ansa, passing in front of the coraco-brachialis longus. Distally the musculo-cutaneous extends to the extensor surface of the hand.

CHIROPTERA.

D. 839. Part of the vertebral column and the right arm of a Bat (*Pteropus edwardsi*), with the brachial plexus and nerves of the limb displayed.

The plexus is compounded of roots derived from the last three cervical and first two thoracic spinal nerves, the last root being very minute. The usual mammalian nerve-trunks are given off from the plexus — the supra-scapular from the first root at its point of division into ventral and dorsal branches; the musculo-cutaneous from the ventral divisions of the first and second roots; the median from the ventral divisions of the second, third and fourth roots, and the ulnar from the fifth root and the ventral division of the fourth. Of the chief dorsal nerves, the circumflex is derived from the dorsal divisions of roots one and two, and the musculo-spiral from those of roots two, three and four.

The ulnar nerve unites with the median in the fore-arm.

PRIMATES.

D. 840. Left arm and part of the trunk of an Orang-utan (*Simia satyrus*), showing the brachial plexus and the nerve distribution in the limb. In this specimen, the union of the ventral divisions of the first three roots of the plexus to form an outer cord from which arise the musculo-cutaneous nerve and the anterior component of the median, and the similar union of the ventral divisions of the two posterior roots to form an inner cord from which the internal cutaneous and ulnar nerves and the posterior component of the median are given off, is more definite than in the Chimpanzee, and even more closely resembles the condition typically found in Man. The distribution of the peripheral nerves is essentially the same as in Man. There is no blending of the median and ulnar nerves as seen in the Chimpanzee. Elaborate descriptions of the brachial plexus and limb nerves in the Anthropoid Apes and comparisons between them and those of Man will be found in the following papers.

Saberton, Stud. Anat. Univ. Manchester, Young, vol. iii. 1906, p. 166.

Sperino, Anat. d. Chimpanzé, 1898, p. 401.

D. 841. Left arm and part of the trunk of a Chimpanzee (*Anthropopithecus troglodytes*), showing the brachial plexus and the nerves of the limb. The plexus, as in Man and most other Mammals, is derived from the last four cervical and the first thoracic spinal nerves. The mode of combination of the dorsal and ventral divisions of the roots to form the plexus, and the further distribution of the nerves differ in some particulars from the condition most usually found in Man. The three anterior roots divide into dorsal and ventral divisions before uniting. Their ventral divisions, together with that of the combined fourth and fifth roots, after having given origin to the anterior thoracic, musculo-cutaneous, ulnar, and internal cutaneous nerves, unite to form the median nerve, but there is no definite formation of inner and outer cords, as in Man. The dorsal roots in a similar way combine to form the musculo-spiral after having given off the subscapular and circumflex nerves from the point of union of the dorsal divisions of the two anterior roots. It should be noticed that a large nerve, with a distribution similar to that of the flexor branches of the ulnar in Man, is formed in the hollow of the elbow by the union of two cords derived respectively from the median and ulnar nerves (*cf.* C. 170). A connection of an apparently similar character is found in other Primates and is of frequent occurrence in Man.

Gruber, Arch. f. Anat., 1870, p. 501.

D. 842. Nerves of the left fore-arm of a Chimpanzee (*Anthropopithecus troglodytes*), isolated and spread out to show in a diagrammatic fashion the connection between the median and ulnar nerves and the distribution of their various branches.

Pelvic Plexus *.

PISCES.

ELASMOBRANCHII.

Braus, Jena. Zeits., Bd. xxxi. 1898, p. 319.

D. 843. Part of the trunk of a Tope (*Galeus communis*) including the right pelvic fin. The nerves to the fin have been exposed. The plexus is of a slight and extremely simple character. The several limb nerves split into dorsal and ventral divisions which are distributed to the muscles and skin upon the corresponding surfaces of the fin and are united at its base by a few feeble connections. At the anterior end of the plexus the dorsal nerves are connected by a longitudinal trunk that runs forward to the fourth spinal nerve in advance of the plexus and there vanishes. This "collector" nerve is regarded by some as a vestige indicating the path of a backward migration of the limb.

AMPHIBIA.

D. 844. The right hind-limb and part of the trunk of a Bull-Frog (*Rana catesbiana*), showing the pelvic plexus. The plexus is formed by the coalescence of the seventh, eighth and ninth spinal nerves—the last of which emerges from the neural canal between the sacrum and urostyle. These nerves unite at some distance from the vertebral column and immediately give off a nerve (indicated by a black bristle) that breaks up into ilio-hypogastric and crural branches. The latter supples the rectus femoris anticus, ilio-psoas, pectineus, and adductor longus, thus combining in part

* The following specimens also show the pelvic plexus, or nerves of the leg:—C. 179, C. 180, *Crocodilus*; C. 187, *Apteryx*; C. 188, *Pauxi*; C. 190, *Dendrocygna*; C. 191, *Buteo*; C. 192, *Cathartes*; C. 193, *Buceros*; C. 207 A, *Dasyurus*; C. 209, *Myrmecophaga*; C. 216, *Elephas*; C. 232, C. 233, *Hylobates*; C. 242, *Anthropopithecus troglodytes*.

the distributions of the anterior crural and obturator nerves of higher Vertebrates. The main trunk derived from the plexus forms the sciatic nerve, and passes to the outer side of the leg behind the ilium. Its distribution is shown in the next specimen.

D. 845. Left hind-limb of a Bull-Frog (*Rana catesbiana*), with the distribution of the nerves shown. The whole musculature of the limb, with the exception of the muscles mentioned in the description of the previous specimen as being supplied by the anterior crural trunk, is innervated by branches of the great sciatic nerve. The chief trunk of this nerve passes down the thigh between the biceps and the semimembranosus. Its branches to the thigh muscles (adductors, extensors and flexors) are given off soon after its passage into the limb. At the lower end of the thigh it divides into two main trunks, that pass respectively on either side of the tendon of insertion of the biceps. The outer of these (peroneal nerve) supplies the skin on the outer surface of the knee and the extensor muscles of the shank and foot. Below the knee it divides into two branches that again unite, after passing one on either side of the flexor tarsi posterior, to form a common trunk from which are given off the nerves for the extensor surface of the foot. The inner trunk subdivides in the hollow of the knee into tibialis and suralis nerves. The latter innervates the gastrocnemius and is distributed to the skin of the shank and sole of the foot. The tibialis runs within the substance of the tibialis posticus and is finally distributed to the flexor muscles of the foot. A delicate commissure unites the tibialis and suralis nerves across the point of the heel.

Ecker's Anat. des Frosches, 2• Aufl. Gaupp, Abt. 2, p. 191.

AVES.

In groups higher than the Amphibia, the pelvic plexus can be subdivided into three distinct parts—a crural plexus from which nerves are distributed to the extensor muscles of the thigh; a sciatic plexus for the innervation of the flexors of the thigh and the muscles of the shank; and a pudendal plexus for the supply of the perineal region. The boundaries between these several parts are marked in each case by a divided root that contributes a branch to either plexus. The nerve that shares thus in the formation of the crural and sciatic plexuses, is known as the furcal, that which stands in a similar relation to the sciatic and pudendal, as the bigeminal.

The separation of the roots of the plexus into dorsal and ventral divisions from which respectively the extensor and flexor aspects of the limb receive their nerve-supply, is less clearly marked in the pelvic than in the brachial plexus. The obturator, by which the adductors are innervated, is however always unmistakeably a derivative of ventral divisions, and the crural trunk almost as clearly of dorsal.

D. 846. Part of the body and right hind-limb of a Ki-Wi (*Apteryx oweni*), showing the crural and sciatic plexuses and the distribution of some of the nerves that arise from them. The crural plexus is composed of the anterior branch of the furcal nerve and three whole roots; the sciatic plexus of the posterior branch of the furcal nerve and five whole roots. The nerves given off from the plexuses are, so far as shown, essentially similar in their origin and distribution to those of the Heron (D. 847).

D. 847. Part of the vertebral column and of the right hind limb of a Heron (*Ardea cinerea*), showing the crural, sciatic, and pudendal plexuses and the distribution of the nerves of the limb. The crural plexus is composed of three whole roots (the anterior of which is very small) and of the anterior branch of the furcal nerve. It gives off a bundle of branches for the innervation of the extensor cruris, sartorius, and skin on the outer side of the thigh, and from its lowest part a nerve (peculiar, it is said, to Birds, Crocodiles, and Monotremes) that passes between the femur and the ilio-femoralis internus, supplies that muscle, and is ultimately distributed to the knee-joint and skin on the inner surface of the shank. It is marked in the specimen by black paper. The obturator nerve arises by two roots from the ventral surface of the second and third components of the crural plexus; within the pelvis it innervates the obturator muscle, but in this specimen its further distribution to the accessorius obturatoris and pubi-ischio femoralis is not shown. The sciatic plexus consists of the posterior branch of the furcal nerve and four whole roots; it has apparently no connection with the pudendal plexus. The sciatic nerve before passing through the pelvis gives off branches to the ilio-fibularis (biceps), caudi-ilio-flexorius (semimembranosus), and ischio-flexorius (semi-tendinosus), and to the skin of the back of the thigh. External to the pelvis it divides into two trunks. The upper of these passes through the sling of the biceps in the hollow of the knee, and after giving off small branches to the extensors of the shank, continues, as two cords (marked by a red rod), to the foot. The lower trunk subdivides, about the middle of the thigh; its upper branch passes through the sling of the biceps and beneath the outer head of the deep flexor, to the outer malleolus; its ultimate distribution to the foot is not shown. The lower branch divides in the hollow of the knee into numerous branchlets that supply the gastrocnemius and superficial and deep flexors of the shank.

D. 848. Right hind-limb and part of the vertebral column of a Hornbill (*Buceros* sp.), showing the crural, sciatic, and pudendal plexuses and the distribution of the chief nerves of the limb. The plexuses include remarkably few spinal nerves. Two whole roots and the anterior branch of the furcal nerve combine to form the crural plexus, and the posterior branch of the furcal nerve three whole roots and the anterior branch of the bigeminal, the sciatic. The obturator nerve arises by two roots given off respectively from the distal and proximal ends of the anterior arm of the furcal nerve. The nerve distribution to the muscles of the limb is essentially the same as in the Heron.

MAMMALIA.

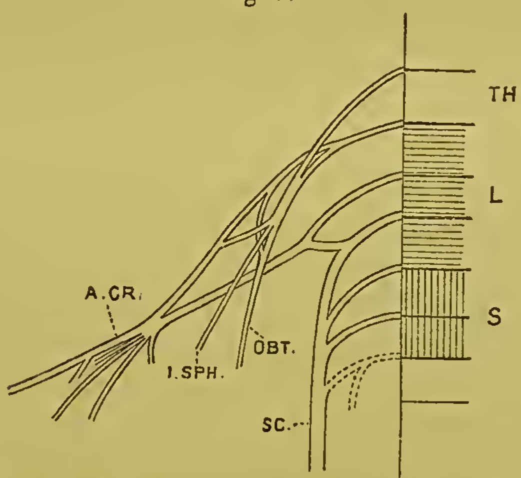
MONOTREMATA.

D. 849. Part of the vertebral column of a Duck-billed Platypus (*Ornithorhynchus anatinus*), showing the crural and sciatic plexuses. Both are remarkably small, including together only four spinal nerves—the two last thoracic and the two lumbar. The crural plexus is formed by two whole roots and the anterior branch of the furcal nerve. The obturator nerve is derived from the crural plexus only, although a delicate anastomosis passes outwards from its root to the furcal nerve. The sciatic plexus has only one whole root.

Westling, Bihang Kgl. Sven. Vet.-Akad. Handlingar, Bd. ix. 1884–5, p. 36.

D. 850. Right hind-limb and part of the vertebral column of a Spiny Anteater (*Tachyglossus* [*Echidna*] *aculeatus*), showing the crural and sciatic plexuses and the distribution of the nerves arising from them. The plexuses are far larger

Fig. 7.



The pelvic plexus of *Tachyglossus aculeatus.*

A.CR. Anterior crural. I.SPH. Internal saphenous. L. Lumbar vertebræ. OBT. Obturator. S. Sacral vertebræ. SC. Sciatic. TH. Thoracic vertebræ.

than in *Ornithorhynchus,* including altogether seven spinal nerves—the last two thoracic, three lumbar, and the first two sacral. The second lumbar nerve is the furcal. The four roots of the crural plexus combine two and two to form two cords that later unite and give origin to a large bundle of crural nerves. The obturator nerve is derived by three roots from the two anterior components of the crural plexus. The sciatic plexus is formed by the posterior branch of the furcal nerve, two whole roots, and the anterior branch of the bigeminal nerve.

MARSUPIALIA.

D. 851. Part of the vertebral column with the right hip and thigh of a Wallaby (*Petrogale penicillata*), showing the pelvic plexus. The crural part of the plexus has two roots derived from the third lumbar and the furcal nerves. Each root gives off a ventral division for the formation of the obturator. The cutaneous branches of the anterior crural nerve are shown on the inner surface of the thigh.

The sciatic plexus is composed of the minute posterior branch of the furcal nerve, two whole roots (the fifth and sixth lumbar nerves), and the anterior branch of the bigeminal (first sacral) nerve. The second and third lumbar nerves give origin to genito-crural and external cutaneous branches.

Parsons, Proc. Zool. Soc. 1896, p. 710.

D. 852. Left hind-limb of a Wallaby (*Petrogale penicillata*), showing the distribution of the anterior crural and sciatic nerves. The muscular branches of the anterior crural to the extensors of the knee are more clearly shown than in the previous specimen ; they are numerous and well developed. The sciatic nerve during its passage past the sciatic notch gives off a strong bundle of nerves to the hamstring muscles. The main trunk passes behind the great trochanter as a single cord, and then shortly divides into three branches—short saphenous, for the supply of the skin upon the outside of the leg and of the fifth toe, and internal and external popliteal, the former for the innervation of the calf muscles, the latter for that of the extensors of the leg and of the dorsal surface of the foot. It should be noticed that in correspondence with the absence of the first toe there is no anterior tibial branch.

Parsons, Proc. Zool. Soc. 1896, p. 710.

EDENTATA.

D. 853. Right hind-limb and part of the vertebral column of a Three-toed Sloth (*Bradypus tridactylus*), showing the crural and sciatic plexuses and the distribution of the chief nerves of the limb. The crural plexus (seen best on the left side of the specimen) is formed by roots derived from the second, third, and fourth (furcal) lumbar nerves. A ventral branch from its last whole root joins a branch from the posterior (sciatic) division of the furcal nerve to form the obturator nerve. The sciatic plexus consists of four roots—the posterior division of the furcal nerve, two whole roots (the first and second sacral nerves), and the anterior division of the bigeminal (third sacral) nerve. The further course of the sciatic nerve is shown on the reverse side of the specimen. In the thigh it innervates the flexors including the præsemimembranosus, and then divides in the hollow of the knee into external and internal popliteal branches. The latter innervates the flexors of the shank and foot; the former subdivides into short saphenous, peroneal and musculo-cutaneous, and anterior tibial nerves that respectively innervate the soleus and the skin on the outer side of the foot, the peronei and the dorsum of the foot, and the extensors of the shank.

D. 854. The pelvis with the hinder end of the body of a Two-toed Sloth (*Cholœpus didactylus*), showing the pelvic plexus. This differs from that of *Bradypus* in the inclusion of an extra root: the crural plexus being formed by the first three lumbar nerves, and the sciatic by the third and fourth lumbar and the first three sacral. The third lumbar nerve, and not as in *Bradypus* the fourth, is the furcal nerve. The origin of the obturator is essentially the same as in *Bradypus*.

UNGULATA.

D. 855. The left hind-limb and part of the trunk of a Goat (*Capra hircus*), showing the pelvic plexus and the nerve-supply to the limb. The plexus is formed by the last three lumbar nerves and the first two sacral, the last lumbar being the furcal nerve. The obturator arises by two roots derived respectively from the united whole roots of the anterior crural and from the stem of the furcal nerve. The branches of the sciatic to the hamstring muscles and its internal and external popliteal divisions are shown by the removal of parts of the gracilis, semimembranosus, and adductors.

RODENTIA.

D. 856. Part of the trunk and right hind-limb of a Rabbit (*Lepus cuniculus*), showing the pelvic plexus. The anterior crural nerve is mainly derived from the sixth lumbar, it receives a small root from the fifth lumbar, but no contingent from the furcal (seventh lumbar) nerve. The sciatic nerve has only one whole root—the first sacral nerve. This feature is general among Rodents. The obturator, as usual, has two roots derived respectively from the anterior crural and the furcal nerves.

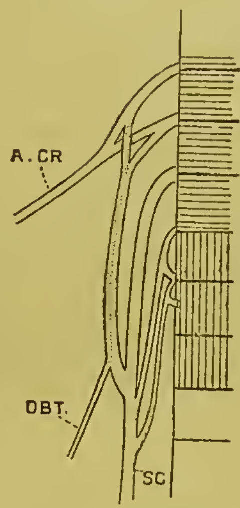
Krause, Anat. des Kaninchens, 1868, p. 252.

INSECTIVORA.

D. 857. Left hind-limb and part of the vertebral column of a Hedgehog (*Erinaceus europæus*), showing the pelvic plexus and the course of the chief nerves of the limb. The crural plexus results from the combination of two whole roots (the second and third lumbar nerves) with the anterior division of the furcal nerve (the fourth lumbar). The sciatic plexus consists of the posterior division of the furcal nerve, two whole roots (the fifth and sixth lumbar nerves), and a minute branch of the bigeminal (the first sacral) nerve. The obturator is derived from the posterior division of the furcal nerve and from the two whole roots of the anterior crural. Isolated specimens of the plexuses of another individual are mounted at the side to show more clearly than in the entire specimen the relations of the furcal nerve to the crural and sciatic plexuses and to the obturator nerve.

D. 858. Right hind-limb and part of the trunk of a Golden Mole (*Chrysochloris trevelyani*), showing the pelvic plexus. This is smaller than in the Hedgehog, and consists of only five roots—a whole root (second lumbar nerve) and the anterior division of the furcal nerve forming the crural plexus, and the posterior division of the furcal, two whole roots, and the anterior division of the bigeminal (second sacral), the sciatic.

Fig. 8.



Pelvic plexus of *Chrysochloris trevelyani.*

A.CR. Anterior crural. OBT. Obturator. SC. Sciatic. Dotted: the obturator root from the anterior crural. Horizontal lines: lumbar vertebræ. Vertical lines: sacral vertebræ.

CHIROPTERA.

D. 859. The posterior end of the vertebral column, with the pelvis and left hind-limb of a Fruit Bat (*Pteropus edwardsi*), showing the pelvic plexus. The last lumbar but one is the furcal nerve. It gives off roots to the anterior crural (visible with difficulty and only on the right side) and to the obturator. The anterior crural is also derived from the two lumbar nerves above, and the sciatic from the last lumbar and first sacral. Upon the left side the branches of the sciatic nerve have been exposed.

PRIMATES.

D. 860. The left leg and hip of an Orang-utan (*Simia satyrus*), showing the distribution of the nerves that arise from the pelvic plexus. In comparison with the same system in Man, it may be noted that, the anterior crural divides up into its several main branches while yet within the pelvis, the middle cutaneous being given off while the nerve is still under cover of the ileo-psoas muscles, and the combined internal saphenous and pectineal branch leaving the main trunk some 2 inches (5 cm.) within the brim of the pelvis.

The great sciatic, as it passes the trochanter gives off a large branch for the hamstring muscles; later it divides in the usual way into internal and external popliteal branches. Elaborate descriptions of the plexuses and limb-innervation in the Anthropoid Apes and detailed comparison with the same structures in Man will be found in the following papers:—

Bolk, Morph. Jahrb., Bd. xxv. 1898, p. 305.

Saberton, Stud. Anat. Univ. Manchester, Young, vol. iii, 1906, p. 166.

Sperino, Anat. d. Chimpansé, p. 434.

D. 861. Right half of the posterior end of the vertebral column of a Chimpanzee (*Anthropopithecus troglodytes*), showing the pelvic plexus. The anterior crural nerve is formed by the union of the second and third lumbar nerves with branches from the first and fourth. The posterior division of the fourth lumbar (furcal) nerve combines with the first sacral, and with the anterior division of the second sacral, to form the sciatic nerve. The obturator arises by three roots, derived respectively from the two whole roots of the anterior crural and from the furcal nerve. This plexus closely resembles that of Man except for the presence of only one whole sciatic root.

D. 862. The left leg and hip of a Chimpanzee (*Anthropopithecus troglodytes*), showing the distribution of the nerves that arise from the pelvic plexus. The main branches of the anterior crural and sciatic nerves closely resemble in their general disposition and mode of branching those of Man, and apparently show none of the peculiarities noted in the previous specimen of the Orang-utan.

Sympathetic System.

The sympathetic is a portion of the cerebro-spinal system set apart for the innervation of the viscera and the control of the blood-vessels, glands, and involuntary muscles. The nerves that compose it consist of visceral motor and to a less extent of visceral sensory components. Branches of the spinal and also in most cases, of the cranial nerves, containing both afferent and efferent fibres, form connections (rami communicantes) with a series of ganglia (vertebral sympathetic ganglia). From these ganglia fibres, more numerous than those that enter by the rami communicantes, are given off for the innervation of the visceral and vascular system either directly or through the mediation of secondary (prevertebral) sympathetic ganglia.

An anatomically separate sympathetic system has not hitherto been discovered in the Dipnoi, and in Cyclostomes it is extremely rudimentary; but in the other classes of Vertebrates it is always present, sometimes only in the trunk region (Elasmobranchs), though usually extending from the trigeminal to the hinder end of the body or even (Teleostea, Urodeles) to the tip of the tail. In Mammals it consists of a cranial part which is derived from certain fibres in the 3rd, 7th, 9th, and 10th cranial nerves, and of a spinal part which is wholly derived from the thoracic and anterior half of the lumbar spinal nerves: the other spinal nerves not contributing to it at all. Behind the head, the vertebral ganglia are arranged on either side of the mid-line in linear series united by longitudinal connectives, the whole being known as the sympathetic cord. The nerves that spring from these ganglia are chiefly gathered together at certain points to form plexuses and ganglionic masses, from which are given off nerve filaments for the various visceral regions. Thus in Mammals, where these nervous concentrations are most definite, cardiac, solar, and hypogastric plexuses can be distinguished for the supply of the thoracic, abdominal and pelvic viscera. Sympathetic fibres are also distributed to the blood-vessels and the sweat-glands and the *arrectores* of the hairs of the skin.

Jaquet, Arch. des Sci. Méd., t. v. 1900, p. 163.
Gaskell, Jour. Physiol., vol. vii. 1886, p. 1.

PISCES.

ELASMOBRANCHII.

D. 863. Part of the trunk of a Ray (*Raja clavata*), showing portions of the sympathetic nervous system stained with osmic acid. The most anterior sympathetic ganglion is intimately united with the foremost adrenal body. It lies at the side of the œsophagus close behind the "diaphragm," and receives a large number of rami communicantes from the anterior spinal nerves (seven are visible in this specimen). From its medio-ventral border a number of anastomosing branches follow the cœliac and superior mesenteric arteries to the abdominal viscera.

Other sympathetic ganglia lie within the mesentery, either free or in connection with the adrenal bodies. The latter receive connectives from the spinal nerves and are connected longitudinally by an irregular network of fibres, which spreads downwards over the mesentery and there enters into connection with the above-mentioned isolated ganglia. A minor splanchnic nerve formed by the concentration of the general mesenteric network accompanies the inferior mesenteric artery.

Chevrel, Arch. Zool. Exp., t. v *bis*, 1887, p. 56.

AMPHIBIA.

D. 864. A Frog (*Rana temporaria*) with the sympathetic system shown from the ventral aspect. Within the head, the sympathetic cord extends forward to the trigeminus (*cf.* D. 814) and passes backwards from this point across the median surface of the periotic capsule to the root of the vagus, with which it leaves the skull.

From the ganglion of the vagus it runs back closely applied to the ventral surface of the hypoglossal (first spinal) nerve and to the roots of the brachial plexus. From this point to its termination upon the posterior root of the sciatic plexus, the cord lies at some distance ventral to the spinal nerves but is connected to each by a long slender ramus communicans. The point of union of each ramus with the cord is marked by a pigmented ganglion.

In this specimen the cranial, spinal, and limb nerves are also shown. O. C. 1311 H.

Ecker's Anat. des Frosches, 2nd Aufl. Gaupp, Abt. 2, p. 214.

REPTILIA.

EMYDOSAURIA.

D. 865. Head and trunk of a young Alligator (*Caiman sclerops*) with the sympathetic system exposed from the ventral aspect. The cervical part of the system is stated to be double and to consist of superficial and deep cords. In this specimen the deep cord only is shown passing backwards within the vertebral canal. The cord is connected with each spinal nerve as it passes it, but shows no sign of ganglionic enlargement except at the hinder part of the neck in the region of the brachial plexus, where ganglia are well marked. Several of the cervical ribs have been removed to expose this part of the system more clearly. A double connective embracing the transverse process of the vertebra unites the last brachial with the next following ganglion.

On a level with the seventeenth to the twentieth vertebræ several large branches are given off from the sympathetic cord to form the chief visceral plexus of the body. Beyond this point the cord is not shown.

Jaquet, Arch. des Sci. Méd., T. v. 1900, p. 186.

CHELONIA.

D. 866. Head, neck, and body of *Sternotherus derbianus*, showing portions of the sympathetic system. In the neck, the sympathetic cord accompanies the vagus, and shows in the specimen three small ganglionic enlargements, the last of which is situated opposite the anterior roots of the brachial plexus. This is succeeded by two ganglia lying upon the posterior roots of the plexus, and from that point backwards the sympathetic chain is represented by a delicate cord, closely adherent to each spinal nerve.

Jaquet, Arch. des Sci. Méd., T. v. 1900, p. 187.

AVES.

Thébault, Ann. Sci. Nat., sér. 8, T. vi, 1898, p. 1.

D. 867. The vertebral column and neighbouring parts of a Wild Duck (*Anas boscas*), showing the ganglionated cords of the sympathetic system and the origin of the splanchnic nerves. In the cervical region the sympathetic cords lie within the vertebral canal closely united by a series of ganglia to the successive spinal nerves. A superficial cord (not shown in this specimen) is stated to accompany the vagus from the anterior cervical sympathetic ganglion to the brachial plexus. On a level with the brachial plexus the ganglionic chain leaves the vertebral canal and lies upon the ventral surface of the spinal nerves close to the vertebral column, united to each by a large ganglion. The primary ganglia in the trunk are connected by a single nerve strand that passes dorsal to the ribs. An additional connective occurs ventral to the ribs between the three anterior thoracic ganglia. The great splanchnic nerve is formed by the union of branches derived from the second, third, fourth, and fifth thoracic ganglia. Branches from the three succeeding ganglia combine to form the lesser splanchnic. In the abdominal region the sympathetic cords are less developed and the ganglia are further removed from the spinal nerves, being connected with them by long rami communicantes.

Marage, Ann. Sci. Nat., sér. 7, T. vii. 1889, p. 16.

D. 868. The rectum of a Wattled Brush-Turkey (*Catheturus lathami*), with its mesentery, showing the intestinal cord of the sympathetic system. This nerve-cord runs in the mesentery parallel to the rectum at about 10 mm. distance from it, and gives off numerous minute branches to the gut-wall. Anteriorly it is continuous with a less conspicuous sympathetic cord (removed in the specimen) that follows the course of Meckel's loop and arises in the gastric plexus. Posteriorly it receives several strong branches from the hinder end of the abdominal sympathetic and spreads out on the cloaca.

The cord is double in its posterior half, and shows here and there indistinct ganglionic enlargements.

MAMMALIA.

Jaquet, Arch. des Sci. Méd., T. v. 1900, p. 203.

UNGULATA.

D. 869. Head and trunk of a Goat (*Capra hircus*), with the sympathetic system shown from the left side. The general arrangement of the sympathetic cords is very similar to that of the Cat (D. 871). The combined posterior cervical and anterior thoracic ganglion is, however, relatively not so large, and has rami communicantes to the last two cervical and the first thoracic spinal nerves only. The ramus to the seventh cervical is, however, continued forward in a series of loops (indicated by black bristles) from nerve to nerve within the vertebral canal, where it goes by the name of the vertebral nerve. This nerve occurs in several Mammals, but not in Man, and may extend forward as far as the cranium. The close union of the free part of the cord between the anterior and posterior cervical ganglia with the vagus trunk is well shown. The posterior cervical and the first, fifth, and sixth thoracic ganglia contribute to the cardiac plexus. Splanchnic nerves for the solar plexus arise from the twelfth, thirteenth, fourteenth, and fifteenth thoracic ganglia, and branches are given off opposite the kidney to form the hypogastric plexus.

D. 870. One of the semilunar ganglions of a Horse (*Equus caballus*). O. C. 1383. *Hunterian.*

CARNIVORA.

D. 871. Head and axial parts of the trunk of a Cat (*Felis domestica*), showing the sympathetic cords from the ventral aspect together with some of the branches and plexuses given off from them. Within the neck, the cord stretches free between an anterior cervical ganglion (on a level with the ganglion nodosum of the vagus) and a small middle cervical ganglion situated opposite the last cervical vertebra. Branches are contributed from both these ganglia to the cardiac plexus. The middle cervical ganglion is connected by two cords to the combined posterior cervical and anterior thoracic—a large compound ganglion united by rami communicantes to the last two cervical and first three thoracic spinal nerves, from which a strong branch is contributed to the cardiac plexus. Between this ganglion and the diaphragm, the cord is represented by a chain of small ganglia, each connected by a ramus communicans of variable length to a spinal nerve. The ganglia on the confines of the thoracic and lumbar regions supply splanchnic nerves to the solar plexus and semilunar ganglion. Behind the diaphragm, the ganglia of the chain become somewhat larger and the cords approximate to the axial line.

PRIMATES.

D 872. A human semilunar ganglion, showing its great size in comparison with that of the Horse. O. C. 1382.
Hunterian.

E.

ORGANS OF SPECIAL SENSE.

John Hunter, Croonian Lecture on Muscular Motion, No. 1, 1776. Works of Hunter, Palmer, vol. iv. p. 198. Lectures on the Principles of Surgery, *ibid.* vol. i. p. 261.
Essays and Observations, edit. R. Owen, vol. i. p. 165.
Retzius, Biol. Untersuch. N. F. iv. 1892, p. 49.

All living matter is in a general way responsive to alterations in the condition of the media in which it exists. But apart from this general sensitiveness, in Metazoa certain cells either belonging to or derived from the integument are modified in a definite manner to respond to particular kinds of stimulation only, and so form specific organs of sense. Thus, there are special organs of touch affected only by alterations in pressure, organs of taste and smell for the discrimination of certain chemical properties of matter when in solution, organs of hearing for the appreciation of material (sound) vibrations, organs of vision and light-perception responsive in an analogous way to etherial (light) vibrations, special organs of equilibration (response to alterations in the position of the body) which usually are combined with the auditory organs, and, in the lower Vertebrates and in Invertebrates, certain sense organs of unknown function.

Besides these special sense organs, examples of which are included in this section, mention must also be made of sense organs for the perception of temperature variations, and of the muscular sense by which the amount of the contraction of the muscles is gauged, although in the absence of any concentration of the minute end organs concerned upon special modified parts of the body, they cannot be represented in this collection.

The mechanism for the reception and transmission of sensory stimuli consists in its simplest terms of an epidermal senso-neural cell, provided distally with a process which is directly acted upon by the exciting cause, and drawn out proximally into a conductive filament (afferent nerve-fibre) that conveys the stimulation to a nerve centre composed of the aggregation of similar afferent fibres with motor and connecting nerve elements. It seems probable (Retzius) that during the course of evolution the senso-neural cells which, in simple animals (*e. g.* Annelida), retain their primitive position in the epidermis and may even still be found there in the highest animals in special sense organs (*e. g.* the nose), have gradually migrated into the body towards the central nervous system, where they form the sensory ganglia upon the cranial and spinal nerves, and at the same time retain their connection with the integument or sensory epithelium of the special sense organs by filiform processes (afferent nerve-fibres) that end either freely between the cells of the epithelium or in contact with particular cells which have been secondarily developed to form the special receptive end organs for the various senses.

TACTILE ORGANS.

John Hunter, Croonian Lecture on Muscular Motion, No. 1, 1776. Works of Hunter, Palmer, vol. iv. 1837, p. 198.
Essays and Observations, edit. R. Owen, vol. i. p. 182.

INVERTEBRATA.

Although in the simpler Metazoan Invertebrata the restriction of each sensory end organ to response to one particular form of stimulation is probably not complete, in the majority certain sense-cells which are chiefly concentrated upon feelers or similar appendages are solely or pre-eminently tactile. These cells lie in the surface-epithelium when the integument is soft and moist, and are thread-like with a terminal process or tuft of processes projecting freely into the surrounding medium; but when the body is covered with a hard cuticle (*e.g.* Arthropods) they lie deeper, and are stimulated indirectly by the movements of special cuticular setæ.

CŒLENTERATA.

E. 1. The oral disc with the surrounding tentacles of a Sea Anemone (*Actinia* sp.). The tentacles, which, in addition to their offensive, defensive, and food-capturing functions, may be regarded as tactile organs of a very simple character, are hollow processes of the body-wall, and are the special seat of sensory cells. The epithelial sense-cells in the Actiniæ are stated (Hertwig) to be elongated in form, with a median or basal nucleus, and to be produced superficially into one, or at most two, fine hair-like processes and to give off from their deeper surface a number of fibrillæ that join the meshwork of nerve-fibres situated between the outer epithelial and muscular layers of the body-wall.

O. C. 1386. *Hunterian.*

O. & R. Hertwig, Jena. Zeits., Bd. xiii. 1879, p. 478.

E. 2. A Sea Anemone (*Anthea cereus*) with its crown of tentacles extended.

E. 3. A craspedote Medusa (*Olindias mülleri*). The margin of the umbrella is beset by a number of long flexible tentacles, which, because of the large proportion of sensory cells in their epithelial covering, are no doubt simple touch organs, although they are also the special seat of nematocyst batteries and are actively used in the pursuit of prey. Between every two tentacles are small pear-shaped bodies of unknown function, which may possibly be immature stages of prey-catching tentacles; or perhaps organs of equilibration.

Müller, Arch. f. Naturgesch., Bd. xxvii. 1861, p. 314.

E. 4. An acraspedote Medusa (*Pelagia noctiluca*). The umbrella edge is divided by sixteen indentations, alternately shallow and deep, into a series of sensory folds. Eight long (30–40 mm.) tactile tentacles arise from the margin in the deeper clefts, and within the shallower clefts, enveloped in processes of the sensory folds, are peculiar sense-organs (rhopala) of unknown function, though possibly they may be in some sense equilibrating organs. A typical rhopalon consists of a minute finger-shaped process containing at its free end a mass of crystals embedded in the cells of the endoderm, and with its base surrounded by a pad of elevated sensory epithelium. Upon the upper margin of the specimen two rhopala have been displayed by removing the greater part of the sensory folds; they have the appearance of two black specks. The other rhopala can also be seen, though with more difficulty, deeply buried between the sensory folds.

O. & R. Hertwig, Das Nervensystem u. Sinnesorg. der Medusen, 1878, p. 109.

ANNELIDA.

Jourdan, Ann. Sci. Nat., sér. 7, T. xiii. 1892, p. 227.

Retzius, Biol. Untersuch., N. F. iv. 1892, p. 1; vii. 1895, p. 6; viii. 1898, p. 94; ix. 1900, p. 85; x. 1902, p. 25.

E. 5. The anterior part of a Marine Worm (*Marphysa sanguinea*). The head region is provided with five straight tactile tentacles, situated upon the prostomium and innervated (*cf.* D. 5) from the mid-brain. Small conical tactile cirri occur also upon each body segment, one at the base of each neuropodium and notopodium. These though minute are distinctly visible in the region of the body anterior to the gills.

ARTHROPODA.

von Rath, Zeits. f. Wiss. Zool., Bd. lxi. 1896, p. 499.

CRUSTACEA.

von Rath, Zool. Anz., Bd. xiv. 1891, pp. 195, 205.

Retzius, Biol. Untersuch., N. F. vii. 1895, p. 12.

E. 6. The brain and left antenna of a Lobster (*Homarus vulgaris*). The antenna consists of a long filament (flagellum) borne upon three enlarged basal joints. The distal (filamentary) part is covered with large numbers of tactile hairs and although very flexible, owing to its cuticle consisting alternately of rings of soft and hard chitin (*cf.* B. 45), has no power of movement in itself but can only be directed as a whole to any desired spot by the action of suitable muscles upon the three basal joints. The nerve for the antenna arises from the side of the brain, and until it reaches the base of the flagellum contains both motor and sensory fibres. From this point it becomes purely sensory and divides into a brush of separate fibre bundles.

INSECTA.

E. 7. A Black-beetle (*Periplaneta orientalis*). The antennæ are long, filiform and flexible, and probably serve chiefly as organs of touch, although the histology of the brain centres from which they are supplied (*cf.* D. 27) and the structure of some of the end organs upon them suggest that they possibly also have an olfactory function. The brain has been exposed to show the large antennary lobes upon its anterior surface from which the nerves to the antennæ arise.

MOLLUSCA.

Retzius, Biol. Untersuch., N. F. iv. 1892, p. 11; ix. 1900, p. 94.

E. 8. The soft parts of a Scallop (*Pecten maximus*) minutely injected. The left lobe of the mantle and corresponding branchiæ have been removed showing the muscular organ called the " foot," which protrudes from the antero-ventral surface. It terminates in an expanded disc, which is an organ of adhesion and (in the young) subservient to locomotion as well as touch. Numerous small tentacles or feelers are arranged along the thickened margin of the mantle, and the sense of touch is probably further exercised by the highly vascular fimbriated palps that extend from either side of the mouth. Their situation is indicated by a bristle which is placed in the mouth.

O. C. 1388. *Hunterian.*

Rawitz, Jena. Zeitschr., Bd. xxii. 1888, p. 478.

E. 9. A similar specimen in which the blood-vessels have not been injected.

E. 10. A Cockle (*Cardium norvegicum*) with the hinder parts of the valves removed to expose the mantle border in this region and the siphons. Tentacles, chiefly it would seem of tactile function, are confined to these parts of the mantle edge, this being the only part of the mantle exposed in the ordinary half-buried position of the animal. The mouth of the incurrent (lower) siphon in particular is guarded by a fringe of slender tentacles that overhang the orifice.

Drost, Morph. Jahrb., Bd. xii. 1887, p. 163.

VERTEBRATA.

In Vertebrata, as in Invertebrata, the sense of touch is distributed over all parts of the body surface, but certain areas are in a higher degree than others the seat of tactile nerve-endings and are also frequently modified in form to fit them to act in a special sense as organs of touch.

Amongst the numerous kinds of sensory nerve terminations that occur in or beneath the skin, it is extremely difficult to determine which are those specially adapted for the reception of tactile impressions. In Fishes and aquatic Amphibia the sense of touch is probably lodged, to some extent, in certain end organs known as "nerve-buds" which occur in various places upon the surface of the skin and resemble "taste-buds" in structure (in many Fishes taste-buds with truly chemical, *i. e.* gustatory function, are found on the outer surface of the head, especially in barbules &c.). In the higher, land Vertebrates the specific functions of the various cutaneous nerve-endings are most obscure. In Mammals certainly, hairs in all parts of the body are extremely sensitive to touch and no doubt are particularly well adapted to stimulate, by the movements of their roots, tactile end organs in the deeper part of the skin. These end organs, in the case of special bristles, such as the "whiskers" of Carnivora or the bristle-like feathers at the root of the beak in some Birds, are most probably the "tactile cells" found at the base of these structures, but in the case of ordinary hairs such cells have not been observed, and it must be supposed that the stimulation is received by the meshwork of nerve fibrillæ that envelopes the hair follicle.

There is also much reason to include amongst organs of touch the "touch (Meisner's) corpuscles" which occur in great numbers in the dermal papillæ of the hairless parts of the skin (palmar and plantar surfaces of Man), and, in Birds, Gandry's corpuscles and, in Amphibia, the touch spots.

As regards the functions of the other cutaneous sensory nerve-endings—free filamentary nerve terminations, Pacinian corpuscles, end-bulbs (Krause's corpuscles), Ruffini's corpuscles, &c. —very little definite is known, but it seems likely that they are influenced rather by temperature, pain, and muscular sense impressions, than by touch.

PISCES.

Jobert, Ann. Sci. Nat., sér. 5, T. xvi. 1872, p. 29.

Tactile organs on the Head.

GANOIDEI.

E. 11. A portion of the skin from the lower surface of the snout of a Sturgeon (*Acipenser sturio*) including two tactile barbels. Bristles have been inserted into the orifices of some of the mucous canals, which are situated abundantly on this part of the head (see Organs of the Lateral Line). O. C. 1397. *Hunterian*

Dogiel, Arch. f. mikr. Anat., Bd. xlix. 1897, p. 769.

E. 12. A portion of the lip of the same Sturgeon, showing its villous surface. This is probably specially sensitive to tactile impressions. O. C. 1396. *Hunterian.*

TELEOSTEA.

Leydig, Zool. Jahrb., Bd. viii. 1895, p. 1.

E. 13. A Red Mullet (*Mullus barbatus*). Two white, stiff barbels, part of the hyal apparatus, are attached to the chin. They are constantly used as touch organs when the fish is feeding on the bottom. When swimming freely in the water, they are completely concealed in a groove beneath the head.

Preserved in 50 per cent. glycerine.

Jobert, Ann. Sci. Nat., sér. 5, T. xvi. p. 59.

E. 14. A Cat-fish (*Bagrus docmac*). The mouth is surrounded by eight flexible tactile barbels of different length. On either side, one arises from the front margin of the posterior nostril, one—by far the longest—from the skin covering the upper jaw, and two from the posterior edge of the mandible. The Cat-fishes are bottom feeders.

E. 15. The head and fore part of the trunk of a Three-bearded Rockling (*Motella tricirrata*). Upon the head there are three tactile barbels—two formed by a prolongation of the upper border of the anterior nostrils, and the third upon the chin. The pelvic fins are also modified, by the elongation and marked sensitiveness of the two anterior rays, to act as special organs of touch. They appear to be the chief agents in the search for food. The way in which they are used has been described by Bateson; he says: "The Rockling searches by setting its filamentous pelvic fins at right angles to the body, and then swimming about feeling with them. If the fin touch a piece of fish or other soft body, the Rockling turns its head round and snaps it up with great quickness."

Bateson, Jour. Mar. Biol. Assoc., vol. i. 1889, p. 214.

E. 16. The head of a Sole (*Solea vulgaris*). In this fish the surface of the face, on the blind side, is covered by a number of small conical sensory papillæ, which are used in the search for food. As the fish crawls over the sea-floor by means of its dorsal and ventral fin-rays, it pats about with its head, thus bringing the papillæ on its cheek into contact with all parts of the underlying surface, and by their means examining and testing any substance likely to serve as food. As a rule the papillæ are grouped in clusters of five or six upon a common fleshy base. They cover the whole blind surface of the face, with the exception of the lips and nostrils, and extend back as far as the level of the sixth dorsal fin-ray. Behind that line they occur only over certain areas: along the dorsal and ventral margins of the head and upon the anterior parts of the lateral line.

Bateson, Jour. Mar. Biol. Assoc., vol. i. 1889, p. 240.

Tactile organs on the Pectoral Fins.

TELEOSTEA.

E. 17. An Indian Fish (*Polynemus paradiseus*) that frequents estuaries, feeding near the muddy bottom. The seven lower pectoral fin-rays on each side are free and greatly elongated, the upper three being often longer than the body. They are used as touch organs. O. C. 1398 B.

Tactile organs on the Pelvic Fins.

TELEOSTEA.

E. 18. A small Fish (*Trichogaster fasciatus*). The pelvic fins are represented by a pair of long tactile filaments.
O. C. 1398 A.

AMPHIBIA.

Leydig, Morph. Jahrb., Bd. ii. 1876, p. 287.

E. 19. A small part of the body with the right anterior extremity of a Siren (*Siren lacertina*). The limb is terminated by four straight digits which however are mutilated in the specimen. In the Siren the anterior extremities alone are developed, and apparently serve more as tactile than as locomotive organs. O. C. 1399. *Hunterian.*

John Hunter, Essays and Observations, edit. R. Owen, 1861, vol. ii. p. 393.

AVES.

E. 20. The cranium and upper mandible of a Spoon-bill (*Platalea leucerodia*), minutely injected to show the great vascularity of the dilated extremity of the mandible, which in the natural state is covered with a soft cuticle in which are lodged numbers of special tactile end organs known as "Herbst's corpuscles." The beak is thus well adapted to the office of exploring in mud or sand for the small worms, molluscs, &c., which constitute the food of this Bird.
O. C. 1402. *Hunterian.*

Jobert, Comptes Rendus, Ac. Sci., T. lxxv. 1872, p. 1780.

E. 21. Head of a Duck (*Anas boscas*), in which some of the main trunks of the trigeminus have been exposed. The great size of this group of nerves in the Duck and certain other Birds is necessary for the innervation of special sense organs (Gandry's corpuscles), probably of a tactile nature, that occur in great numbers along the margins of the beak and upon the surface of the mouth and tongue.

Hesse, Arch. f. Anat., 1878, p. 288.

MAMMALIA.

In selecting examples of tactile organs among Mammals it has been decided to ignore, except in a few cases, the special tactile function of the ventral surfaces of the fore and hind feet, for, apart from the hands of Primates, this is not their most important function, which in almost all cases is locomotion. The few specimens that have been retained in this section to show the ventral surface of the fore-feet, have been chosen with a view to illustrate the arrangement and distribution of the papillary ridges. These were probably at first developed to assist in locomotion by the prevention of slipping, but among Primates, and especially in Man, have become important accessories to the organs of touch, by mechanically stimulating the end organs in the underlying papillæ by their movements due to friction upon their exposed edges.

Whipple, Zeitschr. f. Morph., Bd. vii. 1904, p. 261.
Klaatsch, Morph. Jahrb., Bd. xiv. 1888, p. 407.

MONOTREMATA.

E. 22. Head of a Duck-billed Platypus (*Ornithorhynchus anatinus*) with the calvaria removed. It shows the numerous large branches of the trigeminus distributed to the "bill." In the skin of the bill are vertically arranged cylinders of epithelium (push rods), which can be slightly depressed, and by thus compressing a group of Pacinian bodies upon which they rest, initiate a centripetal nervous impulse. O. C. 1380 I.

Poulton, Quart. Jour. Micr. Sci., vol. xxxvi. 1894, p. 143.

E. 23. A similar preparation with the lower jaw removed. O. C. 1380 H.

MARSUPIALIA.

E. 24. The right fore- and hind-foot of a Flying Phalanger (*Petaurus sciureus*). In the fore-foot (the left-hand specimen) upon the ventral surface of the arm close above the wrist, there is a slight integumentary eminence pitted by several large hair follicles that during life lodged a tuft of vibrissæ. A similar tuft of relatively large hairs (indicated by black paper) is present in a corresponding position upon the ankle. Such tufts of vibrissæ (see Nos. E. 28, E. 30, E. 31, E. 35, E. 36, E. 47, E. 55, E. 56), are commonly found upon the wrist in those Mammals whose fore-limbs are not solely used for walking. The tuft on the ankle is rare. Although the use of these tufts is not definitely proved, there can be little doubt that they are special touch-organs comparable to the "whiskers" of a Cat.

The skin upon the surface of the pads of the fore-foot can be seen, though not very easily, to be corrugated by delicate transverse ridges similar to the papillary ridges of the palmar and plantar surfaces of Man.

*Beddard, Proc. Zool. Soc., 1902, vol. i. p. 127.
Klaatsch, Morph. Jahrb., Bd. xiv. 1888, p. 407.

E. 25. The fore-feet of a native Cat (*Dasyurus* sp.). The palmar surface is naked and is covered with small warty excrescences of the integument except along the central ridge of each foot-pad, where to the naked eye the skin appears smooth. A slight magnification (fig. 9, p. 54), however, shows that the epidermis upon these areas is raised into a series of close-set parallel ridges arranged at right angles to the long axis of the pad. These are comparable to the papillary ridges of Primates, and like them are probably accessories to the organs of touch.

* This specimen and Nos. E. 28, E. 30, E. 35, and E. 47, were selected from those described by Mr. Beddard; the rest of the dissections referred to in his paper are preserved in the College stores.

E. 26. The left fore- and hind-foot of an Opossum (*Didelphys marsupialis*). The foot-pads are large and prominent in this species, and are covered all over by papillary ridges,

Fig. 9.

Fig. 10.

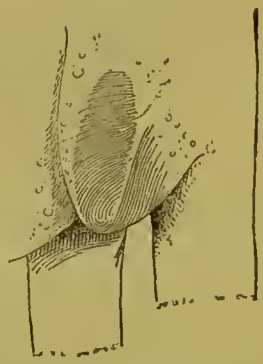


Fig. 9.—The first and second interdigital pads of the fore-paw of *Dasyurus* sp.

Fig. 10.—Interdigital pad of the fore-paw of *Didelphys marsupialis*.

except in the case of the ulnar and last interdigital pads of the fore-foot, which are smooth. The ridges upon the proximal pads are transverse in direction as in the Dasyure, but upon the interdigital and terminal pads are more complicated, being arranged in the first case in concentric loops around the apex of the pad and in the latter case having a longitudinal direction, those at the sides passing transversely across the apex of the pad.

E. 27. Right fore- and hind-foot of a Phalanger (*Phalanger maculatus*). The system of papillary ridges is more highly developed than in either of the previous specimens and covers the whole of the plantar and palmar surfaces to the roots of the digits, and occurs also upon the terminal digital pads. In the hand, the palmar ridges are arranged transversely upon the apices of the foot-pads, becoming circumferential in the intermediate spaces, and in the centre of the palm and around its margin being broken up to form prominences intermediate in appearance between papillary ridges and papillæ. In the foot, fully formed ridges cover the whole plantar surface, and, except upon the apex of the fibular pad, are not clearly separable by their direction into those upon the apex of the pads and those in the intermediate spaces, but form a continuous pattern in which the general direction of the lines is at right angles to the plane of closure of the foot in grasping. The ridges upon the terminal pads in both feet are arranged as in the same pads in the Opossum.

EDENTATA.

E. 28. The left fore-arm and foot of a Hairy Armadillo (*Dasypus villosus*). The skin has been partially raised from the flexor surface of the limb to show a nerve entering the skin beneath a tuft of coarse hairs situated upon the radial side of the wrist. These hairs, although little, if at all, different from the rest of those upon the fore-arm, from their position and special innervation should probably be regarded as an extremely generalised form of carpal tuft. The foot-pads are not clearly defined and have a perfectly smooth surface.

E. 29. The skin from the intermandibular space of a Hairy Armadillo (*Dasypus villosus*) mounted, with the anterior end uppermost, to show a tuft of five strong vibrissæ implanted in a rounded prominence of the skin.

UNGULATA.

HYRACOIDEA.

E. 30. Foot and part of the fore-limb of a Cape Hyrax (*Procavia capensis*). The skin has been raised from the underlying tissues to show the follicles of the carpal vibrissæ. They are only two in number, one having fallen out. Mr. Beddard states (*l. c.* p. 133) that in this specimen no nerve could be traced to the carpal tuft. The foot-pads have the normal positions, but are much expanded and extended owing to the locomotive adaptations of the foot (see Section H, Locomotive Organs). Their surface is smooth.

E. 31. Right fore-limb of a Hyrax (*Procavia* sp.), in which some of the chief nerves have been exposed to show the innervation by the internal cutaneous nerve of an integumentary excrescence, in the position of the carpal tuft.

PROBOSCIDEA.

E. 32. Trunk of a fœtal Indian Elephant (*Elephas indicus*). The right side shows the numerous large branches of the trigeminal and facial nerves. The skin is highly sensitive. The trunk (nose) is used for prehension, small bodies being grasped between the dorsal and ventral portions at the tip, or the trunk being coiled around the object when it is larger. It is also used in drinking, &c. O. C. 1379 B.

E. 33. A transverse section through the trunk of a young Indian Elephant (*Elephas indicus*) in which the chief nerves shown in the previous specimen have been cut at a higher level than the muscles and skin to show clearly their true position on either side of the nasal passages. O. C. 288 O *a*.
Presented by A. H. Garrod, Esq.

ARTIODACTYLA.

E. 34. Anterior part of the head of a Sheep (*Ovis aries*), showing the distribution of the trigeminal and facial nerves to the nostril and upper lip. The branches of the trigeminal are of great size to furnish the necessary nerve-supply to the tactile vibrissæ and highly sensitive muzzle.

The anterior part of the lacrymal canal and two branches of the olfactorius upon the septum nasi, are also shown in this specimen.

RODENTIA.

E. 35. The right fore-limb of a Squirrel (*Ratufa indica*). The skin has been removed from the radial surface to show a large branch of the ulnar nerve passing directly to the base of a remarkably well marked tuft of carpal vibrissæ. The surface of the foot-pads is marked by extremely fine striæ.

Klaatsch, Morph. Jahrb., Bd. xiv. 1888, p. 421.

E. 36. The left fore- and hind-foot of a Grey Squirrel (*Sciurus cinereus*) showing a similar tuft of vibrissæ on the ulnar side of the wrist. As in most Mammals, there is no corresponding tuft on the ankle. O. C. 1415.
Hunterian.

PINNIPEDIA.

E. 37. A portion of the skin of the cheek of a Seal (*Phoca* sp.) showing the large branches of the trigeminal distributed to the roots of the vibrissæ.

Numerous forms of nerve-ending have been observed in and around the roots of these specialised hairs, and although there is much uncertainty in assigning to each its special function, there is no doubt that some are tactile.

O. C. 1380 K.

Ksjunin, Arch. mikr. f. Anat., Bd. liv. 1899, p. 403.

E. 38. The skin of the upper lip of a Bearded Seal (*Phoca barbata*) showing the disposition of the whiskers in regular rows curving outwards and upwards from the mesial line of the muzzle and margin of the upper lip.

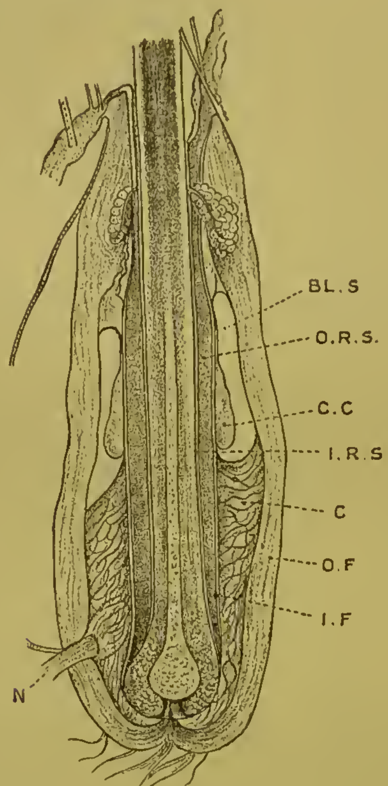
O. C. 1972 A.

E. 39. Three whiskers from the lip of a Sea Lion (*Otaria jubata*), in two of which the root-sheath is shown, and in the third the root-sheath with the dermal follicle and the nerve attached to its base. O. C. 1970. *Hunterian.*

E. 40. A section of the lip of a Sea Lion, in which the follicles of three whiskers are exposed and the large nerves which pass to them dissected out. O. C. 1971. *Hunterian.*

E. 41. A section of the lip of a Sea Lion with the sockets of several of the whiskers laid open. In the uppermost of these the blood-sinus of the follicle is plainly visible. This sinus is characteristic of tactile hairs of this description, and forms the upper part of an investment of erectile

Fig. 11.



Longitudinal section of the "whisker" of a Cat.
(After Dietl, Sitz. Ak. Wiss. Wien, Bd. lxiv. pl. i. fig. 2.)

BL.S. Blood sinus. C. Cavernous tissue. C.C. Circumferential cushion. I.F. Inner layer of follicle. I.R.S. Inner root-sheath. N. Nerve. O.F. Outer layer of follicle. O.R.S. Outer root-sheath.

tissue that surrounds the lower end of the outer root-sheath. This tissue serves to erect the bristle when in use.

O. C. 1972. *Hunterian.*

E. 42. The skin of the upper lip and cheek (including the border of the nostril and the angle of the mouth) from the right side of an adult male Elephant Seal (*Macrorhinus leoninus*), showing the large stiff whiskers and the short bristly hair

which covers the general surface of the skin. The whiskers are arranged in regular parallel rows as in *Phoca barbata* (E. 38), but are fewer in number and relatively smaller.
O. C. 1972 B. *Presented by Capt. R. C. Packe.*

E. 43. A section of the lip of a Walrus (*Odobœnus rosmarus*). On the left, three follicles and their contained whiskers have been so cut as to show the follicles, dermal papillæ and blood-sinuses. Within each sinus can also be seen a small mass of tissue attached to the inner wall. This forms a projecting ridge around the hair, and is always found in this position in the blood-sinus of these special tactile hairs.
O. C. 1974. *Hunterian.*

E. 44. A piece of the lip of a Walrus (*Odobœnus rosmarus*) including the follicles of three whiskers. From one of these the whisker has been withdrawn; a second is left entire with the whisker *in situ*; in the third a longitudinal section has been removed from the follicle and root of the hair exposing the dermal papilla and the root-sheath. The large nerves of these apparently rude organs of sensation are distinctly shown. O. C. 1973. *Hunterian.*

CARNIVORA.

ARCTOIDEA.

E. 45. The left fore-foot of a Ratel (*Mellivora indica*) showing the naked skin covering the soft foot-pads. The skin of the palmar surface is raised into small warty processes that give it a granular appearance. There is no difference in this respect between the skin of the foot-pads and that of the rest of the palmar surface. The Ratel uses its fore-paws for burrowing. O. C. 1414. *Hunterian.*

E. 46. The right fore- and hind-foot of a Racoon (*Procyon lotor*). O. C. 1414 A.
Presented by St. George Mivart, Esq.
Hoggan, Jour. Anat., vol. xiii. 1884, p. 183.

E. 47. Distal part of the left fore-limb of a Coatimundi (*Nasua nasua*) dissected to show the innervation of the carpal tuft of vibrissæ. The palmar integument of the paw shows the same warty surface as in the Ratel, without any linear arrangement on the foot-pads. This general granulation of the surface is usual among Carnivora and is also found among Aplacental mammals in Kangaroos. It is probably a more archaic condition than the grouping of the papillæ into parallel ridges.

Klaatsch, Morph. Jahrb., Bd. xiv. 1888, p. 416.

AILUROIDEA.

E. 48. A section of the lip of a Tiger (*Felis tigris*) exposing the roots of the whiskers and the dermal follicles in which they are lodged. One of the whiskers has been extracted and the dermal papilla upon which it rests exposed and made more visible by a bristle being placed behind it.

O. C. 1966. *Hunterian.*

E. 49. A section of the lip of a young Lion (*Felis leo*), minutely injected, showing the follicles of two whiskers which are laid open exposing the roots of the hairs. The large branches of the trigeminus by which the whiskers are innervated have been exposed a little way below the opened follicles. O. C. 1968. *Hunterian.*

INSECTIVORA.

E. 50. The head and shoulders of a Mole (*Talpa europæa*) with the maxillary trunk of the trigeminal exposed upon the left side. After passing through the infraorbital foramen this nerve gives rise to a bundle of large branches (indicated by a black bristle). The uppermost of these runs directly to the snout disc and there supplies a number of special tactile papillæ which cover its entire surface. These organs have been described by Eimer as consisting of masses of epidermic tissue each perforated by a tube filled to within a short distance of the surface with an homogeneous substance within which runs a bundle of nerve-fibrils. Each fibril is connected by a series of knob-like nerve-endings with the cells that form the walls of the tube.

The snout is certainly one of the most important of the

Mole's sense-organs and its extreme sensitiveness is shown by the fact, apparently well authenticated, that the slightest blow upon it causes immediate death.

Eimer, Arch. f. mikr. Anat., Bd. vii. 1871, p. 181.

E. 51. A Star-nosed Mole (*Condylura cristata*). The snout-disc is surrounded by a fringe of conical fleshy tentacles. These are the seat of special tactile papillæ, which are arranged in rows parallel to the axis of the tentacle and are similar in essential structure to those upon the snout of *Talpa*.

Ayers, Biol. Centralbl., Bd. iv. 1885, p. 356.

CHIROPTERA.

E. 52. The skin of the head of a Leaf-nosed Bat (*Megaderma frons*). The integument of the muzzle is enlarged to form a leaf-like expansion that surrounds the nostrils and stands up like the petal of a flower in front of the forehead. This "nose-leaf" is said to be innervated by strong fibres from the ophthalmic and maxillary branches of the trigeminus, and is probably a highly sensitive touch organ. A similar expansion of surface, extremely sensitive to touch, is provided by the enormous development of the pinnæ, upon the surface of which numerous small tactile vibrissæ are scattered. O. C. 1423 B.

Presented by G. E. Dobson, Esq.

Dobson, Brit. Mus. Cat., Chiroptera, 1878, p. xvi.

E. 53. The head of a Horseshoe Bat (*Rhinolophus luctus*), showing a similar but far more complicated nose-leaf than that seen in the last specimen. The nose-leaf in the Horseshoe Bats consists "of three distinct portions—anterior, central, and posterior; the anterior horizontal portion is horseshoe-shaped, usually angularly emarginate in front, containing within its circumference the nasal orifices and the central erect nasal process; the posterior nose-leaf is triangular, erect, with cells on its anterior surface; the central process rises between and behind the nasal orifices, is flattened anteriorly and posteriorly, sends backwards a vertically laterally compressed process which is either connected with the front surface of the posterior nose-leaf or free." (Dobson, Brit. Mus. Cat., Chiroptera, 1878, p. 100.)

Redtel, Zeitschr. wiss. Zool., Bd. xxiii. 1873, p. 254.

PRIMATES.

Whipple, Zeits. f. Morph., Bd. vii. 1904, p. 261 (*Papillary ridges*).

Schlaginhaufen, Morph. Jahrb., Bd. xxxiii. 1905, p. 577, and Bd. xxxiv. 1905, p. 1 (*Papillary ridges*).

LEMUROIDEA.

E. 54. The skin of the head of *Galago demidoffii*. Above the inner canthus of each eye is a small whitish pimple from which springs a tuft of long fine vibrissæ. O. C. 2152 I *b*.

E 55. Left hand and skin of the wrist of *Microcebus coquereli*. There is a well marked tuft of four dark coloured carpal vibrissæ upon the fore-arm above the ulnar foot-pad. The skin upon the eminences that correspond to the foot-pads of lower Mammals is covered by papillary ridges that in the main are arranged concentrically to the apex of the pad, or in the case of the terminal digital pads parallel to the long axis of the finger. The skin between the pads is smooth. O. C. 2152 I.

Bland Sutton, Proc. Zool. Soc., 1887, p. 372.

E. 56. Three specimens of the hand and distal part of the forearm of *Lemur catta* : above, the right hand of a fœtus ; below, on the left, the left hand of an adult ; and on the right, the right hand of a still older example. In all three specimens there is a tuft of carpal vibrissæ. The two adult specimens also show an area of thickened hairless integument extending from the ulnar foot-pad upwards towards the radial border of the arm. The upper part of the patch is somewhat enlarged, and in the older specimen bears upon its ulnar border a horny spur-like process. This structure was supposed to be the hardened secretion of a large aggregation of sweat-glands that underlies

the callous patch (see the reverse of the specimen), but latterly it has been shown by Beddard to be a local development of the corneous layer of the epidermis. (See also in Section F, Integumentary Series—*Galago*, *Equus*.)
O. C. 2152 I *a*.

Sutton, Proc. Zool. Soc., 1887, p. 369.
Beddard, Proc. Zool. Soc., 1902, vol. ii. p. 158.

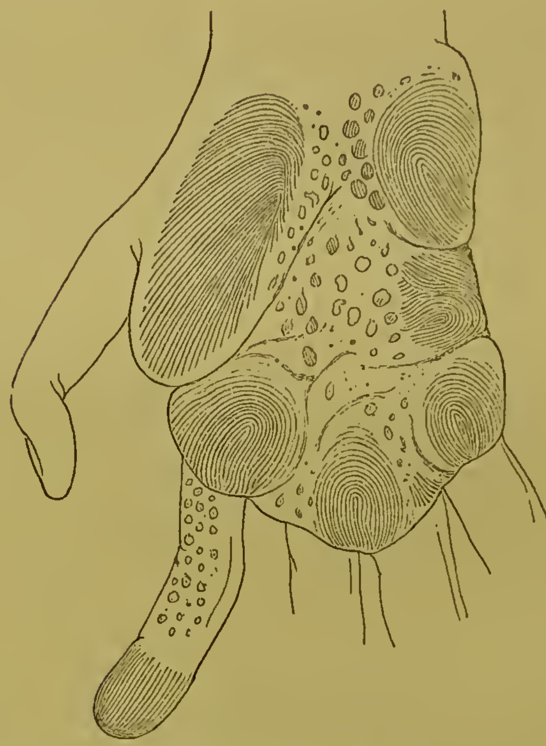
E. 57. The right fore- and hind-foot of a Lemur (*Lemur* sp.). The hand is very similar to the oldest shown in the previous specimen, but the wrist has been so cut as just to exclude the tuft of carpal vibrissæ. Upon both extremities the tips of the digits are swollen to form soft pads, which are probably very sensitive to tactile impressions, although no doubt their most important use is in enabling the finger-tip to obtain a firm grip of the branches of trees. The palmar and plantar skin is much shrunken in this specimen and in consequence the papillary ridges, which in Lemurs occur upon certain areas that correspond to the foot-pads of lower Mammals, are difficult to see.
O. C. 1419. *Hunterian*.

E. 58. The right fore-foot of a Slow-paced Lemur (*Loris tardigradus*), showing the dilatation of the finger-tips to form soft adhesive and tactile pads supported dorsally by flat broad nails. The first digit is directed laterally so as to act as an opposable instrument or thumb to the other digits. The papillary ridges, which in this genus are more universally distributed over the palmar surface than in *Lemur*, are scarcely visible owing to the state of preservation of the specimen. O. C. 1416. *Hunterian*.

ANTHROPOIDEA.

E. 59. The hand of a Squirrel Monkey (*Chrysothrix sciureus*) from which most of the epidermis has been removed. In the Anthropoidea the papillary ridges are distributed over practically the whole volar surface. They are unfortunately too indistinct to be seen in this specimen, but their arrangement is shown in the accompanying figure. The spaces between the pads are covered by irregular granular eminences, the surface of many of which show well-marked papillary ridges. The extremities of the three outer digits are much expanded, as in the Lemurs;

Fig. 12.



Hand of *Callithrix sciureus*, showing papillary ridges.

but the eminences corresponding to the foot-pads of lower Mammals are less clearly defined than (for instance) in *Microcebus* (E. 55). O. C. 1420. *Hunterian.*

John Hunter, Essays and Observations, edit. R. Owen, 1861, p. 27.

E. 60. The right hand of an Entellus Monkey (*Semnopithecus entellus*). The papillary ridges are very strongly marked, especially over the surface of the palm.

E. 61. The head of a Chimpanzee (*Anthropopithecus troglodytes*). The lips, by reason of their great sensitiveness and mobility, serve as efficient organs of touch.

O. C. 1424. *Hunterian.*

E. 62. The right hand of a Chimpanzee (*Anthropopithecus troglodytes*), showing the palmar surface covered with papillary ridges. O. C. 1421. *Hunterian.*

E. 63. The lower part of the face of a Human subject, injected, to show the vascularity of the highly sensitive and delicate integument of the lips. O. C. 1425. *Hunterian.*

E. 64. The left hand of a Woman, injected, and with the epidermis removed. The ends of the digits which are specially sensitive to touch impressions are pointed and protrude as soft fleshy cushions beyond the nails, which serve for their support. O. C. 1431. *Hunterian.*

E. 65. The left hand of a Woman, injected, dried, and preserved in oil of turpentine, showing the high vascularity of the integument. O. C. 1432. *Hunterian.*

E. 66. Left hand, supposed to be that of Thomas Beaufort, second son of John of Gaunt, *obiit.* A.D. 1424, *ætat.* 52, *efoss.* Feb. 26, 1772. The interest of this specimen consists in the state of preservation of the tissues after the body had been buried about 300 years. The abdominal viscera had been removed, the body wrapped in cere-cloth, and enclosed in a leaden coffin in which holes had been made. It was buried in earth. O. C. 1437. *Hunterian.*

Collignow, Phil. Trans., vol. lxii. p. 465.

E. 67. The right hand of the same body. O. C. 1437 A.

Presented by Sir Thomas Gery Cullum, Bart.

E. 68. A Human finger in which the arteries have been injected with mercury. O. C. 1433 D.

Hunterian (*Kew Collection*, No. 11).

E. 69. The last joint of a Child's thumb, injected, and with the epidermis removed. O. C. 1433. *Hunterian.*

E. 70. A longitudinal section of one of the fingers of a Child's hand with the arteries injected with mercury, dried and preserved in oil of turpentine, showing the plexus of vessels at the tactile extremity. O. C. 1433 C.

Presented by Sir William Blizard.

E. 71. The hand of an Infant similarly prepared, showing the rich network of vessels with which the fingers are surrounded. O. C. 1433 B.

Presented by William Lawrence, Esq.

E. 72. The hand of an Infant, minutely injected. O. C. 1433 A.

Presented by Sir William Blizard.

GUSTATORY ORGANS.

John Hunter, Essays and Observations, edit. R. Owen, vol. i. p. 180.

The organs of Taste and Smell have much in common, both being concerned in the distinction of certain chemical properties of matter: the one (Taste) only when the matter is in a liquid condition, the other usually when it is gaseous.

In Invertebrates, although the skin is sensible of chemical differences either all over or especially in certain regions, the sense of taste is apparently very partially developed, and it is rare to find anatomically distinguishable organs clearly specialised for the performance of this function. In Arthropods, where the epidermal and cuticular sense-organs have reached a relatively high state of perfection, certain structures upon the lips, palate, and mouth-parts have been identified as taste organs, but it is only in Vertebrates that taste organs are met with suitable for display in an Anatomical Collection. In Fishes the lips, tongue, mouth-cavity, and pharynx are covered with aggregations of sense-cells resembling taste-buds, and similar end-buds (innervated by visceral sensory components) occur also on the surface of the head and in some cases upon parts of the body. In Amphibia and Sauropsida organs of taste are restricted to the mouth and are developed feebly, when present at all. In Mammals taste-buds occur chiefly upon the tongue (upon the fungiform, circumvallate, and foliate papillæ) and to a less degree upon the palate and walls of the pharynx. These organs are innervated by the glosso-pharyngeal and by the fibres of the chorda tympani and are apparently responsive to only a few chemical properties, which give rise to acid, salt, sweet, bitter, and metallic tastes. Other tastes, or rather flavours, act upon the olfactory organs and not the gustatory.

VERTEBRATA.

Gottschau, Zool. Cbl., Bd. ii. 1882, p. 298.

PISCES.

Nagel, Biblioth. Zool., Bd. vii. 1894, p. 182.

ELASMOBRANCHII.

E. 73. The floor of the mouth and fauces of a Port Jackson Shark (*Cestracion francisci*). The anterior part is slightly raised to form a fleshy but completely attached tongue, very like that of a Crocodile. Upon the mucous membrane covering the tongue and fauces are a number of fungiform papillæ similar in appearance to those of Mammals. They are most numerous about the centre of the tongue and lessen in number near the tip and towards the fauces, extending in the latter direction to about the level of the penultimate gill-arch. Probably these papillæ are the seat of taste-buds.

Todaro, Cbl. med. Wiss., Bd. x. 1872, p. 227 (*Trygon*).

MAMMALIA.*

Münch, Morph. Arb., Bd. vi. 1896, p. 605.

E. 74. Part of the base of the tongue of an Elephant (*Elephas* sp.) showing four large circumvallate papillæ. They are arranged in pairs on either side of the mid-line, one behind the other. O. C. 1490. *Hunterian.*

Münch, *l. c.*, p. 641.

* A few examples of the tongue selected to show the most marked variations in the position and development of the fungiform, circumvallate, and foliate papillæ, are exhibited in this section. The bulk of the collection is in "Section J, Digestive Organs."

E. 75. The base of the tongue of a Dromedary (*Camelus dromedarius*). The circumvallate papillæ have the same linear type of arrangement as in the Elephant. There are four on the left side and five on the right. The second, counting from in front, is of very great size. In this region of the tongue the mucous membrane is raised into a series of conical processes. O. C. 1495. *Hunterian.*

Münch, *l. c.*, p. 643.

E. 76. The hinder part of the skull of a Sheep (*Ovis aries*) with the tongue and the right ramus of the mandible, showing the nerves that supply the tongue. The lingual branch of the trigeminus innervates the organs of general sensation, and also by means of fibres contributed by the chorda tympani some of the more anteriorly placed organs of taste. It is of great size and enters the tongue just external to the genio-glossus in company with the branches of the equally strongly developed motor nerve (hypoglossus). The majority of the taste organs are supplied by the glosso-pharyngeal, which is quite a small nerve and enters the tongue at its base, passing upwards near the surface towards the foliate and circumvallate papillæ upon which the taste-buds are mainly situated. Upon the right side the nerves have been separated out and traced as far as possible towards their final distribution; upon the left the relations of their main trunks to the surrounding parts are retained.

E. 77. The tongue of a Rabbit (*Lepus cuniculus*). The fungiform papillæ are almost entirely confined to the dorsal surface and margins of the free end of the tongue, being particularly numerous upon the anterior margin. There are two circumvallate papillæ placed transversely at the posterior end of the body of the tongue, and laterally to them upon its sides are two very strongly marked foliate papillæ. Numerous taste-buds occur upon the apposed surfaces of the leaves of which these papillæ are composed.

E. 78. The tongue and fauces of a Gibbon (*Hylobates* sp.). The papillæ on the tongue are very clearly defined. There are four circumvallate papillæ, one on either side and two in the mid-line posterior to them. The lateral parts of the tongue are covered with scattered fungiform papillæ, and the whole of the dorsal surface is velvety from the presence of filiform papillæ. Foliate papillæ are present on either side in front of the anterior pillars of the fauces. The fungiform, circumvallate and foliate papillæ, but not the filiform, are said to be the seat of taste-buds.

E. 79. The tongue of a nearly adult Chimpanzee (*Anthropopithecus troglodytes*), showing the arrangement of papillæ upon its dorsal surface. The fungiform papillæ are very conspicuous and are scattered over the dorsal surface of the whole of the organ in front of the circumvallate papillæ. There are six of the latter arranged upon the base of the tongue in the form of a **Y**, corresponding exactly in position to the six circumvallate papillæ of the Gibbon. Foliate papillæ are present at the sides of the tongue on a level with the anterior circumvallate papillæ. O. C. 1523 D.

Münch, *l. c.*, p. 636.

E. 80. A Human tongue. The fungiform papillæ are scattered over the dorsal and lateral surfaces of the anterior parts of the tongue, but are most numerous along the sides. There are seven obscure circumvallate papillæ arranged in a **V** shape upon the base of the tongue. Somewhat indefinite foliate papillæ are also present on either side in the usual position in front of the anterior pillars of the fauces.

Münch, *l. c.*, p. 639.

E. 81. A Human tongue, with the hypoglossal and lingual nerves exposed. The lingual is distributed to the tip and sides of the tongue. It is not in the main a gustatory nerve, but innervates the organs of general sensation. Some of its fibres, which reach the brain by way of the chorda tympani, do however carry true taste stimuli. The hypoglossal supplies the muscles of the tongue, entering it behind the lingual nerve. O. C. 1380 L.

Zander, Anat. Anz., Bd. xiv. 1898, p. 131.

OLFACTORY ORGANS.

John Hunter, A description of the nerves which supply the organ of smelling, Animal Œconomy, Works of Hunter, Palmer, vol. iv. p. 187.
Essays and Observations, edit. R. Owen, vol. i. p. 177.
Nagel, Biblioth. Zool., Bd. vii. 1894–96, pp. 1–63.

The olfactory sense is closely allied to that of taste, both being concerned with the discrimination of certain chemical properties of matter. In Man and presumably in lower land Animals the olfactory organ is capable of response to the stimulation of odoriferous substances only when they are in a gaseous form, but in Fishes in which the sensitive surface is actually bathed in water this is obviously not the case, and in this group the distinction between taste and smell is not very clearly defined. The acuteness of smell differs enormously in different animals. The sense is entirely absent in the Toothed Whales, and in Man and Apes and in most Birds is very weak, but on the other hand in some Insects and in many Mammals it reaches a power and delicacy of discrimination of which it is difficult for us to form a conception.

In aquatic Vertebrates its use is apparently confined to the seeking out and recognition of food only within quite a limited area; but with the greater opportunities offered by the rapid diffusion of odorous particles in air, its range and sensitiveness have increased in land Vertebrates till it has become in many cases the most important of all the senses, giving information of the whereabouts of mates, friends, enemies, or prey, often at almost incredible distances, and being used, as we use sight, in the detailed examination of near objects. The prime importance of this sense is also suggested by the fact that its nerve centres were the first to form connections with the cerebral cortex (see this Catalogue, Vol. II. p. 112).

INVERTEBRATA.

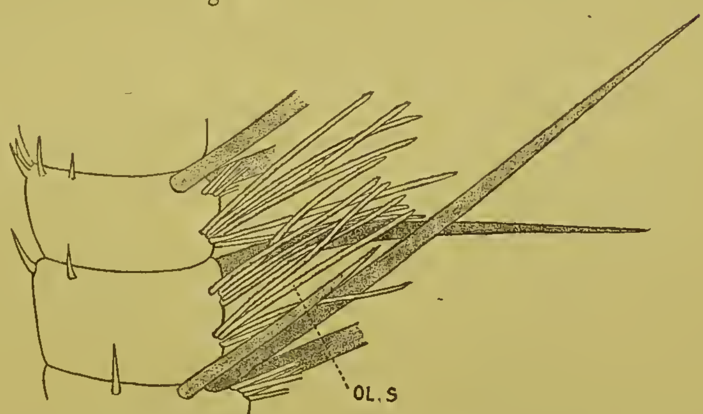
Nagel, Biblioth. Zool., Bd. vii. 1894–96, pp. 67–182.

Little is known of the sense of smell in Invertebrates. In the lower forms there are probably no organs set apart for this function, but in Worms sensory epithelial areas in the nuchal region, and in Molluscs aggregations of sense-cells upon certain parts of the mantle and head, have been thought to be sensitive in a somewhat special degree to the chemical condition of the surrounding medium. However, among Arthropods and especially among the Insecta there is no doubt that the olfactory sense is extremely keen, the sense organs concerned being apparently placed for the most part upon the antennæ.

ARTHROPODA.

E. 82. The antennule of a Lobster (*Homarus vulgaris*), with the cerebral ganglion attached. The nerve for the supply of the antennule emerges from the anterior surface of the

Fig. 13.



A small part of the exopodite of the antennule of *Homarus vulgaris*, showing olfactory setæ.

OL.S. Olfactory setæ.

ganglion (arising within it by two roots, one of which takes origin from a glomerulated mass of neuropile—the globulus, *cf.* D. 14. Physiol. Series) *. Within the basal part of the appendage the nerve gives off a small branch to the auditory sac, and then divides into branches for the exo- and endopodites. The nerves to the exopodite are partly distributed to a number of delicate tubular processes

* Glomerulation of the neuropile is, in Vertebrates, always found in the olfactory bulbs.

situated along the lower border of the ramus, towards its distal end. In the specimen they look like a whitish coagulum lodged amongst the longer and stiffer tactile setæ. These processes are considered to have an olfactory function.

MOLLUSCA.

Yung, Arch. Psychol., T. iii., 1903, p. 1.

E. 83. A Whelk (*Buccinum undatum*) with the mantle-wall divided and reflected to either side to show the osphradium or false branchia. This organ, which is supposed to have an olfactory function, lies close below and parallel to the attached border of the gill axis near its anterior end. It consists of a central axis beset on either side by a series of triangular pigmented leaflets. The organ is innervated from the visceral loop through the mediation of a nerve centre that forms the core of its axis, and from which delicate branching filaments pass into each leaflet. The innervation is not shown in the specimen.

Bernard, Ann. Sci. Nat., sér. 7, T. ix. p. 202.

E. 84. Head of a Cuttle-fish (*Sepia officinalis*) dissected from the posterior (dorsal) aspect to show a pair of integumentary pits, possibly olfactory in function, situated behind the eyes *. Upon the left side a nerve has been traced from the base of the pit to a small rounded ganglion upon the dorsal (anterior) surface of the optic stalk. The nerve does not terminate here, but passes on into the cerebral ganglion. Red rods have been inserted into the mouths of the olfactory pits. O. C. A 1527.

Jatta, Boll. Soc. Natural. Napoli, vol. i. pp. 30 & 92.

VERTEBRATA.

In Vertebrates the olfactory membrane lines part of a paired cavity (nasal chamber) that lies in front of or above the mouth, and may either serve solely for the lodgement of the olfactory sense organ, or may in addition become either the chief or the

* The olfactory pit of *Nautilus macromphalus* is shown in the dissection of that species prepared to show the eyes. No. E. 1071.

only respiratory passage, by the development of a posterior connection with the mouth-cavity. The liquid or gas in which the odoriferous substance is diffused can generally be forcibly brought into contact with the olfactory membrane by some special mechanical means. This may either be by the action of ciliated cells that line the cavity, by valvular arrangements of the nostrils to deflect the water into the nasal cavities during forward progression, by dilatable accessory pouches in connection with the true olfactory chamber, or by acceleration of the inspiratory air-current.

The end organs peculiar to the olfactory sense closely resemble the epithelial senso-neural cells of some Invertebrates, each being an elongated cell terminating distally in a brush of slender processes freely exposed upon the surface of the mucous membrane, and drawn out proximally into an afferent nerve-fibre that breaks up in neuropile glomeruli in the olfactory bulbs of the brain. In certain Fishes (e. g. *Belone*) the olfactory cells are grouped to form bud-like organs scarcely distinguishable from end- or taste-buds, but in other genera these are more and more coalesced till the type of olfactory membrane common to most Vertebrates is produced—that is, an epithelium composed of senso-neural, supporting, and glandular cells evenly distributed.

Olfactory Chamber.

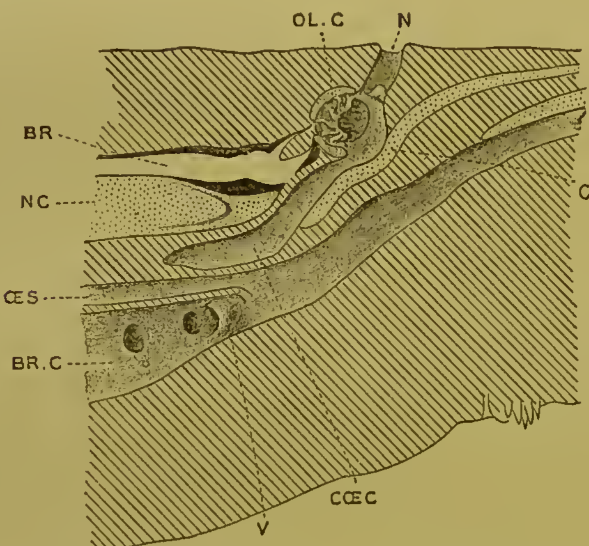
PISCES.

Blaue, Arch. f. Anat., 1884, p. 231.
Bateson, Jour. Mar. Biol. Assoc., vol. i. 1889, pp. 235, 246.

CYCLOSTOMI.

E. 85. The head of a Sea-Lamprey (*Petromyzon marinus*) in sagittal section. The olfactory sac is single and median. It communicates with the exterior by an opening with prominent lips, situated in the dorsal mid-line slightly in front of the plane of the eyes. A short passage leads from the nostril to a globular olfactory chamber the posterior wall of which lies close in front of the brain and is radially pleated to increase the surface covered by the olfactory membrane. The lower and anterior parts of the sac are prolonged backwards between the skull and front end of the notochord and the pharynx as a blind pouch, which is tubular and surrounded by cartilage in front, but behind is dilated and is separated from the branchial chamber by the narrow œsophagus only. This bulb-like posterior dilatation shares in the alternate expansion and contraction of the branchial cavity, and is thus a mechanism for the production of currents of water into and out of the olfactory chamber (Bert, Ann. Sci. Nat., sér. 5, T. vii. 1867, p. 372). The passage of the incoming water through the olfactory chamber is ensured by a suitably arranged pair of valves situated at the lower end of the first segment of the nasal passage.

Fig. 14.



Sagittal section of the nasal region of *Petromyzon marinus.*

BR. Brain. BR.C. Branchial chamber. C. Cartilage of skull. CŒC. Cœcum of nasal chamber extending between the notochord and the œsophagus, compressed during expiration. N. Nostril. NC. Notochord. ŒS. Œsophagus. OL.C. Olfactory chamber. V. Valve between the respiratory chamber and the mouth-cavity.

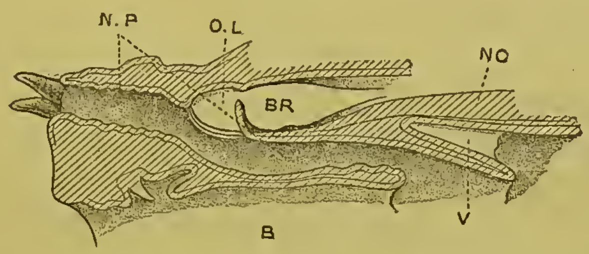
A black bristle has been passed from the nostril, through the olfactory chamber into the cæcal pouch. A red rod is inserted into the respiratory division of the pharynx and purple rods through the first two gill-openings.

O. C. 1527 A.

Ballowitz, Arch. f. mikr. Anat., Bd. lxv. 1905, p. 78 (*Hist.*).

E. 86. Two specimens showing the olfactory organs of a Hag-fish (*Myxine glutinosa*). The organ is similar to that of *Petromyzon* in being single and median, but differs from it in having an open communication with the pharynx. The specimen on the left shows the head in sagittal section.

Fig. 15.



Sagittal section of the nasal region of *Myxine glutinosa.*

B. Buccal cavity. BR. Brain. NC. Notochord. O.L. Olfactory leaflets. N.P. Nasal passage. V. Velum.

The nasal passage can be traced from its opening at the anterior end of the snout to its passage into the pharynx slightly behind the posterior limit of the brain. The first part of the passage, owing to the forward position of the nostril, is relatively longer than in the Lamprey and is supported by rings of cartilage. Close in front of the brain the dorsal parts of the passage enlarge to form the true olfactory chamber occupied by a series of seven plates arranged longitudinally in the vertical plane. These plates are covered by olfactory epithelium, and are innervated (as in the Lamprey) by a pair of nerves that enter the anterior end of the brain. The posterior part of the nasal passage runs close beneath the brain-case and opens by a wide mouth into the pharynx in front of a pendulous flap—the velum.

In the right-hand specimen the alimentary canal, palate, and ventral wall of the nasal passage have been longitudinally divided and spread apart to show the roof of the nasal passage and the arrangement of the plates in the olfactory chamber. A red glass rod marks out the passage of the left half of the buccal cavity into the pharynx.

ELASMOBRANCHII.

E. 87. Head of a Dog-fish (*Acanthias vulgaris*), showing the olfactory organs. Upon the left side, where the parts are undisturbed, is shown the subdivision of the single opening of the olfactory sac into an outer (inhalent) and an inner (exhalent) channel by the overlapping of projections from its anterior and posterior borders. Upon the right side the ventral half of the olfactory sac has been removed and the olfactory part of the brain exposed. The sac has an oval form and is occupied by a series of leaflets that project from its walls transversely to its length, and are separated into two series by a fibrous longitudinal axis that extends from end to end of its floor. The middle part of the free border of each leaflet projects as a tongue-shaped process into the cavity of the sac. The olfactory bulb (see also D. 71) lies close behind the olfactory sac and gives off for its innervation three large nerve-bundles of indefinite outline. Olfactory epithelium is said (Blaue) in Elasmobranchs to clothe only the deeper parts of the clefts between the leaflets.

Blaue, Arch. f. Anat., 1884, p. 267.

E. 88. Part of the head of a Skate (*Raja batis*) including the right olfactory organ. The cavity has the form of a transversely elongated depression upon the ventral surface of the head, partially covered over by a deep overhanging lip (*cf.* subsection : Nostrils). The deeper parts of the cavity are lined by an olfactory membrane, thrown into a series of folds arranged at right angles to a ligamentous axis disposed in the long axis of the pit. The free margin of each lamella is extended about the middle of its length by a triangular process. The specimen is mounted with the posterior border uppermost to allow the cavity of the olfactory sac to be seen. O. C. 1528. *Hunterian.*

E. 89. A transverse section through the head of a Ray (*Raja clavata*), showing from in front the olfactory organs and their connection with the brain. On the left the pigmented covering of the nasal sac has been exposed ; it is continuous with the dura mater. On the right, the olfactory sac has been mesially divided by a section parallel to its long axis, to show its lateral elongation, the arrangement of the olfactory lamellæ at right angles to a median longitudinal raphé, the position of the olfactory bulb along the dorsal border of the sac, the passage of a bundle of nerve-fibres from the bulb into each olfactory lamella, and the partially closed gutter leading from the cavity of the sac to the corner of the mouth.

E. 90. Transverse section through the olfactory organ of a Skate (*Raja batis*). In this specimen a pair of leaflets are shown, lying on either side of the central axis and with triangular processes of their free borders projecting into the cavity of the sac. The olfactory bulb is cut transversely and on the left side gives off a large bundle of nerve filaments (marked by a black bristle) to the corresponding leaflet. The olfactory mucous membrane upon the surface of each leaflet is pleated at right angles to the wall of the sac.

GANOIDEI.

E. 91. A portion of the head of a Sturgeon (*Acipenser sturio*) including the right olfactory organ. The olfactory nerve (*cf.* D. 86), which is of large size, is visible on the reverse of the specimen cut obliquely close to the olfactory pit. It expands towards its termination upon the olfactory membrane, which lines a cavity of hemispherical form and is disposed in a series of deep but thin semilunar folds that radiate from a ligamentous centre.

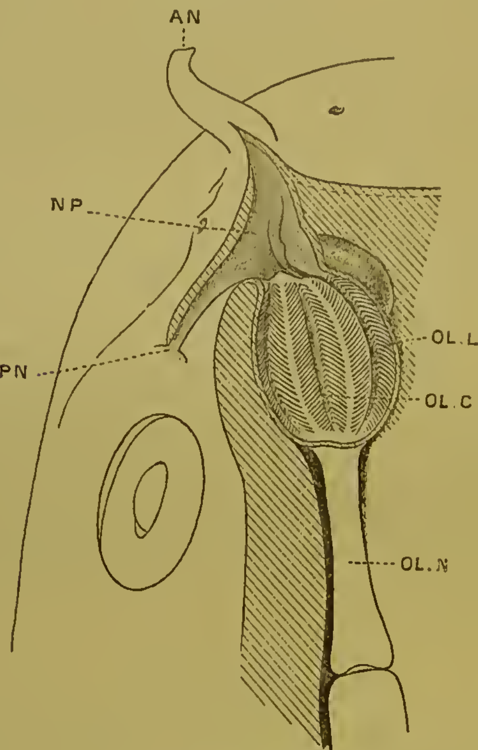
O. C. 1527. *Hunterian.*

Dogiel, Arch. f. mikr. Anat., Bd. xxix. 1887, p. 77.

E. 92. Head of *Polypterus lapradii*, with the olfactory organs and brain displayed from above. Each olfactory organ consists of two distinct parts :—(1) a passage that passes directly between the anterior and posterior nostrils, and (2) an olfactory chamber in connection with it. The nostrils lie at a considerable distance apart (14 mm.), the anterior at the end of a flexible tube, as in many Bony

Fishes with keen scent, and the posterior, which is slit-like, close in front of the eye. A narrow opening leads through the median wall of the passage that connects the

Fig. 16 A.



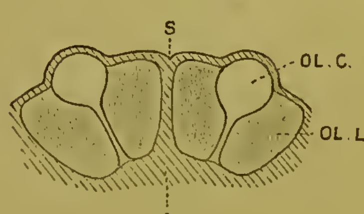


Fig. 16 B.

Fig. 16 A.—Olfactory organ of *Polypterus lapradii*, opened from above.
Fig. 16 B.—Diagram of section through part of the olfactory chamber of *Polypterus*.

A. Axis of olfactory chamber. A.N. Anterior nostril. N.P. Nasal passage. OL.C. Cavity of olfactory compartment. OL.L. Olfactory leaflets. OL.N. Olfactory nerve. P.N. Posterior nostril. S. Septum between two contiguous compartments of olfactory chamber.

two nostrils into the anterior end of a large oval olfactory chamber built up of a number (about 6) of sausage-shaped compartments arranged around a central axis. The partition walls between every two compartments are covered by a series of leaflets arranged at right angles to the long axis of the organ and filling up the greater part of each compartment. The olfactory nerves are strongly developed; each leaves the posterior end of one of the olfactory chambers and at the fore end of the brain enters a large pear-shaped olfactory bulb. Upon the left side, the roof has been removed from the passage between the nostrils and from three compartments of the olfactory chamber, showing the connection between these two parts of the olfactory organ and the arrangement of the olfactory leaflets. On the right, the dorsal surface of the olfactory chamber has been exposed and green rods have been inserted into the nostrils. One may suppose, from the complexity of the olfactory chamber and from the size of the olfactory nerves and bulbs, that the power of scent in this fish is exceptionally great.

Presented by J. S. Budgett, Esq.

Waldschmidt, Anat. Anzeig., Bd. ii. 1887, p. 308.

TELEOSTEA.

E. 93. Head of a Gar Fish (*Belone vulgaris*), showing the olfactory organs. Each olfactory sac is a shallow open pit of roughly triangular outline and measuring some 7 mm. in diameter, situated at the side of the head close in front of the eye. From the upper part of its cavity a smooth club-shaped fleshy mass protrudes slightly beyond the general surface-level of the face. This represents in a much simplified form the olfactory rosette characteristic of the olfactory organ of the vast majority of Bony Fishes. The extremely simple character of the olfactory organs indicates that the sense of smell is feeble.

The olfactory epithelium in its structure resembles a collection of end-buds such as occur upon the skin of the head (Blaue).

Blaue, Arch. f. Anat , 1884, p. 241.

E. 94. Three specimens of the olfactory organ of a Cod (*Gadus morrhua*). The olfactory sacs are hemispherical in shape and lie on either side of the snout about halfway between its extremity and the orbits. Each sac opens to the exterior by two nostrils—an anterior, which is the smaller of the two and is bordered by a lip produced behind to form an upstanding flap by which the water is deflected into the nostril during the forward progression of the fish, and a larger posterior nostril of oval form also bordered by a low membranous lip. The olfactory sac is almost completely filled by a series of leaflets attached to its floor and sides and converging to a longitudinal raphé that extends backwards from the anterior border of the anterior nostril about half way along the floor of the sac. The free edge of each leaflet is prolonged into a tongue-shaped process. Beneath the median raphé of this rosette of leaflets lies the olfactory bulb connected by a long slender tract to the brain.

The resemblance in general structure between this olfactory organ and that of *Acanthias* (E. 87) is very striking. The upper specimen shows the sac divided parallel to the axial raphé of the rosette. The lower shows it in surface view after the removal of the skin. The middle specimen is the skin removed from the preceding showing the nostrils.

E. 95. Two specimens of the olfactory organ of a Sea-Bream (*Pagellus centrodontus*). The nostrils are in much the same position as in the Cod. The anterior is circular, the posterior oval and valved along its hinder margin to prevent entry to the sac. The rosette is more circumscribed than in the Cod and is surrounded above, below, and behind by a plain area of the olfactory sac. In this plain area close behind the rosette are two openings that lead from the olfactory sac into two accessory chambers that lie respectively behind the median process of the præmaxillæ and behind the maxilla. When the mouth is closed the accessory chambers are compressed by these bones, but can freely expand when the mouth is opened. By their means water can thus be drawn into the olfactory sac and again expelled following the movements of the jaws. Water can only enter the sac by the anterior nostril which lies directly over the olfactory rosette. The upper specimen shows the nostrils and the compressed condition of the lower accessory sac when the mouth is closed. In the lower specimen the olfactory sac has been opened to show the rosette, and the accessory sacs are fully expanded, the mouth being wide open.

E. 96. Head of a Conger Eel (*Conger vulgaris*), showing the olfactory organs. Upon the right side green rods have been inserted into the anterior and posterior openings of the olfactory chamber; and upon the left the roof of the chamber has been removed and the brain and left olfactory nerve exposed. The olfactory organs are very strongly developed. Each has the form of a flask-shaped chamber, opening in front upon the margin of the snout by a short tube, and behind by a simple opening situated close in front of the eye; the two openings being separated by a distance of 60 mm. The anterior or inhalent orifice leads into a short vestibule separated from the olfactory part of the chamber by a valvular projection. The main cavity of the organ is almost completely filled by flat leaflets, like gill lamellæ, that project in close-set transverse series from its dorsal and ventral walls, and meet along its median side in a central axis. From the posterior end of the main cavity a short tube leads outwards to the exhalent opening. The olfactory nerve leaves the organ by its median border. It is of great size and is divisible into three bundles. The olfactory bulb, which is small in comparison with the nerve, is sessile upon the brain. The olfactory epithelium is confined to the surfaces of the leaflets but does not extend to their bases or upon the wall of the chamber between them (Blaue, *l. c.*, p. 265).

E. 97. The head of *Tetrodon bimaculatus*. The floor of the olfactory pit is only slightly sunk below the general surface of the skin, but the roof is raised to form a dome-shaped elevation perforated by large inhalent and exhalent orifices.

Wiedersheim, Anat. Anzeig., Bd. ii. 1887, p. 652.

E. 98. The head of *Tetrodon fahaka*. The olfactory organ is represented by a bifoliate tentacle, attached to the surface of the head by a short pedicle. The olfactory epithelium covers the apposed surfaces of the leaves. This condition has been shown (Regan, Proc. Zool. Soc., 1902, vol. ii. p. 292) to be traceable to an olfactory pit of the normal type. It results from the shallowing of the pit, and the raising and subsequent rupture of the bridge of integument between the inhalent and exhalent orifices. This and the previous specimen are examples of stages two and four of the accompanying scheme.

Fig. 17.

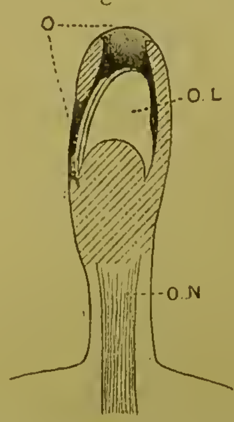
I. II. III. IV.

Diagram illustrating the probable course of evolution of the tentacular olfactory organ in the genus *Tetrodon*.

I. Normal olfactory pit (e. g. *T. sceleratus*). II. Elevated roof (*T. bimaculatus*). III. Ruptured bridge. IV. Bifoliate tentacle (*T. fahaka*).

E 99. A portion of the fore part of the head of a Fishing-Frog (*Lophius piscatorius*), showing the olfactory organs. In this fish, which does not actively pursue its prey, the

Fig. 18.



Olfactory tentacle of *Lophius piscatorius*: enlarged.

O. In- and exhalent openings. O.L. Olfactory leaflets. O.N. Olfactory nerve.

olfactory organs and brain (*cf.* D. 100) are remarkably small. Each olfactory pit is situated at the extremity of a short solid pedicle, and opens to the exterior by two apertures (indicated on the right by a red rod) placed one at the extremity of the pedicle and the other upon its anterior face. Upon the left side, the portion of the olfactory nerve in front of the orbit has been exposed and the olfactory pedicle longitudinally divided. The surface of the olfactory pit is increased by the presence of several delicate olfactory lamellæ, projecting from its floor.

AMPHIBIA.

Blaue, Arch. f. Anat., 1884, p. 282.
Seydel, Morph. Jahrb., Bd. xxiii. 1895, p. 453.
Mihalcovics, Anat.-Hfte., Bd. xi. 1898, p. 1 (*Jacobson's organ*).

With the adoption of a terrestrial mode of life, the nose becomes a respiratory passage as well as an olfactory organ, and for this purpose acquires a direct opening into the mouth through the choanæ or posterior nares. At the same time the nasal cavity becomes more or less definitely divided into olfactory and respiratory regions lined respectively by sensory and ciliated epithelia. The primitive choanæ lie in the anterior part of the palate, but in the higher groups of land Vertebrates the respiratory part of the nose cavity is extended backwards beyond them and opens into the pharynx immediately above the glottis thus ensuring a practically continuous air-passage from the nostrils to the lungs. An increase in the area of the lining membrane of the nose-cavity necessary for the proper warming of the inspired air (in warm-blooded animals) and for the full development of the olfactory sense, is effected by prominences of the nasal walls. These can be supported by special skeletal elements, and being then very constant in position though variable in form, are distinguished from mere fleshy protuberances of different sorts as "turbinals" (see Mammalia, Introduction).

The olfactory membrane is mainly confined to those parts of the lateral walls and septum of the nose that lie near the entry of the olfactory nerves, but in many groups a detached portion of somewhat peculiar structure is lodged in a pair of cavities in the floor of the nasal chamber on either side of the septum. These, known as Jacobson's organs, are

G 2

first recognisable in the Amphibia, where they are simple diverticula of the general cavity opening near the choanæ. In higher groups they become more cut off from the nose-cavity and open relatively further forward, not into it, but into a pair of canals or blind pits, the naso-palatine canals, that, when not degenerate, connect the front part of the nose-cavity with the mouth and probably represent the original choanæ, left behind in the above-mentioned backward extension of the respiratory passage. The function of these organs is very obscure, but it has been suggested that they may serve to test the flavours of food during the act of expiration.

E. 100. Head and shoulders of *Necturus maculatus*, with the olfactory organs shown. On the right side the skin has been removed to expose the external surface of the olfactory capsule with its supporting skeleton of transverse cartilaginous bars. The capsule is an elongated chamber of slightly crescentic form with the concavity directed outwards. It opens to the exterior in front on the margin of the snout, and posteriorly into the mouth-cavity by a slit-like orifice lying between the maxilla and the palatine teeth. The openings are indicated by green rods. On the left the chamber has been opened from above. The lining membrane is thrown into numerous transverse pleats to provide increase of surface, as in the olfactory organ of most Fishes. The olfactory nerves (marked by black bristles) are very large and leave each organ along its median margin. Their course within the skull and relation to the fore-part of the brain are shown by removal of the cranial roof.

In the Urodeles examined by Blaue the olfactory cells were arranged, as in many Fishes, in bud-like groups separated by indifferent epithelium.

Wiedersheim, Morph. Jahrb., Bd. ii. 1877, p. 392.

E. 101. The head of a Frog (*Leptodactylus pentadactylus*) in which the nasal cavities have been opened from the dorsal aspect. Each cavity is spaceous in the horizontal plane and opens posteriorly into the mouth by a large round opening on the level of the palatine teeth. The lips of this opening do not unite laterally, but cross one another (the posterior above), and thus give rise to a gutter by which the lateral parts of the nose cavity are continued into the mouth alongside the upper jaw. This gutter is probably a rudiment of the maxillary sinus and backward respiratory extension of the nasal cavity of higher forms. From an opening in the floor of the nasal cavity (marked on the left by a red rod) a pit or recess extends to the septum. This recess, which is an antero-median prolongation of the maxillary sinus, is lined by olfactory epithelium and probably represents the Jacobson's organ of higher Vertebrates.

REPTILIA.

Solger, Morph. Jahrb., Bd. i. 1876, p. 467.

LACERTILIA.

E. 102. Right half of the head of a Spiny-tailed Lizard (*Uromastix spinipes*), showing the cavity of the nose and the brain. The cavity is short and deep and consists of two divisions—a vestibule and an olfactory chamber. The former lies just within the nostril, in front and slightly to the side of the olfactory chamber, and is occupied to a considerable extent by a large protuberance of its lateral wall. Posteriorly it communicates with the olfactory chamber by a large round opening in the upper and anterior part of the turbinal that stretches diagonally like a diaphragm across the nose-cavity from its outer wall posteriorly to the septum in front, and probably corresponds to the maxillo-turbinal of Birds and Mammals. The posterior nares are a pair of slits in the palate that extend side by side from the level of the septal attachment of the turbinal (which is seen in the specimen as a cut edge) to the hinder limit of the nose-cavity. The olfactory membrane is innervated from an olfactory bulb situated above the orbit close behind the nasal chamber. A long slender tract connects the bulb to the cerebrum. In this specimen Jacobson's organ of the right side can be seen in longitudinal section beneath the nose-cavity just in front of the posterior nares. It is a curved tube (with the concavity ventral) about 2 mm. in length.

Presented by Professor G. Elliot Smith.

E. 103. A series of sections, five transverse and one horizontal, through the nose of a Spiny-tailed Lizard (*Uromastix spinipes*). The approximate levels of the section surfaces are shown in the accompanying diagram.

Fig. 19.

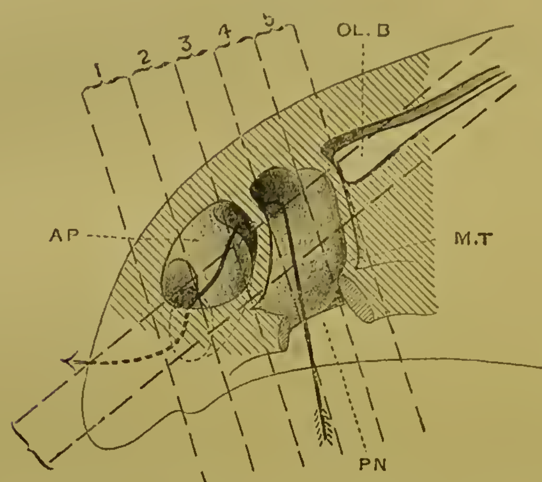


Diagram of a sagittal section of the nose of *Uromastix spinipes.*

AP. Atrial process. M.T. Maxillo-turbinal. OL.B. Olfactory bulb. P.N. Posterior nares. 1, 2, 3, 4, 5. The positions of the transverse sections; an arrow passes from the posterior nares through the nose-cavity and anterior nostril.

The first section (counting from above and from left to right) shows the left anterior nostril; the second passes through the protuberance of the lateral wall of the vestibule; the third shows the septal termination of the turbinal and the anterior extremity of the olfactory chamber and of the posterior nares; the fourth includes the passage from the vestibule into the olfactory chamber; and the fifth (seen from in front) shows the hinder part of the olfactory chamber and of the vestibule.

In the horizontal section the serpentine form of the nasal cavity is shown.

Presented by Professor G. Elliot Smith.

E. 104. A section of the head of an Iguana (*Iguana tuberculata*) with the left half of the cavity of the nose exposed. A bristle is passed from the nostril through the vestibule, olfactory chamber, and posterior nares into the mouth. The vestibule lies above and to the external side of the olfactory chamber and communicates with it by a circular opening. Part of the olfactory nerve has been exposed; it is distributed to the greater part of the epithelium of the olfactory chamber. O. C. 1531. *Hunterian.*

OPHIDIA.

E. 105. A series of transverse sections through the nose of a *Boa constrictor.* The sections are arranged vertically in pairs with the point of the nose above. In each pair the left-hand section is seen from behind, the right-hand from in front.

The cavity of the nose is relatively simple and extends forward some little way beyond the nostrils (first pair of sections). Close behind the nostril a lateral projection indicates the beginning of a turbinal comparable to the maxillo-turbinal of Birds and Mammals (second pair of sections). Further back the turbinal enlarges, assumes a plate-like form, and shifts its attachment upwards. From the eighth section backwards its attachment is transferred from the dorsal wall to the floor of the chamber by the encroachment of a forward diverticulum of the hinder part of the nasal cavity. The body of the turbinal is free at quite the hinder extremity of the cavity and ends in a blunt scroll (final pair of sections). In this pair of sections the communication between the nose and the mouth by the slit-like posterior nares is also shown. In addition to these points, in the third pair of sections is shown Jacobson's organ situated between the nose-cavity and the mouth, and in the fifth pair the position of the olfactory bulbs.

E. 106. Longitudinal section of the head of an Anaconda (*Eunectes murinus*), showing the olfactory organ and the brain. The nose-cavity and the turbinal in essentials resemble those of the Boa Constrictor. In this view the position of the turbinal and the contour of its median surface are shown, but the lateral diverticulum of the olfactory chamber is concealed behind its posterior end. The right olfactory bulb is exposed, showing its relatively large size and the nerves given off from its anterior end to an area of pigmented tissue at the extreme postero-dorsal part of the olfactory chamber. The position of Jacobson's organ should be noted in the floor of the nose about half way between the anterior and posterior nares.

EMYDOSAURIA.

E. 106 a. The head of a young Long-nosed Crocodile (*Crocodilus cataphractus*) in vertical longitudinal section, showing the right half of the nose-cavity and brain. The posterior limit of the septum is indicated by the retention of a small piece of its upper and lower parts. The nasal cavity on either side is single in front for about half its length, but is posteriorly divided into an upper olfactory chamber and a lower respiratory passage by a horizontal septum that stretches from the side walls to the septum. The single part of the cavity is partly occupied by a longitudinal prominence that projects from its roof and probably represents the atrial prominence in the nose of Lizards and Birds. Within the olfactory chamber are a couple of turbinal-like prominences. The anterior of these corresponds with the true turbinal of Lizards and Birds, but the posterior is the projecting wall of a sinus in connection with the nose-cavity and is comparable to the olfactory eminence in Birds. The olfactory bulb and tract are of large size, and in the specimen the olfactory nerves can be traced owing to the pigmentation of their sheaths beneath the mucous membrane of the olfactory eminence and turbinal. The nerves that supply the corresponding part of the septum have been cut short.

Solger, *l. c.*, p. 483.

CHELONIA.

Seydel, Festschr. z. Gegenbaur, Bd. ii. 1896, p. 387.

E. 107. Two sagittal sections through the nose of a Turtle (*Chelone mydas*), showing, in the upper specimen, the septum and, in the lower, the outer wall of the right half of the cavity. The nostril leads into a tubular vestibule which is directly continuous with a cylindrical respiratory

segment of the nasal chamber. At the entry into this it expands to form a flattened chamber that stretches upwards, downwards and forwards, and towards the septum. The downward extension is compared by some (Seydel) to Jacobson's organ. Just behind these expansions is a globular diverticulum of the roof of the nasal chamber which is lined by olfactory epithelium. O. C. 1534 A.
Presented by G. A. Ring, Esq.

E. 108. A longitudinal section of the anterior part of the head of a Turtle (*Chelone mydas*), showing the distribution of olfactory nerves of considerable size upon the septum and walls of the olfactory chamber. The section has divided the septum and exposed the median parts of the vestibular expansions. The nostril, which can be seen on the reverse of the specimen, is a simple oval aperture.
O. C. 1532. *Hunterian.*

E. 109. The opposite half of the same head.
O. C. 1533. *Hunterian.*

E. 110. A dissection from above of the olfactory organs of a Turtle (*Chelone mydas*). The two olfactory nerves are shown. The olfactory cavity has been opened on the left side. O. C. 1534. *Hunterian.*

E. 111. The supporting cartilages of the olfactory organs of a Turtle (*Chelone mydas*). O. C. 1535. *Hunterian.*

AVES.

Gegenbaur, Jena. Zeitschr., Bd. vii. 1873, p. 1.
Hill, 'Nature,' vol. lxxi. 1905, p. 318.

E. 112. The head of a Ki-Wi (*Apteryx mantelli*), divided sagittally to show the olfactory organ and brain. The small nostrils, unlike those of other Birds, open close to the tip of the beak. In consequence the nasal cavity is elongated and can be separated into two regions—a long tubular "vestibule" that extends from the nostril to the base of the beak and is longitudinally ridged by a delicate atrial "process"; and a true nasal cavity occupied by several turbinal prominences and opening into the mouth by the posterior nares. The turbinal system is more developed than in other Birds and superficially bears a strong resemblance to that of a Mammal, four mock "ethmo-turbinals" being ranged in series between the maxillo-turbinal and the cribriform plate. The second of these is a direct continuation of the maxillo-turbinal. The great development of the turbinal system is accompanied by a similar enlargement of the olfactory bulb. The division between this lobe and the rest of the hemisphere is distinct only below, but roughly the bulb has the size and appearance of the end of a little finger, the area from which nerve-fibres are given off to the mucous membrane of the septum and turbinals measuring in an antero-posterior direction 9 mm. From the anatomical features of this specimen, as well as from direct experiment, it is clear that the Ki-Wi has an olfactory sense far more highly developed than that of the generality of Birds.

Benham, Nature, vol. lxxiv. p. 222 (*Physiol.*).

E. 113. A longitudinal section of the head of a Peacock (*Pavo cristatus*), showing the nasal cavity, brain, and olfactory nerve of the right side. The cavity contains the three prominences (atrial process, maxillo-turbinal, and olfactory eminence) characteristic of Birds. The sense of smell, judging by the size of the olfactory nerve, must be very slight.

E. 114. A similar section of the head of a Swan (*Cygnus olor*), showing the septum nasi perforated opposite the nostrils by an oval aperture. This condition is common to Anserine Birds, and is also met with in *Ornithorhynchus* (E. 185). A bristle has been inserted into the Eustachian tube. Upon the reverse of the specimen the lacrymal canal (marked by a black bristle) and maxillary sinuses have been laid open. O. C. 1536. *Hunterian.*

John Hunter, Essays and Observations, edit. R. Owen, 1861, vol. ii. p. 318.

E. 115. Median longitudinal section of the head of a Cygnet (*Cygnus olor*), with the right wall of the nasal cavity exposed by the removal of the septum nasi. The anterior nares open into a vestibular chamber imperfectly separated from the rest of the nasal cavity by a prominent ridge—the atrial process—that runs diagonally from the upper border of the nostril to the lower part of the septum. In the post-atrial nasal cavity there are two main prominences—a maxillo-turbinal, that originates above the atrial process as a narrow ridge and expands posteriorly. It separates the upper (olfactory) half of the nasal chamber from a lower (respiratory) passage that lies upon the palate and opens into the mouth by a pair of slit-like posterior nares, fringed by several rows of stout conical papillæ. Above and behind the maxillo-turbinal lies the olfactory eminence, a triangular expansion which is supplied by the olfactory nerve and is the chief area covered by the olfactory membrane.

The large ophthalmic branch of the trigeminus, which in its natural position lies beneath the mucous membrane of the septum, has been retained, isolated. A black bristle marks the passage from the nose cavity to the frontal sinuses, and a red rod has been inserted into the slit-like opening of the lacrymal duct.

E. 116. Transverse sections through the nose of a Goose (*Anser ferus*). The approximate levels of the section surfaces are

Fig. 20.

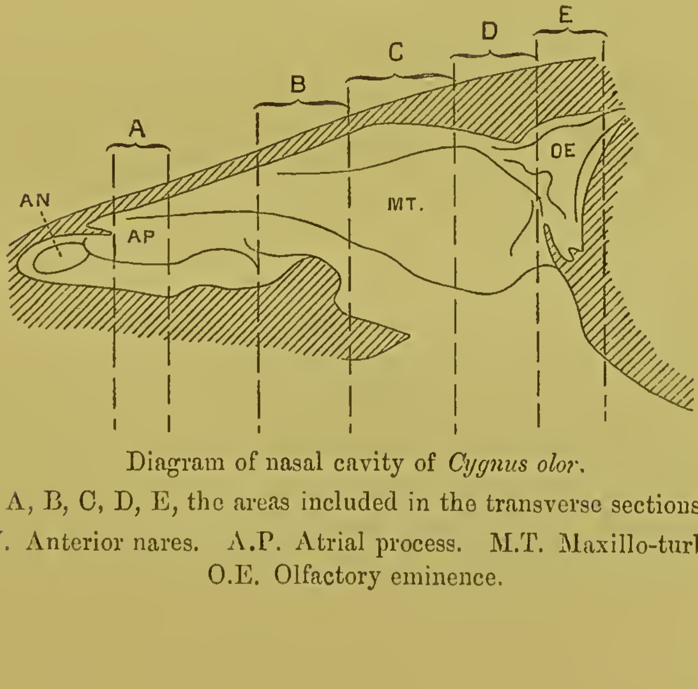


Diagram of nasal cavity of *Cygnus olor*.

A, B, C, D, E, the areas included in the transverse sections.

A.N. Anterior nares. A.P. Atrial process. M.T. Maxillo-turbinal. O.E. Olfactory eminence.

shown on the accompanying diagram from E. 115. Sections A B and E are seen from in front, C and D from behind.

The atrial process and the perforation of the septum are shown in A; the beginning of the maxillo-turbinal and the swelling on the septum at the hinder end of the atrial process in B; the scrolled structure of the maxillo-turbinal and the anterior limit of the posterior nares, in C; the hinder end of the maxillo-turbinal and the anterior extremity of the olfactory eminence, in D; and the olfactory chamber and its separation from the posterior narial passage by the hinder attachment of the maxillo-turbinal, in E.

The maxillary sinus, which has no connection with the nose cavities, is shown in B, C, D, and E.

Green rods have been inserted into the lacrymal duct.

E 116 a. Part of the head of an Albatross (*Diomedea exulans*) in sagittal section, showing the brain and the right half of the nasal cavity.

The brain is remarkable for the large size of the olfactory bulbs, which measure 7 mm. in length × 8 mm. vertically, the length of the rest of the hemisphere being 35 mm. This strong development of the olfactory bulbs is accompanied by a corresponding enlargement of the olfactory eminence, which lies in a backward extension of the upper part of the nasal chamber imperfectly separated from the rest by a shelf-like process of the septum (most of this process has been removed). Olfactory nerves are distributed to the surface of the olfactory eminence and to the neighbouring parts of the septum. They are indicated in the specimen by a faint longitudinal striping of the mucous membrane. Their cut ends can be seen projecting from the left olfactory bulb. It seems likely that in this and certain other aquatic Birds the sense of smell is relatively strong.

The maxillo-turbinal and atrial process are not remarkable. Upon the free edge of the latter the opening of the duct of the nasal gland (*cf.* E. 180) can be seen filled with black injection. A green rod has been passed into the lacrymal duct.

E. 117. The head of a Gannet (*Sula bassana*) in mesial sagittal section, showing the reduced condition of the olfactory organ. There are no anterior nares, and the olfactory chambers are reduced to a pair of dome-shaped pits that extend upwards into the skull from the hinder parts of the palate. The pits are separated mesially by a septum that terminates ventrally some distance within the common opening of the posterior nares. The inner surface of the olfactory chamber is smooth. The olfactory nerve (indicated by black paper) and bulb are small compared with those of many Birds. A hair has been inserted into the duct of the nasal gland. This reduced condition of the nose, with the absence of the anterior nares, is common to members of the Order Steganopodes, all of which are aquatic Birds.

E. 118. A longitudinal section of the head of a Golden Eagle (*Aquila chrysaëtus*), showing the lateral wall of the left half of the nasal cavity. The vessels of the maxillo-turbinal have been minutely injected to show the high degree of vascularity of the mucous membrane. The maxillary sinus, situated beneath and to the side of the nasal cavity, has been opened, and bristles have been passed from the puncta lacrymalia (see reverse of the specimen) through the lacrymal duct into the nose. The opening of the duct lies close behind the hinder end of the atrial process.

O. C. 1538. *Hunterian.*

E. 119. A similar specimen in which the brain, olfactory bulbs and nerves, and olfactory eminence are shown.

E. 120. A transverse section through the head of an Erne (*Haliaëtus albicilla*) taken through the mid-region of the maxillo-turbinals. The cavities of the maxillary sinuses are well shown, as also is the position of the lacrymal ducts (marked by black bristles). Bristles have also been inserted into the common opening of the Eustachian tubes, situated behind the posterior nares. Upon the reverse of this specimen a dissection has been made of the eyes—the left eye having been divided to show the pecten, and a preparation having been made of the muscles of the globe and of the nictitating membrane on the right side.

O. C. 1539. *Hunterian.*

E. 121. The anterior part of the same head, showing the terminations of the maxillo-turbinals and of the lacrymal ducts (indicated by black bristles), and also the passage of the maxillary sinuses into the cancellous tissue of the beak.

O. C. 1540. *Hunterian.*

E. 122. The head of a young Rook (*Trypanocorax frugilegus*) in sagittal section, showing the right half of the nose cavity and brain. The atrial process and maxillo-turbinal are well developed, particularly the latter, which has a swollen cylindrical form. The olfactory eminence and olfactory bulb and nerve are, on the other hand, peculiarly small, showing that the sense of smell is feeble.

MAMMALIA.

Zuckerkandl, Das periph. Geruchsorg. Säugethiere, Stuttgart, 1887.

Paulli, Morph. Jahrb., Bd. xxvi. 1900, pp. 147, 179, 483.

In Mammals the respiratory passage occupies the anterior and lower parts of the nose cavity, and is separated from the olfactory chamber by the maxillo-turbinal in front, and behind by a horizontal septum (lamina terminalis) that stretches forward from the sphenoid bone and is united to the side walls of the cavity and to the septum. The maxillo-turbinal, which is chiefly used in warming and filtering the inspired air, is homologous to the only true turbinal of Reptiles and Birds and occurs in a considerable variety of forms, due apparently to the progressive division and scrolling of the free border of an originally simple plate.

The olfactory chamber is filled by ethmo-turbinals that spring from the cribriform plate and are also attached to the lateral walls of the cavity and to the lamina terminalis. An ethmo-turbinal in its simplest form is a plate (basal lamella) attached along one margin, and with its free edge thickened or bent upon itself to form a double or single olfactory scroll. The basal lamella is usually simple, but it may divide longitudinally and give rise to two or more marginal scrolls, or again it may be complicated by the development of small secondary scrolls upon its sides. The ethmo-turbinals are divisible into two series (figs. 22. 23):—

(1) Endo-turbinals, whose marginal olfactory scrolls abut on the septum and are visible from the mesial aspect. They are usually five in number and very constant. (2) Ecto-turbinals, smaller scrolls attached in varying numbers to the nasal walls between the endo-turbinals and in mesial view concealed by them.

The first or most dorsally attached of the endo-turbinals extends forward along the nasal bone, and to distinguish it from the rest is usually called the naso-turbinal. In most cases the cavity of the olfactory chamber is further extended

Fig. 21 A.

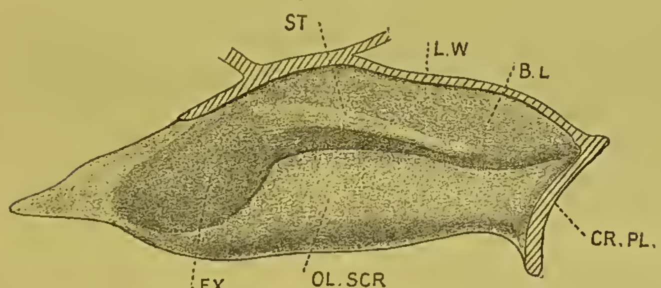


Fig. 21 B.

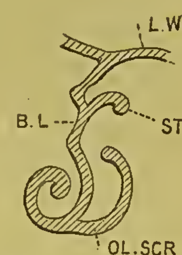


Fig. 21 A.—Second endo-ethmoturbinal of *Lepus cuniculus*.
Fig. 21 B.—Transverse section of the same turbinal.

B.L. Basal lamella. CR.PL. Cribriform plate. EX. Free extremity. L.W. Lateral wall of nasal chamber. OL.SCR. Olfactory scroll. S.T. Secondary turbinal.

by the outpushing of recesses and accessory cavities into the neighbouring bones of the skull. In lower (osmatic) Mammals some of these spaces form simple outpushings or recesses of the general nose cavity, and serve for the lodgment of ethmo-turbinals and for the increased extension of the olfactory membrane, while others, both in osmatic and anosmatic Mammals, form vacant pneumatic chambers or sinuses in more or less open communication with the nose cavity or its recesses *. In Man the sinuses are almost completely cut off from the nose cavity, and are known as the antrum or maxillary sinus, the frontal and sphenoidal sinuses, and the ethmoid cells, and are lodged respectively in the maxilla, the frontal bone, the pre-sphenoid, and the lateral parts of the ethmoid, but the position of these cavities is no true guide to their homology, which can only be determined by their point of connection with the nose

* Specimens of these sinuses are also shown in section A.

cavity. Thus the maxillary sinus may frequently extend into the frontal or sphenoid bones, but its opening always lies between the hinder end of the maxillo-turbinal and the anterior attachment of the second endo-turbinal. In like manner the frontal sinuses, whatever their extension, open between the basal lamellæ of the first and second endo-turbinals, and the sphenoid sinus and ethmoidal cells in different positions between the basal lamellæ of the succeeding endo-turbinals. In the following descriptions the term recess denotes an open extension of the nose cavity containing turbinals, and the term sinus a vacant pneumatic cavity opening into a recess or into the main cavity of the nose.

The olfactory membrane is chiefly confined to the upper part of the septum and the ethmo-turbinals, thus the number and complexity of these turbinals taken in conjunction with the size of the olfactory parts of the brain give a rough measure of the degree of perfection of the olfactory sense.

MONOTREMATA.

E 123. Sagittal section of the fore part of the head of a Duck-billed Platypus (*Ornithorhynchus anatinus*), showing the right half of the nasal cavity. The olfactory organ is degenerate in the Platypus, owing to the unimportance of the sense of smell to an aquatic animal, and also differs in form entirely from that of its only near ally—Echidna. The olfactory chamber, which is not separated from the hinder part of the respiratory passage by a lamina terminalis, is occupied by three endo-ethmoturbinals, one of which, however (Paulli, *l. c.*, p. 170) bears two terminal olfactory scrolls. The olfactory region of the brain is relatively small (*cf.* D. 189), and the apertures of the cribriform plate are reduced as in some Primates to one on either side. In comparison with this reduced condition of the olfactory parts of the nose cavity, the respiratory region is well developed. The maxillo-turbinal is large and of complex structure, conforming to Zuckerkandl's multi-scrolled type. It arises midway between the nostril and the cribriform plate, and at once swells to form a large spindle of scroll systems filling the nasal cavity. It terminates posteriorly below the last ethmo-turbinal. The nostril lies upon the dorsal surface of the snout as in Echidna. Its orifice is valved (*cf.* E. 185). The floor of the nose just behind the nostril forms a considerable projection (the anterior end of the horizontal lamina shown in E. 185), within which lies the organ of Jacobson. In the specimen the mesial wall of this organ has been removed, showing the free edge of a turbinal-like prominence that projects into its cavity.

Symington, Proc. Zool. Soc., 1891, p. 575.

E. 124. Right half of the head of a Spiny Ant-eater (*Tachyglossus* [*Echidna*] *aculeatus*), in which the nasal cavity has been exposed by the removal of the septum. The organ of smell is remarkably developed. This is shown by the large size of the cribriform plate (*cf.*, D. 191) and the great development of the ethmo-turbinals and hinder part of the septum, which form the chief area covered by the olfactory membrane. There are seven endo-ethmoturbinals (Paulli, *l. c.*, p. 171) represented by eight olfactory scrolls, which are further complicated by numerous secondary foldings. The root of one of the ecto-ethmoturbinals is visible between the third and fourth endo-turbinals. The extent of the olfactory membrane is yet further increased by numerous turbinal-like outgrowths upon the hinder part of the septum. These in the natural condition interdigitate with the foldings of the four last ethmo-turbinals. They are shown upon a portion of the septum mounted beside the main specimen. The maxillo-turbinal is relatively simple. It begins anteriorly at the nostril and for more than half its length is represented by a simple fold. Behind, it spreads out to a spindle shape and is grooved by a deep furrow upon its median surface. It terminates posteriorly beneath the fourth ethmo-turbinal. The olfactory chamber is separated from the hinder part of the respiratory passage by a small lamina terminalis, but there are no accessory cavities. The nostril lies upon the dorsal surface of the tip of the snout.

Zuckerkandl, *l. c.*, p. 10.

MARSUPIALIA.

E. 125. Head of a Spotted-tailed Dasyure (*Dasyurus maculatus*) divided by a longitudinal section to show the extent of the nasal cavity in the vertical plane and the septum nasi.

The septum is free along its lower border backwards from the naso-palatine canal. It is grooved below in its anterior parts and embraces an upstanding ridge of the maxillæ but without actual fusion. In its hinder part it is joined laterally by the two halves of the lamina terminalis. The extent of this union (20 mm.) is shown on the section surface by the cut edge of the lamina.

The size of the cribriform plate indicates a well-developed olfactory bulb (*cf.*, D. 197). The naso-palatine canal of the left side has been opened.

E. 126. The right half of the head of a Walleroo (*Macropus robustus*), showing the nasal cavity and the arrangement of the turbinal bones. The cavity is oblong in the sagittal plane, the fore part being peculiarly spaceous. The large maxillo-turbinal is fluted upon its inner and upper surfaces by two deep furrows that limit separate scroll systems. In addition to the naso-turbinal, which is plate-like, there are four endo-ethmoturbinals somewhat similar to those of the Sheep in form. The olfactory bulb is fairly large, but the general anatomical characters of the nose do not suggest any great development of the olfactory sense. In this specimen the naso-palatine and part of the nasal branch of the trigeminal are indicated by black bristles ; they are of considerable size. The cut end of the chief branch of the olfactorius to the septum is also shown, and part of the ventral edge of the septum has been retained to show the point at which it becomes free of the palate.

E. 127. A series of eight transverse sections through the nose of a Black-faced Kangaroo (*Macropus melanops*). The following are some of the chief points shown in the several sections :—A. The external aspect of the muzzle and the position of the nostrils. B. The plate-like anterior extremities of the maxillo- and naso-turbinals, and the opening of the naso-palatine canals into the mouth. C. The middle part of the maxillo-turbinals. This is a good example of the multi-scrolled type of this turbinal ; it differs considerably from that of *M. robustus* (previous specimen). D. The hinder end of the maxillo-turbinals and (on the right side) the anterior conical free-end of the second endo-ethmoturbinal. The scroll-systems of the maxillo-turbinal are converging together to form its hinder stalk of attachment. The two walls of the naso-turbinal are spreading apart and contain between them the anterior extremity of a cavity that further back becomes the frontal recess. E. The anterior limit of the opening from the general nose-cavity into the frontal recess and within the latter, parts of ecto-ethmoturbinals. F. The frontal ecto-turbinals are now more complex. The remains of the naso-turbinal have diminished in size and the anterior ends of the second and third endo-turbinals have appeared. G. Appearance of the fourth and fifth endo-ethmoturbinals.

Fig. 22.

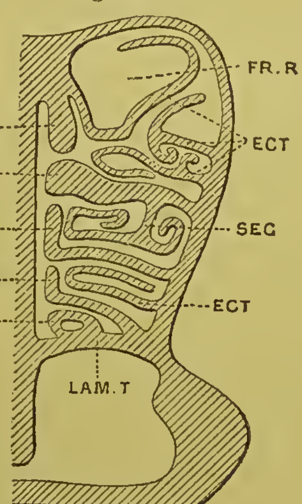


Diagram of Section G.

I, II, III. IV, V. Endo-ethmoturbinals. ECT. Ecto-turbinals. FR.R. Frontal recess. LAM.T. Lamina terminalis. SEC. Secondary turbinal.

In this section the relative positions of the endo- and ecto-turbinals are very clearly shown, especially on the left side. There are three ecto-turbinals between the first and second endo-turbinals, and one between the third and fourth. The basal lamella of the second endo-turbinal gives origin to a secondary turbinal. The lamina terminalis is now formed. The frontal recess merges into an empty space—the frontal sinus. H. The frontal sinuses above are separated by the olfactory bulbs from the sphenoidal recesses in which lie the fifth pair of endo-turbinals.

In sections C, D, and E, Jacobson's organs and Jacobson's glands can be seen at the lower end of the septum.

E. 128. The nasal septum and two transverse sections through the nose of a Black-faced Kangaroo (*Macropus melanops*), showing the organ of Jacobson. In the upper specimen the right organ is exposed from the side. It is a long tube surrounded anteriorly by a scroll-like cartilage, lined by olfactory epithelium and enveloped, especially posteriorly, by a mass of gland tissue (Jacobson's gland) and blood-vessels. It is situated beside the base of the septum, and opens anteriorly into the naso-palatine canal (black bristle) and receives numerous strong nerves from the olfactorius, as well as branches from the trigeminus. A considerable part of Jacobson's gland has been removed to show the branches of the olfactorius going to the organ. The sections show the opening of Jacobson's organ into the naso-palatine canal, and the organ in cross section.

Symington, Jour. Anat. & Physiol., vol. xxvi. 1891, p. 371.

E. 129. Right half of the head of a Phalanger (*Trichosurus vulpecula*) with the nasal cavity exposed by the removal of the septum. The arrangement of the five endo-ethmo-turbinals is very similar to that of the Kangaroo; the fifth is, however, larger and more oblong in outline. Between the roots of the first and second endo-turbinals can be seen part of an ecto-turbinal. The maxillo-turbinal is multi-scrolled.

EDENTATA.

E. 130. Left half of the head of an Ant-eater (*Myrmecophaga jubata*), showing the form and extent of the nasal cavity and the arrangement of the turbinal bones. The whole cavity is greatly lengthened. The maxillo- and naso-turbinals are simple and differ little from those of the Sheep. They extend forward to the nostril. The naso-turbinal, which in front is a simple solid lamina, becomes inflated posteriorly. Including the naso-turbinal, there are five endo-ethmoturbinals, the second of which is continuous anteriorly with the hinder end of the maxillo-turbinal and is provided with two marginal olfactory scrolls, as in the Rabbit or the Bat. The roots of several ecto-turbinals can be seen between those of the endo-turbinals. Judging by the size of the cribriform plate, the sense of smell is acute. The lower edge of the septum has been retained to show the point at which it becomes free of the palate.

Upon the reverse of this specimen, the muscles of the lips and snout are shown.

Paulli, *l. c.*, p. 509.

E. 131. A small piece of the other half of the same head showing in transverse section the maxillo- and naso-turbinals. The former is composed of two simple scrolls arising from a common lamina, the latter is a mere plate-like projection. The section was taken 15 cm. from the extremity of the snout.

E. 132. Right half of the head of a Hairy Armadillo (*Dasypus villosus*) with the nasal cavity exposed. The olfactory labyrinth is remarkably developed, and in the arrangement of the endo-ethmoturbinals has a superficial resemblance to that of Echidna. The maxillo-turbinal is simple and is apparently of the double-scrolled type. There are seven * endo-ethmoturbinals, including the naso-turbinal. The first and second are much elongated, the first, as usual, extending to the nostril, the second to the middle of the maxillo-turbinal. The remainder are oblong in shape, with their length nearly in the vertical plane as in Echidna; they are enclosed in the backward prolongation of the olfactory chamber (sphenoid recess) that lies above the lamina terminalis, and are deeply fluted by superficial corrugations. Above the base of the naso-turbinal a small piece of the partition wall between the accessory cavities in the frontal bones has been removed to expose some of the ecto-ethmoturbinals contained in the frontal recess.

* This may be too high a number, as it is not always possible in this view to distinguish between true turbinals and marginal olfactory scrolls, two of which may belong to one turbinal.

The cribriform plate is of great size and is separated into two distinct areas through which respectively pass the nerves from the turbinals in the frontal recess and from those in the main cavity and from the septum.

The nostril is guarded by a brush of stiff papilliform spines along its lower and outer margin.

Paulli, *l. c.*, p. 511.

CETACEA.

"The organ of smell would appear to be less necessary in these Animals than in those which live in air, since some [the Toothed Whales] are wholly deprived of it; and the organ in those which have it is extremely small when compared with that of other Animals, as well as the nerve which is to receive the impression."—*John Hunter*, *Phil. Trans.*, vol. lxxvii. 1787, p. 428.

E. 133. A small part of the head of a Piked Whale (*Balænoptera acuto-rostrata*) including the left posterior narial opening. This is long and slit-like, slightly curving outwards. Upon the right of the specimen the cut surface shows pieces of the ethmo-turbinals and the cavity occupied in life by the olfactory bulb. This specimen can be better understood by reference to No. 2759 Osteol. Series, which is apparently its counterpart, dried.

O. C. 1546. *Hunterian.*

UNGULATA.

HYRACOIDEA.

E. 134. A sagittal section through the fore-part of the head of a Cape Hyrax (*Procavia capensis*), showing the right half of the nasal cavity. The maxillo-turbinal is peculiarly small and simple. There are four endo-ethmoturbinals, with five marginal olfactory scrolls, each of which presents a perfectly smooth surface towards the septum. The first (naso-turbinal) is broadened out posteriorly, and its lower border is prolonged downwards to form the anterior boundary of a bay in which lies the free end of the second endo-turbinal. The fourth endo-turbinal and the upper scroll of the second are broad and from this aspect roughly triangular in outline, the third and the lower scroll of the second being narrower and more quadrangular. The hinder part of the sphenoid recess is vacant. There is no frontal sinus.

George, Ann. Sci. Nat., sér. 6, T. i. 1874, p. 172.

PERISSODACTYLA.

E. 135. Right half of the head of a fœtal Horse (*Equus caballus*), showing the cavity of the nose. The maxillo-turbinal is flat and simple in form, terminating in front in a pair of ridges, the upper of which (the wingfold) contains the navicular cartilage, the lower being traversed by the lacrymal duct (*cf.*, E. 196). There are six endo-ethmo-turbinals, of which the last three lie in the recess above the lamina terminalis. The naso-turbinal extends as usual from the nostril to the cribriform plate, but is of remarkable breadth for almost the whole distance, occupying nearly half the vertical diameter of the nose-cavity. Its median surface is deeply grooved towards the anterior end. The other five endo-turbinals have a very characteristic form, being short and spindle-shaped and each subdivided by deep longitudinal folding. Parts of ecto-turbinals can be seen between the stalks of attachment of the endo-turbinals. The lining membrane of a large cavity in the lamina terminalis (probably part of the maxillary sinus) has been exposed, and within the brain-cavity the hinder surface and stalk of the olfactory bulb are shown. The dilatation upon the Eustachian tube (*cf.*, E. 327) has been laid bare, and a blue rod has been passed into it from the posterior respiratory passage.

Ellenberger & Baum, Vergl. Anat. Hausthiere, 1903, p. 476.

E. 136. A vertical transverse section through the anterior part of the nasal cavity of a Horse (*Equus caballus*), showing the naso- and maxillo-turbinals, each of which in this region consists of a single scroll. The membrane covering the turbinals is extremely vascular, containing an extensive venous rete—the plexus venosus concharum.

On either side of the base of the septum, Jacobson's organ can be indistinctly seen in section, ensheathed in a scroll-like Jacobson's cartilage. O. C. 1556 B.

Presented by Joseph Swan, Esq.

ARTIODACTYLA.

E. 137. The head of a fœtal Pig (*Sus scrofa*) in sagittal section, showing the brain and nasal cavity—the outer wall of the left half of the cavity in the lower specimen and the septum in the upper.

The maxillo-turbinal is simple, as in other Ungulates. Instead of the usual five endo-ethmoturbinals there are seven, the last two of which are however very small. The second to the fifth resemble those of the Horse in general shape and are subdivided by folds of their surface. The hinder end of the naso-turbinal is separated from the root of the second endo-turbinal by a considerable gap, within which appears part of an ecto-turbinal.

These specimens have been minutely injected.

O. C. 1551 B, & 1551 C.

Paulli, *l. c.*, p. 193.

E. 138. A sagittal section of the head of a Sheep (*Ovis aries*) exposing the right half of the nasal chamber and brain. The maxillo-turbinal is of quite simple form though large. There are five endo-ethmoturbinals with six marginal scrolls. In this view the olfactory labyrinth has an extremely simple appearance, the endo-turbinals being perfectly smooth and of moderate size. In reality the ethmo-turbinals are very complex and numerous. Part of the olfactory bulb has been exposed by the removal of the anterior end of the hemisphere. Most of it is, however, hidden by the roots of the endo-turbinals.

E. 139. Part of the right half of the head of a Sheep (*Ovis aries*) showing the distribution of the olfactorius and trigeminus nerves upon the septum nasi. The chief septal branch of the olfactorius runs downwards and forwards to be distributed to Jacobson's organ. In the specimen the branches of this nerve are indicated by a red rod. A large naso-palatine branch of the trigeminus runs forward in the angle formed by the septum and the floor of the nasal cavity. Other nasal branches of the same nerve can be seen entering the substance of the maxillo-turbinal. The forward parts of the septum are innervated by a fine nerve given off from the spheno-palatine ganglion.

E. 140. Six transverse sections taken at different levels through the nose of a Sheep (*Ovis aries*), in which the following points are shown in particular :—

A (the most anterior section). The cavity is plain in outline with a prominence—the anterior end of the maxillo-turbinal—projecting from its lateral walls. The passage of Jacobson's organ into the naso-palatine canal is shown, the cavities of Jacobson's organ (red rod) and of the naso-palatine canal (purple rod) being united by a narrow cleft upon the section surface. B. The nasal opening of the lacrymal duct is shown on the right by a green rod, and a red rod is inserted into the cavity of Jacobson's organ. C. The maxillo-turbinal has increased in size and has assumed a double-scrolled form. Above it lies the laminar anterior part of the naso-turbinal. D. The maxillo-turbinal is at its largest. Within the naso-turbinal is a cavity that further back broadens out into the frontal recess. The antrum is shown in this section. E. Below the anterior parts of the frontal sinuses lies the olfactory labyrinth consisting of the endo- and ecto-ethmoturbinals. The majority of the latter lie in the frontal recess—an out-pushing of the nose-cavity between the first and second endo-turbinals. F. The hinder part of the nose-cavity showing the frontal sinuses above separated by the olfactory bulbs from the respiratory passages and the recess containing the lower endo-turbinals.

All the sections with the exception of E are seen from in front.

E. 141. Two specimens showing the Jacobson's organ of a Sheep (*Ovis aries*). This organ, as in other Ungulates, is strongly developed, and lies alongside the ventral border of the septum nasi, surrounded by a cartilaginous sheath (Jacobson's cartilage). It has the form of a long laterally flattened tube, blind and pointed posteriorly and opening in front by a slit-like aperture into the naso-palatine canal. In cross section the lumen is crescentic, with its concavity directed outwards. The walls are thick and vascular; they are chiefly composed of glandular tissue (Jacobson's glands); the lumen is lined by olfactory epithelium similar in histological structure to that in the Reptilian Jacobson's organ. The organ is innervated from the olfactorius and trigeminus.

In the upper specimen the relations of Jacobson's organs to the nose are shown by a transverse section, the lumen of the right Jacobson's organ being indicated by red glass rods. In the lower specimen the left organ has been exposed, showing particularly its innervation and method of opening into the naso-palatine canal. Windows are cut in the canal and in the outer wall of Jacobson's organ.

O. C. B 1559 A.

E. 142. The maxillo-turbinal of a Calf (*Bos taurus*), isolated. It is fusiform in shape, and is attached along one side to the lateral walls of the nasal cavity by a basal lamella, the cut edge of which is shown in the specimen. The free edge of the basal lamella is scrolled outwards on either side, giving rise to the plain rounded form of the turbinal. O. C. 1556. *Hunterian.*

RODENTIA.

E. 143. Anterior parts of the head of a Canadian Porcupine (*Erethizon dorsatum*), in sagittal section, showing the cavity of the nose. The cavity has considerable vertical depth. The hinder part is occupied by the ethmo-turbinals, of which there are four in the median row. Of these the first (naso-turbinal) extends forward above the maxillo-turbinal nearly to its anterior end. A process extends downwards from its lower border in front of the succeeding ethmo-turbinals, and is attached to the lateral nasal wall at a point close in front of the lamina terminalis. The second to the fourth endo-turbinals have a simple dilated form, and are united together distally by a plate that posteriorly merges into the lamina terminalis. An ecto-ethmoturbinal is very plainly visible between the roots of the first and second endo-turbinals.

The maxillo-turbinal, unlike that of the Rabbit, is perfectly smooth mesially. In its posterior segment it is much flattened and is free only dorsally. One centimetre within the nostril it is dilated to form a globular prominence, in front of which is another that contains a cavity, suggestive of the false nostril of the Horse (E. 195), that opens into the nose by a small round aperture just within the nostril. A black bristle has been passed into the naso-palatine canal. A large pneumatic sinus of triangular form is situated beneath the outer and posterior parts of the frontal bone. It is shown by the removal of the anterior wall of the brain-case. At its anterior end it opens into the nasal cavity behind the downward process of the naso-turbinal. The passage is shown by a black bristle. Antero-mesially this sinus is separated by a thin partition wall from another large sinus situated partly beneath the frontal bone and partly in the maxilla.

E. 144. The head of a young Crested Porcupine (*Hystrix cristata*) in sagittal section, showing the surface of the septum. The anterior end of the septum is attached ventrally to the palate, which in this part is dilated by an unpaired sinus, that opens from the anterior end of the posterior respiratory passage just below the thickened anterior end of the free ventral border of the septum. A short distance within the opening are a pair of orifices that lead on either hand into a backwardly directed sinus (maxillary sinus). The free ventral border of the septum is strongly arched upwards and is remarkably broad. Where it spreads out on either side to form the lamina terminalis, a pair of openings, marked by black bristles, lead into air spaces within the basal lamellæ of the ethmo-turbinals.

Paulli, Morph. Jahrb., Bd. xxviii. 1900, p. 516.

E. 145. The head of a Rabbit (*Lepus cuniculus*) in sagittal section, showing the nose-cavity and brain. The maxillo-turbinal is multiscrolled, as in many Marsupials and

Carnivores. The ethmo-turbinals are simple and of relatively small size. There are four endo-ethmoturbinals, of which the first (naso-turbinal) is plate-like in front but inflated posteriorly, the second bears two terminal olfactory scrolls, and the fourth is partly lodged in a recess in the sphenoid bone. The sense of smell is probably not very acute, to judge by the want of complexity of the ethmoid labyrinth and the comparatively small size of the olfactory bulb. There is no naso-palatine canal.

Paulli, *l. c.*, p. 513.

PINNIPEDIA.

E. 146. A sagittal section through the head of a young Walrus (*Odobænus rosmarus*), showing the tubular form of the nasal cavity and the arrangement of the turbinals of the right side. The cavity of the nose is almost completely filled by the highly developed maxillo-turbinal. This in general shape and structure resembles that of the Dog, but is relatively far larger and shows a most elaborate system of scrolling. The naso-turbinal is small and does not reach more than half way to the nostril. The rest of the ethmo-turbinals are also much reduced and extend forward a very little way from the cribriform plate. The outlines of the lower ethmo-turbinals are indistinct. Enough however is shown in the specimen to make it evident that in comparison with the land Carnivora the sense of smell must be insignificant in the Walrus, and that the nose-cavity is essentially a passage in which the air is warmed on its way to the lungs by passing through the interstices of the maxillo-turbinal. O. C. 1557. *Hunterian.*

E. 147. The left maxillo-turbinal from the same Walrus. The general form of the turbinal is shown, and the cut edge of its attachment to the lateral nasal wall. It is fastened along its whole outer aspect, mainly by two broad stalks, one at either end, which are formed by the convergence and coalescence of the numberless scrolls of which the bulk of the turbinal is composed, but also by a narrow lamina that connects the two terminal stalks, and is in fact the basal lamella from which the whole complex scroll-system has grown out. In the specimen the cut off terminal stalks are very plain, but the central lamina is partially concealed by the overlapping of the scroll systems of either side. O. C. 1558. *Hunterian.*

E. 148. A vertical section of the same head including the nasal septum. O. C. 1559. *Hunterian.*

E. 149. A sagittal section through the fore part of the head of a young female Bladder-nosed Seal (*Cystophora cristata*), showing the nose-cavity. The septum has been retained in the anterior part of the nose, but removed from the hinder two-thirds.

The nostril opens into a capacious vestibular chamber of oblong outline. This represents, in a rudimentary condition, the enormous inflatable air-sac of the adult male. Posteriorly and below, the vestibule opens into the nose-cavity proper by a constricted mouth bordered above by a projecting lip. The nose-cavity is almost completely filled by turbinals. It has roughly a square outline in the vertical plane. Its anterior half is occupied by the maxillo-turbinal, which, as in the Walrus, is large, spindle-shaped, and an extremely complex variety of the multi-scrolled type. Its anterior extremity reaches a point just in front of the dorsal lip of the vestibulo-nasal opening, and its posterior end to a point below the last ethmo-turbinal.

The endo-turbinals are five in number, with seven marginal olfactory scrolls, and though short, are considerably developed, with deep pleats upon the surface. The first (naso-turbinal) extends forward to the posterior surface of the dorsal lip of the vestibulo-nasal opening. The cribriform plate is fairly large. O. C. 1556 c.

E. 150. The anterior part of the head of a male Bladder-nosed Seal (*Cystophora cristata*), showing from behind the vestibular cavities and the opening in the posterior part of the floor of each by which it communicates with the nasal chamber proper. These dilatable vestibular chambers are of enormous size in the male. They lie mainly above the level of the cartilaginous nasal septum separated from each other by a partition of soft tissue. Part of the right maxillo-turbinal has been retained, but the left has been removed. O. C. 1556 F.

Presented by Capt. David Gray.

Rapp, Arch. f. Anat., 1829, p. 236.

E. 151. Posterior part of the same head showing the hinder blind extremities of the vestibular chambers and the posterior border of their passage into the nasal chamber. The latter cavity is almost entirely filled by the complex multi-scrolled maxillo-turbinal. O. C. 1556 G.

Presented by Capt. David Gray.

E. 152. The right vestibule removed from the skull of an adult male Bladder-nosed Seal (*Cystophora cristata*), showing the circular form of the nostril, the septum between the two chambers, and the outline of that of the left side in the vertical plane. From an animal brought from Greenland by Mr. Whymper in 1870. The skeleton is Osteol. Series, No. 1101. O. C. 1556 D.

E. 153. A portion of the lateral wall of the left sac of the same individual dissected to show the subcutaneous muscle-fibres radiating over it. O. C. 1556 E.

CARNIVORA.

CYNOIDEA.

E. 154. Fore part of the head of a Foxhound in sagittal section, showing the right half of the nasal cavity.

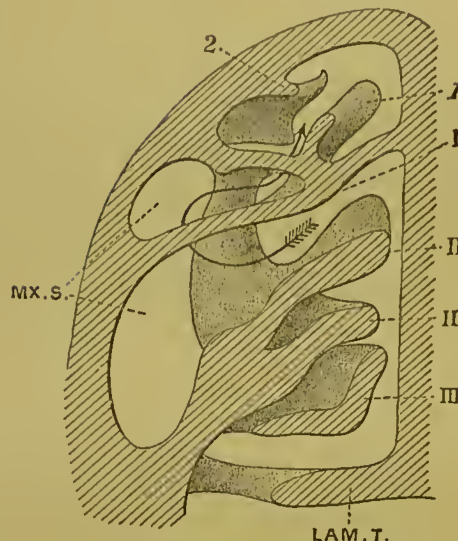
The maxillo-turbinal is spindle-shaped and belongs to the multi-scrolled type. It is continuous in front with a fold supported by the navicular cartilage (*cf.* E. 202)—an internal process of the lateral cartilage of the nasal wall. Its middle region is greatly expanded and is broken up by deep gutters into a number of branching ridges, which are the superficial parts of a complex system of scrolls springing on either side from a central lamina. Posteriorly the scrolls reunite to form a single fold similar to the one in front, that merges into the lateral wall of the nasal cavity in front of the lamina terminalis.

The ethmo-turbinals and the olfactory bulb are very strongly developed, though not quite so much so as in the Cat; the turbinals occupy approximately the hinder half of the entire nasal cavity. There are four endo-ethmo-turbinals with five olfactory scrolls, which differ from those of the Cat mainly in being longer and narrower. The first ethmo-turbinal (naso-turbinal) is plate-like and solid in front, but dilates posteriorly to form the mesial and lower boundary of a large frontal recess which is occupied by a number of ecto-turbinals and communicates with a well-marked frontal sinus. The anterior end of the second endo-ethmoturbinal is closely applied to the hinder margin of the maxillo-turbinal: the two are separated in the specimen by a row of black bristles. The fifth endo-turbinal is elongated and extends to the hinder limit of the sphenoid recess.

Paulli, *l. c.*, p. 489.

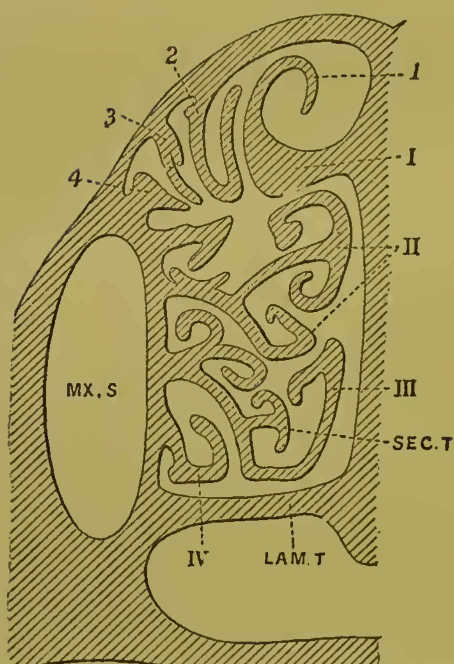
E. 155. A series of nine transverse sections through the nose of a Dog (*Canis familiaris*): sections A and D seen from behind, the rest from in front.—A. Through the anterior ends of the naso- and maxillo-turbinals. On the left side the naso-palatine canal has been opened and a bristle passed into it through the opening of the organ of Jacobson.—B. The maxillo-turbinal is slightly grooved. A green rod is inserted into the opening of the lacrymal duct, a purple into the naso-palatine canal, and a red into Jacobson's organ.—C. Through the scrolled part of the maxillo-turbinal.—D. The naso-turbinal flattens out and contains a cavity (the anterior end of the frontal recess) in which are small processes—the anterior ends of ecto-turbinals. A large passage between the hinder extremity of the maxillo-turbinal and the anterior attachment of the second endo-turbinal leads into a recess in the maxilla (antrum). The septal part of the lamina terminalis is spreading across the nasal chamber.—E. The frontal recess, which is now filled with well-developed ecto-turbinals, becomes continuous with the maxillary sinus and the general nose-cavity. The second and third endo-turbinals are united together and to the lateral wall of the nose-cavity above the lamina terminalis. The lamina terminalis is completed. The

Fig. 23 A.



A diagram of Section E.

Fig. 23 B.



A diagram of Section F.

I, II, III, IV. The Endo-ethmoturbinals. 1, 2, 3, 4. Ecto-turbinals in the frontal recess. LAM.T. Lamina terminalis. MX.S. Maxillary sinus. SEC.T. Secondary turbinal. In Fig. 23 A an arrow is passed from the main nasal cavity into the maxillary sinus and frontal recess.

septum loses its connection with the floor of the nose.—F. Posterior extremity of the maxillary sinus. Second and third endo-turbinals abut against the septum. Black paper has been inserted between the second endo-turbinal and the contents of the frontal recess.—G. Union of the second and third endo-turbinals with the cribriform plate, and consequent separation of the frontal recess with its turbinals from the sphenoid recess containing the fourth endo-ethmoturbinal. The punctum lacrymale of the left side is indicated by a green rod.—H. Above: the hinder end of the frontal turbinals and passage of the frontal recess into the frontal sinus. Below: the posterior end of the fourth ethmo-turbinals in the sphenoidal recesses. In the middle: the olfactory bulbs.—I. The frontal sinuses and the fore part of the cerebral hemispheres.

E. 156. A sagittal section of the head of a Greyhound (*Canis familiaris*), showing the right half of the brain and cavity of the nose. In this Dog, which has been bred to hunt entirely by sight and not by scent, the extent of the surface of the ethmo- and fronto-turbinals, and the size of the olfactory part of the brain are apparently quite as great as in the Foxhound.

AILUROIDEA.

E. 157. The head of a Cat (*Felis domestica*) in sagittal section, showing the right half of the nasal cavity and of the brain. Zuckerkandl (*l. c.*, p. 48) states that of all the Mammals examined by him the Cat has the most extensive olfactory area. This great development of the olfactory organ is indicated in the specimen by the size and extent of the ethmo-turbinals and of the olfactory region of the brain. The maxillo-turbinal is relatively small and is for the most part hidden from view by the forward extension of the second endo-ethmoturbinal. There are four endo-turbinals with five marginal olfactory scrolls, the basal lamella of the second being longitudinally divided. The naso-turbinal is lamelliform and extends forward nearly to the nostril. The second, third, and fourth endo-turbinals are triangular in mesial view, with their free apices directed forward, and are attached posteriorly to the cribriform plate, and ventrally to the lamina terminalis. The mesial surface of the second and third is concave, the concavities being respectively occupied by the free ends of the third and fourth. Behind the fourth endo-turbinal is a vacant recess in the pre-sphenoid (sphenoid sinus). Above the hinder part of the naso-turbinal is a large chamber—a recess from the main nasal cavity—occupied by two scrolled ecto-turbinals. This frontal recess opens posteriorly into a vacant frontal sinus.

Paulli, *l. c.*, p. 502.

E. 158. A series of transverse sections through the nose of a Cat (*Felis domestica*). These sections are intended, as in previous cases, to explain the longitudinal section forming the previous specimen and should be studied in connection with it. Sections A G I K are seen from in front, the rest from behind.—A. The superficial features of the point of the nose and the nostrils.—B. Passes through the front part of the maxillo- and naso-turbinals, and includes the opening of the lacrymal duct (green rod).—C. The maxillo-turbinal is multi-scrolled, though feebly ; a red rod indicates Jacobson's organ.—D. Passes through the free anterior part of the ethmo-turbinals (they have been removed on the left side). The depressed position of the maxillo-turbinal due to the large size of the ethmo-turbinals is shown. The frontal recess begins to appear above the dorsal wall of the nose-cavity and in the substance of the naso-turbinal.—E. The frontal recess is larger and contains pieces of ecto-turbinals. The naso-turbinal begins to flatten out transversely.—F. Anterior border of the opening between the nose-cavity proper and the frontal recess (seen best on the left). The naso-turbinal is almost completely flattened out, and gives attachment to a frontal secondary turbinal. —G. Disappearance of the maxillo-turbinal. Main cavity of the nose in open communication with the frontal recess. The antrum (maxillary sinus) is completely separate from the nose-cavity on the left side, and on the right shows the anterior margin of its mouth. First appearance of the lamina terminalis.—H. Disappearance of the antrum (reverse of the section). Completion of the lamina terminalis. Union of the second endo-turbinal with the cribriform plate.—I. Passage from the frontal recess into the frontal sinus. Third and fourth endo-turbinals join the cribriform plate. The frontal and sphenoidal recesses with the posterior respiratory passage are the only parts of the nose-cavity remaining.—K. The frontal sinuses separated by the olfactory bulbs from the sphenoidal recesses.

E. 159. A longitudinal section of the head of a Leopard (*Felis pardus*), showing the nose-cavity and turbinal bones of the left side. The general form of the cavity and the arrangement of the turbinals, so far as this rather imperfect specimen shows, are exactly as in the Cat. O. C. 1552. *Hunterian.*

E. 160. A longitudinal section of the right side of the head of a Lion (*Felis leo*). In the form of the nasal cavity and of the turbinals the Lion is similar to the Cat in essentials, but in details differs from it considerably. The cavity is more roomy; the maxillo-turbinal is larger and is not covered mesially by the free ends of the ethmo-turbinals; the ethmo-turbinals are shorter, rounder, and more deeply corrugated on their mesial surface. The frontal recess and sinus have been opened. Upon the reverse of the specimen the attachments of the maxillo-turbinal and frontal ecto-turbinals are shown by the removal of the outer wall of the nasal chamber. O. C. 1553. *Hunterian.*

E. 161. The opposite side of the same head, in which the mesial walls have been removed from the frontal ecto-turbinals and fifth endo-turbinal to show the cavities contained within their scrolls. The greater part of the long naso-palatine canal is in section. O. C. 1554. *Hunterian.*

E. 162. The nasal septum from the same head. Branches of the olfactory nerve can be seen running beneath the pituitary membrane towards the thickened base of the septum, to supply Jacobson's organ. The anterior extremities of the naso-palatine canals are shown. They open near the mid-line close behind the median incisors. In this and the two previous specimens the arteries have been injected to show the great vascularily of the pituitary membrane. O. C. 1555. *Hunterian.*

CHIROPTERA.

Grosser, Morph. Jahrb., Bd. xxix. 1902, p. 1.

E. 163. Right half of the head of a Fruit-Bat (*Pteropus medius*), with the nasal septum removed to show the cavity of the nose and its contained turbinals. The maxillo-turbinal is inconspicuous, being half hidden by the large free extremity of the second endo-ethmoturbinal. It shows in this view a plain surface furrowed by one deep longitudinal gutter. Sections show that it is multi-scrolled, though comparatively simple. In the hinder part of the cavity are four olfactory scrolls, which belong to the second, third, and fourth endo-turbinals. The upper two are both attached to one basal lamina and at their anterior end unite in a large flat triangular expansion, which covers the upper and hinder part of the maxillo-turbinal, and is continuous below with the lamina terminalis. The first endo-ethmoturbinal (naso-turbinal) is scarcely visible, being also to a large extent covered by the anterior expansion of the second endo-turbinal.

PRIMATES.

Seydel, Morph. Jahrb., Bd. xvii. 1891, p. 44.

E. 164. The head of a Lemur (*Lemur catta*) in sagittal section, showing the brain and the right half of the nasal chamber.

The ethmo-turbinals have the same arrangement and appearance as in non-primate Mammals, but are relatively somewhat small. The degenerate condition of the olfactory organ is also shown by the rudimentary condition of the ecto-turbinals (two only are said to be present) and by the comparatively small size of the olfactory bulbs.

The maxillo-turbinal is double-scrolled. There are four endo-turbinals, including the naso-turbinal, the second of which has two olfactory scrolls and is prolonged forwards above the maxillo-turbinal in a free point of unusual length.

The third and fourth endo-turbinals are small and lie at the anterior end of a deep sphenoid sinus.

Part of an ecto-turbinal can be seen between the roots of the naso- and second endo-turbinals.

Seydel, Morph. Jahrb., Bd. xvii. 1891, p. 56.

E. 164 a. Right half of the head of a Sooty Mangabey (*Cercocebus fuliginosus*), showing the brain and nasal cavity in sagittal section. The slight importance of the olfactory sense in comparison with that of lower Mammals is indicated by the small size of the olfactory bulb of the brain and the simple character of the ethmo-turbinals. In place of the complex olfactory labyrinth of quadrupeds there are but three vestigeal ethmo-turbinals—a minute naso-turbinal and a pointed plate-like second and a minute third endo-turbinal. The maxillo-turbinal is also of very simple character. Frontal and sphenoidal sinuses are absent.

E. 165. The right half of the anterior portion of the face of a Gibbon (*Hylobates* sp.), showing the nose-cavity and the nasal cartilages. The turbinals occupy a considerable proportion of the nasal chamber, but are very simple in form. The ethmo-turbinals are represented by a single plate-like expansion, with very definite anterior and ventral borders. A deep indentation in the anterior border separates a forwardly directed process of the plate, which represents the naso-turbinal, from the main part, which is probably a fusion of the middle and superior turbinals of Man—the homologues of the second and third endo-turbinals of lower Mammals. The maxillo-turbinal (inferior turbinal of Man) is prominent and formed of a double scroll. The sphenoid sinus is spacious. There is no frontal sinus. The lateral cartilage of the nose is considerably overlapped by the nasal bone, as in Man. The annular cartilage is small and simple.

Zuckerkandl, *l. c.*, p. 67.

E. 166. Sagittal section of the face of an Orang-utan (*Simia satyrus*), passing through the left half of the nasal cavity. The turbinals are more reduced even than in Man. The naso-turbinal is absent, or more probably included in the middle turbinal and represented by a small process of its anterior border. There is no superior turbinal. The entire area of the nose-cavity and cribriform plate are also relatively smaller than in Man (compare with E. 174, a Human specimen of about the same size). These characters indicate an extremely weak power of smell. Bristles have been passed into the opening to the antrum in the middle meatus, into the mouth of the lacrymal duct below the maxillo-turbinal, and into that of the Eustachian tube.

O. C. 1550 D.

E. 167. The right side of the face of a young Orang-utan (*Simia satyrus*), in which the maxillary sinus is exposed by the removal of its outer wall. This cavity is remarkably spacious, and corresponds in position to a combination of the antrum and the sphenoidal sinus. A blue rod has been passed through its opening into the nose-cavity. In this specimen the nostrils and the cartilages of the nose are also shown. The lower lateral cartilages are large, in accordance with the great breadth of the tip of the nose.

Presented by E. J. Steegmann, Esq.

Paulli, *l. c.*, p. 527.

E. 168. The two halves of the head of a Chimpanzee (*Anthropopithecus troglodytes*), showing the nose-cavity and the sinuses in connection with it. In the upper specimen (the right half) the nasal chamber and the cartilages of the nose have been exposed. The ethmo-turbinals are more separated by ethmoidal fissures than in Man. Three separate prominences can be distinguished, a lower, middle, and upper, which respectively correspond to the second, third, and fourth endo-turbinals of quadrupeds, or to the middle, superior, and suprema conchæ of Man. A naso-turbinal is not defined. The maxillo-turbinal is double-scrolled. In the lower specimen the antrum and sphenoidal sinus have been opened. The former is very extensive; a blue rod is passed through its passage into the nose-cavity. The sphenoid sinus is small. In both specimens its opening is marked by a green rod. There is no frontal sinus in this young specimen.

E. 169. The heads of two Infants at birth divided in the longitudinal and transverse vertical planes to show the vestigeal organ of Jacobson. In the sagittal section the opening of the organ into the nose-cavity just above a deep pit that represents the naso-palatine canal is marked by a black bristle. Bristles have also been inserted into the ducts of Jacobson's organs in the transverse section. They have the usual mammalian position, one on either side of the septum. O. C. 1550 F.

Presented by S. G. Shattock, Esq.

E. 170. A longitudinal section of a Human face, minutely injected, showing the septum nasi covered by the pituitary membrane, through which the filaments of the olfactory nerve may be faintly seen radiating from the cribriform plate. The frontal and sphenoidal sinuses have been laid open; and behind the septum the opening of the Eustachian tube, marked by a small quill, is seen bordered by thick swollen lips. The relative positions of the tongue, soft palate and uvula, pharynx, epiglottis, larynx, and sacculus laryngis are also well displayed in this section.

O. C. 1547. *Hunterian.*

E. 171. A longitudinal section of the upper part of the face, including the septum nasi and portions of the turbinal bones of the right side. The specimen has been steeped in an acid and shows several branches of the olfactorius leaving the cribriform plate and distributed to the mucous membrane. This preparation is described and figured in the 'Observations on Certain parts of the Animal Œconomy,' 2nd ed. 1792, p. 259, pls. xvii. & xviii., and served to demonstrate to Hunter that, of the nerves that supply the nose and other organs of special sense, some are solely concerned with the conduction of the special sense stimuli, others being "only for the common sensations of the part and other purposes answered by nerves."

O. C. 1550. *Hunterian.*

E. 172. The Human septum nasi minutely injected, dried, and preserved in oil of turpentine, showing the great vascularity of the pituitary membrane covering that part, and the mode of ramification of the blood-vessels.

O. C. 1551. *Hunterian.*

E. 173. The opposite side of the same head as E. 170, showing the three turbinal or spongy bones dividing the nasal cavity into three passages or "meatuses." The superior meatus is the smallest; it is situated between the middle and superior turbinals which represent the second and third endo-turbinals of Quadrupeds. Bristles are passed from it into the posterior ethmoidal cells and into the sphenoid sinus. The middle meatus lies between the middle and lower (maxillo-) turbinals; a portion of the former has been removed to expose the small opening that leads into the maxillary sinus or "Antrum of Highmore"; the frontal sinus is also in communication with this meatus, and a bristle is passed from one to the other. The inferior meatus, which is situated between the inferior (maxillo-) turbinal and the roof of the mouth and forms the chief respiratory passage, receives the termination of the lachrymal duct. In order to show this opening a portion of the inferior turbinal has been raised, and a bristle inserted into the orifice of the duct.

The Eustachian tube communicates with the nasal cavity about 20 mm. behind the posterior extremity of the maxillo-turbinal. A quill is placed in its opening.

In Man as in other Primates, the turbinals are quite vestigeal. This is particularly the case with the ethmo-turbinals, which are the chief area innervated by the olfactorius.

To judge only from this and from the minute size of the olfactory bulbs, the sense of smell in Man can bear no comparison in its importance in the general life œconomy with that of most of the lower Mammals. O. C. 1548.

Hunterian.

E. 174. A sagittal section through the nose similar to that shown in the previous specimen, but with the turbinals undisturbed. Bristles have been passed into the openings of the antrum, lachrymal duct, and Eustachian tube.

Upon the reverse of the specimen the cavity of the antrum and the ocular end of the lachrymal duct have been exposed. O. C. 1550 B.

E. 175. A transverse section through the nasal cavity and mouth, showing the turbinals and the meatuses between them, the septum nasi, the ethmoidal cells, and the hinder part of the antrum. In this specimen the fauces including the hinder part of the tongue, the soft palate, uvula and tonsils are also well seen. O. C. 1549. *Hunterian.*

Parts accessory to the Olfactory Organ.

PISCES*.

E. 176. Head of a Ray (*Raja clavata*), showing the nostrils and the cartilages that support them and form the olfactory capsule. On the right side the in- and exhalent openings of the olfactory sac are shown. They are formed by overlapping processes of the borders of the sac, in a manner similar to that seen in *Acanthias* (E. 87), but in this case the process of the anterior border is greatly enlarged and forms the median boundary of a deep gutter leading from the inner end of the olfactory sac to the corner of the mouth. Upon the left side the cavity of the olfactory sac has been exposed, and the cartilages that support the borders of the sac left in position. The largest and most important of these lie within the lips of the channel leading to the mouth. The deeper part of the olfactory sac is encapsuled in the actual cartilage of the skull.

REPTILIA.

E. 177. A sagittal section through the right nostril of a Crocodile (*Crocodilus americanus*). The nostril, which is surrounded by a boss-like elevation of the integument, is crescentic in form with the concavity facing backwards, and opens into a narrow vertical nasal passage that soon dilates and turns backwards. The lips of the nostril are

* Nostrils of Teleostea are shown in E. 94, E. 95, E. 96, and of *Polypterus* in E. 92.

said to contain a sphincter of unstriped muscle by which they can be closed. In front of the vertical, dilated part of the nasal passage is a rounded mass of erectile tissue continuous with the vascular layer that underlies the mucous membrane of the floor of the nasal cavity.

AVES.

E. 178. Heads of two Ptarmigan (*Lagopus mutus*). The nostril is protected, as seen in the upper specimen, by feathers of ordinary structure that grow around its margin. In the lower specimen the feathers have been cut off short to show the large oval nostril and the arrangement of their roots around it.

E. 179. The head of a Petrel (*Puffinus* sp.). In members of this group the nostrils are situated at the forward extremities of a pair of integumentary tubes, that run forward along the dorsal surface of the beak for a variable distance from its base. In this specimen they are 10 mm. long.

E. 180. Part of the head of an Albatross (*Diomedea exulans*) dissected to show the nasal gland of the right side. The gland is of great size and occupies a deep groove in the bones above the orbit. From its anterior part a duct (marked by a black bristle) runs directly forward in the frontal bone and beneath the mucous membrane of the nose to open finally upon the free edge of the atrial process a short way within the nostril. The opening of the duct is shown in E. 116 a. The gland is lobulated upon the surface, and has a peculiarly hard compact appearance due to the density of the connective tissue that forms its framework. The nasal gland is found in most Birds, but differs much both in position and in degree of development. It secretes a watery fluid.

E. 181. The head of a Kagu (*Rhinochetus jubatus*). In this bird the nostril is a long slit, bordered below by a slight lip, and overhung by an arched flap of integument. This flap, which projects 5 mm. from the surface of the beak, protects the nose from the entry of foreign matter when the bird digs for its food. Its action is thus described by Dr. Murie: "As the nostril approaches the ground and is touched, its anterior part having a plough-share formation or scroll-like contour sends the earth upwards or over it. The springy semi-elastic lid, from in front to behind, is pressed down and inwards, finally completely closing the aperture as the beak is thrust deep into the earth in search of its living prey." (Trans. Zool. Soc., vol. vii. 1872, p. 486.)

E. 182. The head of a Gannet (*Sula bassana*). In the Gannets and several allied genera there are no anterior nostrils (*cf.* E. 117). In this specimen part of the left side of the head has been removed to show the nasal gland, which has the same hard lobulated appearance as in the Albatross, but is far smaller, globular in shape, and is situated in the maxillary sinus in front of the orbit close against the wall of the nasal cavity. The opening of its duct is shown in E. 117. A black bristle has been inserted into the lacrymal duct.

Ewart, Jour. Linn. Soc., vol. xv. 1881, p. 455.
Pycraft, *ibid.*, vol. xxvii. 1899, p. 207.

E. 183. Head of a Falcon (*Falco* sp.), showing the nostrils. In Birds of Prey the olfactory sense is comparatively keen and the nostrils are large. They have in this specimen a circular form, but are partly occluded by a knob-like prominence that projects downwards from the dorsal border. This prominence is the free end of the greatly developed atrial process.

E. 184. The head of a Raven (*Corvus corax*). The nostrils, though large and widely open, are protected from the entry of foreign matter by a thick covering of stiff bristle-like feathers, that grow forward along each side of the beak from the skin immediately behind the nostrils. On the left side these feathers have been in part removed to show the nostril.

MAMMALIA.

Spurgat, Morph. Arbeit., Bd. v. 1896, p. 555 (*cartilages*).

MONOTREMATA.

E. 185. Two specimens of the snout of a Duck-billed Platypus (*Ornithorhynchus anatinus*), showing the nostrils—in the lower specimen from the dorsal aspect, in the upper in sagittal section. The nostrils are oval in shape, and lie, as in the Echidna, upon the dorsal surface of the snout close together, about 15 mm. from its extremity, and with their long axes transverse and slightly inclined backwards from the mid-line. Just within the nostril (see upper specimen and left side of lower specimen) the roof and floor of the nasal cavity are reflected forward to form a pair of valves that would effectually exclude mud from the nose cavity, though it is difficult to see why they should not also impede the entry of air unless it be that they are too stiff to be put into action by a gentle pressure. In the lower specimen the central part of the dorsal valve has been removed and black paper has been placed beneath the ventral one. The fore-part of the nasal cavity has also been exposed to show a connection through the lower part of the septum between the two nasal chambers (compare with the Anseriform Birds, E. 114 and E. 116), and a horizontal membrane projecting from the septum and partly dividing the anterior end of the nose cavity into two. The opening of the naso-palatine canal beneath the anterior end of this membrane is shown by a black bristle in the upper specimen.

CETACEA.

John Hunter, Phil. Trans., vol. lxxvii. 1787, p. 420.

E. 186. A portion of the upper part of the head of a Piked-Whale (*Balænoptera acuto-rostrata*) showing the external orifices of the nasal passages, or blow-holes. These are paired, unlike the blow-hole of the Toothed Whales, and have the form of two longitudinal clefts, approximated at their anterior ends, but diverging posteriorly. Between them the skin of the head is deeply creased longitudinally.

The left blow-hole has been opened by the removal of its lateral wall, showing that the nasal passage is a direct prolongation of its anterior half. At a depth of some 15 cm. the axis of the passage changes from longitudinal to transverse and is here blocked by a large round boss, projecting from its anterior wall. This swelling is mainly composed of muscle-fibres, that run forward and outward and by their contraction serve to open the nostrils.

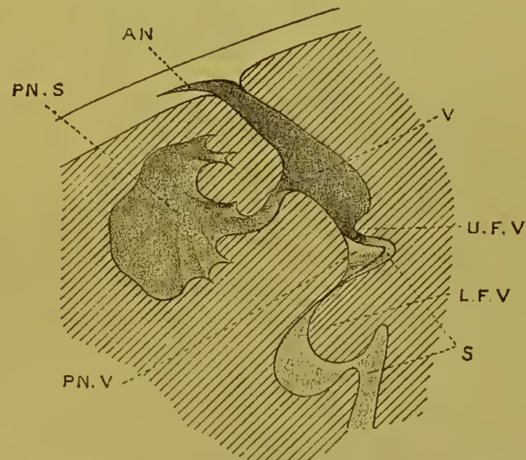
O. C. 1545. *Hunterian.*

Delage, Arch. Zool. Exp., T. iii. *bis*, 1885, p. 108.
Carte & Macalister, Phil. Trans., vol. clviii. 1868, p. 238.

E. 187. A piece of the integument from the upper part of the head of a Porpoise (*Phocœna phocœna*), including the external orifice of the nasal passages, or blow-hole: it is single and of a crescentic form with the concavity turned forwards. O. C. 1541. *Hunterian.*

E. 188. A longitudinal vertical section of part of the head of a Porpoise (*Phocœna phocœna*) passing just to the left of the external nostril through the left prænasal sac. The

Fig. 24.



Sagittal section of the nasal passage of *Phocœna phocœna.*

A.N. Anterior nares. L.F.V. Lower frontal valve. PN.S. Left prænasal sac. PN.V. Prænasal valve. S. Septum nasi. U.F.V. Upper frontal valve. V. Vestibule.

preparation includes the whole of the valvular apparatus for closing the nasal passage. The nostril, through which a quill has been passed, leads into a transversely expanded unpaired vestibular chamber connected anteriorly with a pair of large "prænasal" sacs that extend forward on either side of the nostril close beneath the skin. The floor of each prænasal sac is thick and thrown into irregular transverse folds (seen in section upon the surface of the specimen), but the roof is unpleated and quite thin. Just above the separation of the nasal passage into two by the septum nasi, the anterior wall of the vestibule is thickened to form a pair of transversely disposed eminences (prænasal valves). The posterior wall of the vestibule is smooth, but projects close above the level of the prænasal valves to form a pair of eminences (upper frontal valves) that correspond to the prænasal valves and, when the walls of the vestibule are apposed, fit above them. Below the upper frontal valves are a pair of deep indentations for the lodgment of the prænasal valves, and these are again succeeded by a pair of large rounded prominences (the lower frontal valves) that complete the vestibular locking mechanism by fitting below the prænasal valves.

In this specimen the septum that divides the nasal passage from the level of this valvular apparatus downwards, has been cut through and the interlocking valves separated.

O. C. 1541. *Hunterian.*

Rawitz, Internat. Jour. Anat., vol. xvii. 1900, p. 296.

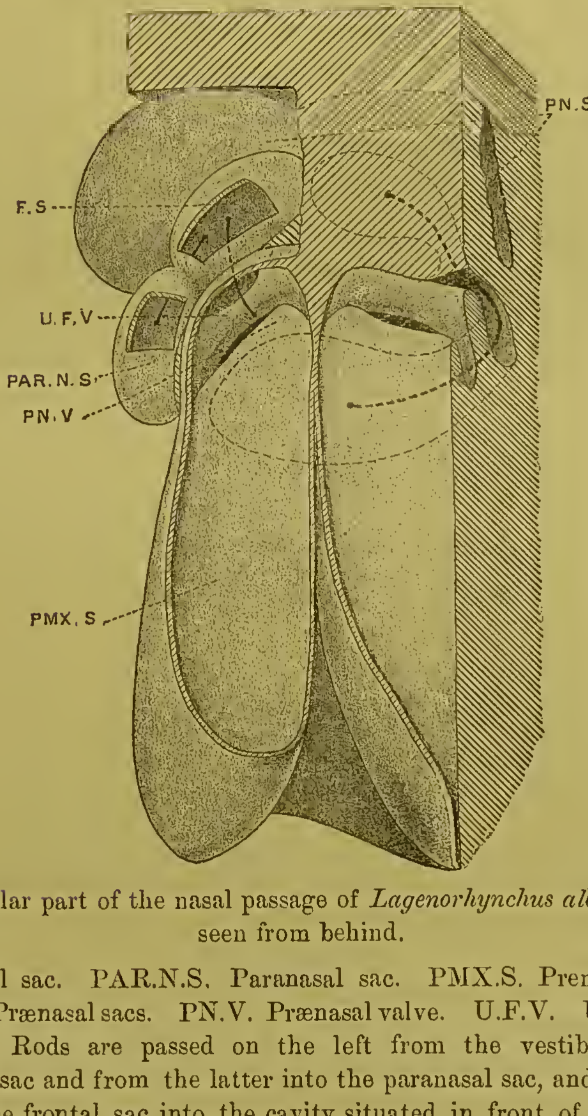
E. 189. Part of the head of a Porpoise (*Phocæna phocæna*) including the anterior border of the nostril, the front wall of the vestibule, and the prænasal sacs. The roof of the left prænasal sac has been retained showing the natural orifice of communication between the sac and the vestibule. On the right the roof has been removed to expose the transverse folds of the floor and front walls of the sac and to show its extent in a lateral direction. The prænasal valves are shown at the lower edge of the specimen.

O. C. 1543. *Hunterian.*

E. 190. A corresponding specimen of the hinder border of the nostril and the posterior wall of the vestibule, showing the two pairs of frontal valves. O. C. 1542. *Hunterian.*

E. 191. Part of the head of a Dolphin (*Lagenorhynchus albirostris*) including the blow-hole, the vestibule of the nasal passage and the sac-like cavities in connection with it. The nostril as in the Porpoise is transverse and crescentic

Fig. 25.



Vestibular part of the nasal passage of *Lagenorhynchus albirostris*, seen from behind.

F.S. Frontal sac. PAR.N.S. Paranasal sac. PMX.S. Premaxillary sac PN.S. Prænasal sacs. PN.V. Prænasal valve. U.F.V. Upper frontal valve. Rods are passed on the left from the vestibule into the frontal sac and from the latter into the paranasal sac, and on the right from the frontal sac into the cavity situated in front of the vestibule (see text).

with the concavity directed forward. Close within the nostril the vestibule opens on either side into a prænasal sac (maxillary sac, Murie), which differs from that of a Porpoise in being without deep transverse folds upon its floor. On the left this sac has been fully exposed and a window cut in its wall, on the right it is seen in section. The prænasal valves are similar in position to those of the Porpoise, but are relatively somewhat larger. They have been exposed from behind and are seen to lie at the upper end of a pair of large bluntly conical nasal sacs (premaxillary sacs, Murie), both of which have been opened in the specimen. The posterior wall of the vestibule has been removed below the level of the upper frontal valves. Through these the vestibular cavity opens into a pair of small frontal sacs (naso-frontal sacs, Murie), lying transversely just beneath the skin. On the left side the lateral extremity of this sac communicates by a small hole with another of oval shape (paranasal sac). A corresponding sac is not present on the right but just above the upper frontal valve the vestibular cavity is continued laterally into a large sac that bends round in front of the vestibule across the mid-line. O. C. 1544 B.

Presented by J. W. Clark, Esq.

Murie, Jour. Anat. & Physiol., vol. v. 1871, p. 123 (*Grampus*).

E. 192. The skin from the middle of the upper surface of the head of a young Gangetic Dolphin (*Platanista gangetica*), showing the longitudinal linear single nostril or "blowhole" which characterises this genus. O. C. 1544 A.

Presented by Sir Joseph Fayrer, K.C.S.I.

UNGULATA.

PROBOSCIDEA.

E. 193. The terminal portion of the trunk of a female African Elephant (*Elephas africanus*). The nostrils are circular in form and lie within a transverse cleft at the extreme end of the trunk separated by the free edge of the nasal septum. The nasal passages are protected from the entry of foreign matter by a number of coarse stiff hairs that project in front of the nostrils from the inner walls of the transverse cleft. The upper lip of the cleft is prolonged to form a finger-like process that can be apposed to the lower lip, forming an efficient grasping organ. This piece of trunk was accidentally torn off by the animal itself in the Zoological Society's Gardens, August 1875. O. C., 288 P *a*.

Presented by the Zoological Society.

PERISSODACTYLA.

E. 194. The proboscis and fore-part of the head of a Tapir (*Tapirus americanus*), showing the nostrils, the muscles of the snout and the accessory nasal diverticula. The levator labii superioris proprius and the caninus are clearly defined and have much the same characters as in the Horse. The other muscles of the snout are indistinct and much matted together. A lateral indentation on either side between the nasal and frontal bones is occupied by a scrolled diverticulum of the nasal cavity. This is enclosed by a tubular extension of the lateral cartilage of the nose and lodges an offshoot of the maxillo-turbinal. The roof of the nose has been laid bare, showing upon the right side the lateral nasal cartilage with its scrolled hinder prolongation resting upon the dorsal surface of the nasal and frontal bones. On the left the nose cavity has been opened to show the continuity of the diverticulum with the main cavity and the extension of the maxillo-turbinal within it. This accessory pouch resembles in some ways the false nostril of the Equidæ, but opens into the nose cavity very much further back. A similar pocket is found in the Rhinoceros (Treves & Beddard, Proc. Zool. Soc. 1889, p. 11).

Upon the reverse of this specimen, the nostrils can be seen. They are a pair of transversely elongated oval openings surrounded and separated by an area of hairless corrugated integument. O. C. 1556 B *ba*.

Murie, Jour. Anat. & Phys., vol. vi. 1872, p. 138.

E. 195. The anterior part of the face of a Horse (*Equus caballus*) dissected to show the nostrils with their muscles and supporting cartilages, the false nostrils, and the opening of the lacrymal duct.

Upon the right side (the reverse of the specimen) the skin has been removed except around the nostril; the superficial muscles of the upper lip and nostril and the surface of the false nostril (diverticulum nasi) have been thus exposed. The false nostril is conical in form and stretches back from the upper part of the true nostril along the lower border of the levator labii superioris proprius. The most important muscles shown on this side are:—the levator labii superioris proprius, the tendon of which unites with that of its fellow in the mid-line between the nostrils to pass along the centre of the upper lip; the upper part of the transversus nasi, passing towards the dorsal mid-line from the plate of the alar cartilage; and the caninus and levator naso-labialis, running backwards from the posterior and lower border of the nostril and false nostril. The three last-named muscles dilate the nostril. Upon this side of the specimen a white rod has been inserted into the mouth of the lacrymal duct, in the median wall of the nostril. (For the lacrymal duct of the Donkey and other Mammals see Section E: Parts accessory to the organs of vision.) Upon the left side a deeper dissection has been made showing the alar cartilage, the cavity of the false nostril and its connection with the nose cavity proper, and the part of the transversus nasi in connection with the cornu of the alar cartilage. O. C. 1556 B *a*.

Ellenberger & Baum, Handbuch der Vergl. Anat. der Hausthiere, 1903, pp. 219, 474.

E. 196. The extremity of the nose of a Horse (*Equus caballus*) showing the cavity from behind, and the relation of Jacobson's organ to the naso-palatine canal.

Upon the left side the section passes just in front of the posterior border of the passage from the nostril cavity to the false nostril, so that these two cavities are continuous. The upper lip of this passage is inturned and scrolled forming the "alar fold," supported by the navicular cartilage—a derivative of the lateral cartilage of the nose. The alar fold is continuous posteriorly with the maxillo-turbinal. Below it, is a vascular swelling of the lateral nasal wall also continuous posteriorly with the maxillo-turbinal. The centre of this is occupied by the lacrymal duct, into which on the right side a rod is inserted. The anterior opening of the duct can be seen at the right side of the specimen.

In the floor of the nasal cavity, on the left side, are two round openings. The outer of these is the naso-palatine canal, the inner, which is surrounded by a cartilaginous tube, the duct of Jacobson's organ. On the right, sufficient of the floor of the nasal cavity has been removed to show the connection between these two ducts. O. C. 1780 E.

E. 197. The left side of the fore part of the face of a Donkey (*Equus asinus*), showing the nostril, the false nostril, the alar cartilage, and the opening of the lacrymal duct.

The alar cartilage and the false nostril are very similar to those of the Horse. The lacrymal duct, however, opens into the nostril, not on the median, but on the lateral side. Its opening is indicated by a white rod. O. C. 1556 B *b*.

Presented by Henry Power, Esq.

ARTIODACTYLA.

E. 198. The skin of the snout of a Pig (*Phacochœrus æthiopicus*(?)) showing the form of the nostrils. They are small and nearly round, and are set very far apart. The broad flat area of skin that surrounds them and forms the point of the snout is highly sensitive. Its upper margin is, however, tough and horny. O. C. 1546 C.

E. 199. The snout of a Pig (*Sus scrofa*) with the nasal cartilages exposed. The dorso-lateral cartilages are continuous with the upper edge of the septum. They are covered for fully half their length by the nasal bones (that of the left side has been removed), and in this part show signs of reduction, in the separation of irregular plates of cartilage from their ventral borders. The anterior end of each is partly separated from the rest as an alar cartilage, by a slit that extends from the free edge to within 7 mm. of the septum,

The anterior extremity of the septum and alar cartilages is greatly thickened to form the support of the snout disc. The ventro-lateral cartilage is small and carries at its anterior end a sickle-shaped cartilago accessoria for the support of the lateral walls of the nostril.

Spurgat, *l. c.*, p. 562.

E. 200. Two specimens of the anterior part of the nose of a Sheep (*Ovis aries*), showing its supporting cartilages. The dorsal and ventral lateral cartilages are continuous with the dorsal and ventral margins of the septum. The dorsal lateral cartilage is considerably reduced, more so than in *Nasua* (E. 201), in that its central parts are replaced by a large membrane-covered space. The alar cartilage is not separated from the anterior end of the lateral cartilage although it is clearly marked off from it by a depression; ventrally, it is prolonged into a narrow bar that bends outwards and terminates in a cross piece—the appendicular cartilage. In the upper specimen the cartilages are seen from without, in the lower from the inner side. In the latter case the intimate connection between the navicular cartilage and the maxillo-turbinal can be seen. Red rods have been placed in the naso-palatine canals and black bristles in the ducts of Jacobson's organs.

Spurgat, *l. c.*, p. 568.

CARNIVORA.

E. 201. The fore part of the head of a Coati-Mundi (*Nasua nasua*), showing the cartilages of the snout.

The chief parts of these cartilages lie in advance of the præmaxillæ and form a double tube consisting of the septal cartilage and its dorsal and ventral wings. Posteriorly the basal part of the septal cartilage is jointed to a cartilaginous bar that runs back along the base of the septum to the præ-sphenoid, but the upper part of its hinder border is separated by a sheet of membrane from the perpendicular plate of the ethmoid. In the same way membrane is interposed between the hinder border of the dorsal lateral cartilages and the nasal bones. The snout thus has great mobility, particularly in the horizontal plane. Its dorso-ventral movements are restrained by a rod of fibro-cartilage that stretches from the nasals to the hinder margins of the cartilages of the snout.

In detail, the whole of the dorsal and the anterior part of the ventral margins of the septal cartilage are reflected outwards to form the dorsal, ventral and lateral walls of a pair of tubes. Where the lateral cartilages meet along the sides of each tube, the ventral one is inturned to form a ridge (navicular cartilage) continuous posteriorly with the maxillo-turbinal. An alar cartilage is not separated off from the front end of the dorsal lateral cartilage. The anterior edge of the septal and dorsal lateral cartilages are inturned to support the borders of the nostrils. The ventral part of this reflection bears at its end a small free cartilage (c. accessoria).

Spurgat, *l. c.*, p. 576.

E. 202. Anterior part of the snout of a Dog (*Canis familiaris*), showing the nose cartilages. The dorsal and ventral lateral cartilages are direct prolongations of the upper and lower margins of the septum. The dorsal lateral cartilage forms the greater part of the side wall of the nose, its lower part (preserved on the reverse of the specimen) is however imperfect and is separated from the rest of the cartilage by a narrow membranous space. The ventral lateral cartilage is inturned, as in *Nasua,* to form the navicular. A large cartilago accessoria for the support of the lateral gutter of the nostril is attached by fibrous tissue to the anterior and lower process of the ventral lateral cartilage and also by an attachment, which has been separated in the specimen, to the anterior end of the lower part of the dorsal lateral cartilage. On the left side the lower part of the dorsal lateral cartilage has been removed to show the inturned navicular cartilage. As in *Nasua* a considerable area of membrane intervenes between the nasal and premaxillary bones and the lateral cartilages, giving a large amount of play to the tip of the nose.

Spurgat, *l. c.,* p. 581.

E. 203. The snout of a Dog (*Canis familiaris*), showing the nostrils and the area of hairless finely granulated skin around them. This bare area is richly supplied with sensory nerve terminations, and in the Dog and many other keen-scented Mammals is kept continually moist by abundant secretion. It has been suggested (Exner) that it may act as an accessory to the sense of smell by giving information of the direction of air currents. The lowering of the temperature due to the impact of a current of air being much increased by the quickened evaporation of the moisture upon the surface. A familiar application of this principle in detecting otherwise imperceptible air currents is to moisten a finger, hold it up, and notice which side becomes cold. The importance to such animals as the Deer of a delicate instrument of this kind by which to determine the direction from which a smell proceeds is obvious.

The Dog, however, does not scent its prey from a distance, and in this case it would seem that the wet sensitive nose is of use in helping it to always work into the wind when hunting over any tract of country.

Exner, Zeitschr. f. wiss. Zool., Bd. xl. 1884, p. 557.
Botezat, Morph. Jahrb., Bd. xxix. 1901, p. 439 (*nerve endings*).

CHIROPTERA.

E. 204. The skin of the head of a Bat (*Pteropus vampyrus*), showing the nostrils and the scroll-like projection of the skin around them—see also E. 52, E. 53, and E. 386.

The ears, which also are shown in this specimen, are small and pointed and without any of the remarkable developments characteristic of many Bats.

O. C. 1551 D.

E. 205. The skin of the head of a Bat (*Noctilio leporinus*). The nostrils are small and oval in outline. They are situated close together at the end of a pair of short tubes that form a projection overhanging the upper lip.

The ears in this specimen are narrow and pointed. The tragus forms an upstanding lamina, toothed along its upper and outer margins. The lower part of the outer margin of the conch is abruptly bent inwards to form the anti-tragus, from the lower end of which a cutaneous ridge runs to the angle of the mouth. O. C. 1607 A *a*.

Presented by J. E. Harting, Esq.

E. 206. Skin of the head of a male *Hypsignathus monstrosus*. The snout is greatly distended and hammer-shaped, terminating in a roughly quadrangular hairless disc. The nostrils lie near the upper border of the disc, surrounded on their upper, mesial and lower sides by a scroll-like projection of the integument which merges below into the lateral parts of the upper lip. The central part of the disc between the nostrils is irregularly sculptured and, along the actual border of the lip, papillate.

O. C. 1551 E.

PRIMATES.

E. 207. The skin of the anterior part of the face of an old male Baboon (*Papio anubis*), showing the external form of the nose. Upon the left side the nasal cartilages have been exposed. The lateral dorsal process of the septal cartilage is extremely small, being only 4 mm. in breadth. It occupies a position at the upper part of the nose, where that organ begins to project from the general surface of the face. On the other hand, the annular cartilage forms an immense scroll situated upon the median, dorsal, and lateral surfaces of the nose from the level of the middle of the lateral cartilage to the tip. Its lower lateral margin is inturned to form the navicular cartilage. No ventral lateral process of the septum is apparent. The nostrils, as in Man, are inclined outwards from the tip of the nose. Their lateral border is strongly impressed by the prominence due to the navicular cartilages. O. C. 1546 D.

E. 208. The skin of the head of a male Proboscis Monkey (*Nasalis larvatus*), showing the nose-like snout. This proboscis differs much in form and size according to the age and sex of the individual, and undergoes a process of development superficially comparable to that of the Human nose. In the fœtus it is short, with the nostrils directed forwards, but gradually the dorsal parts enlarge (not however by the growth of the nasal bones), and in old age a pendulous hooked-nose is formed. The nostrils are situated upon the under surface of the proboscis and as in animal snouts lie near the tip. O. C. 1546 E.

Wiedersheim, Zeits. f. Morph. u. Anthrop., Bd. iii. 1901, p. 300.

E. 209. The skin of the head of a Gibbon (*Hylobates leuciscus*), showing the form and position of the nostrils. The nostrils are narrow and have a vertical position, sloping obliquely towards the mid-line of the upper lip. They are set close together. O. C. 1546 F.

E. 210. The skin of the head of a Gorilla (*Anthropopithecus gorilla*), showing the nose and nostrils. The nose is broad and flat; the nostrils set almost horizontally.

E. 211. A section of the nose and upper lip of a Man, showing the short crisp hair which grows from the inside of the nostril and defends the entrance of the nasal cavity.
O. C. 1932. *Hunterian.*

E. 212. A human nose and part of the upper jaw, showing the nasal cartilages. In comparison with the cartilages of the Coati-Mundi, which approximate to the continuous double tube that was probably the original condition, the cartilages in Man are very degenerate. The dorsal lateral processes of the septal cartilage are overlapped to a certain extent by the nasal and maxillary bones. Posteriorly they are still organically continuous with the septal cartilage, but distally are free from it, and are not prolonged so far forward as is the septum itself.

On either side of the distal end of the septum lie the annular cartilages, completely separated from the dorsal lateral processes of the septal cartilage from which they are derived. They form on either side a ring, incomplete below, for the support of the margins of the nostrils. The extremity of the outer limb of the ring is separated off in the form of small irregular plates (sesamoid cartilages).
O. C. 1550 E *a*.

Spurgat, Anat. Anz., Bd. viii. 1893, p. 228.

AUDITORY AND EQUILIBRATING ORGANS.

John Hunter, Essays and Observations, edit. R. Owen, vol. i. p. 171.

Many Invertebrate and all Vertebrate Animals have special organs for the perception of alterations in the position of the body in space (equilibration) and for the appreciation of vibrations in the surrounding medium (audition). Although these functions are at first sight so distinct, they both as a matter of fact depend upon the stimulation of fundamentally similar sense-organs, in which the special sensory cells are provided with relatively long and stiff hair-like processes which may be acted upon either by the movement of fluids or of hard adventitious bodies (otoliths) in contact with their free ends following any alterations in the position of the organ, or by the vibration of the fluid in which they are bathed. This similarity of structure in the receptive mechanism, together with the curiously conflicting evidence derived from direct physiological experiments, makes any sure discrimination between the two sets of organs extremely difficult even in higher Animals *, where probably a definite part of the ear is set apart for the performance of each function ; but in Invertebrates it is doubtful if any such distinction should be made, for probably the whole organ is sensitive both to changes in its position and to auditory vibrations, and is in truth an undifferentiated equilibrating and auditory organ with probably a preponderance of the equilibrating function. In the perception of sound it is possible to distinguish two degrees of refinement : simple audition—the mere sensitiveness to sound vibrations, without any analytic appreciation of the qualities of the vibrations other than degrees of loudness, and a more refined tonal sense by which the various qualities of a mixture or series of vibrations can be recognised and appreciated. The first is common probably to all conditions of auditory organs and is difficult to distinguish from the mere feeling of jar ; the second only to organs of peculiar structure (chordo-tonal organs) which occur in Insects and the higher Vertebrates (cochlea).

* This difficulty is especially apparent in reading the work done on the ear of Fishes, *cf.* for instance the papers by Kreidl, Lee, and Ayers quoted below under "Vertebrata."

INVERTEBRATA.

Lubbock, The Senses of Animals, 1888, p. 77.
Engelmann, Zool. Anz., Bd. x. 1887, p. 439 (*Physiol.*).

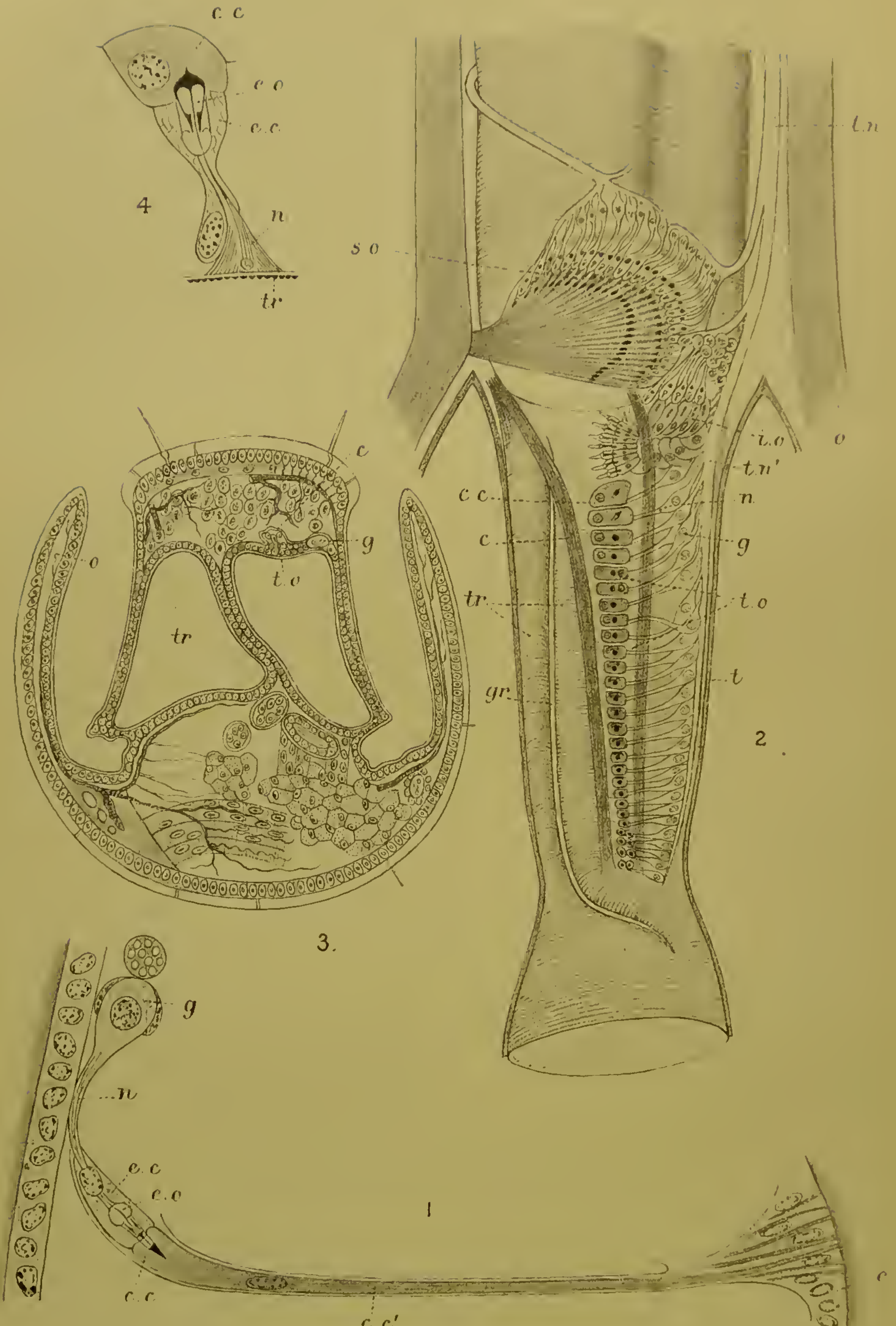
Sense organs, in the form of a pit, sac, or hollow prominence, lined, at least in part, by cells bearing long peripheral sense hairs, and generally containing hard adventitious bodies, occur in most of the chief Phyla of the Invertebrata. Such are the tentaculo-cysts auditory vesicles and rhopala of Cœlenterates, the otocysts of some Platodes Polychæte Worms and Molluscs, the auditory sacs and vesicles of some of the higher Crustacea, and the otocysts of Holothuria and the sphæridia of Echinids. In spite of the various names by which these several organs are known, many of which imply an auditory function, they may probably all be classed together physiologically as equilibrating organs at least as regards their chief function. In Insecta, however, there are organs of an entirely different form which there is every reason to believe are truly auditory in the highest sense.

ARTHROPODA.

CRUSTACEA.

E. **213.** The antennules of a Lobster (*Homarus vulgaris*). In the basal segment of the protopodite of each antennule is an auditory or more probably an equilibrating organ formed by a sac-like involution of the dorsal integument of the segment. The sac is in communication with the exterior by a small aperture near the inner margin of the dorsal wall, protected by a close fringe of setæ springing from its outer and posterior borders. A semicircular area of the ventral wall of the sac is specially modified to receive sense impressions ; internally it bears a number of long vibrissæ, which support minute sand grains intentionally introduced after each moult. The ventral wall of the basal segment of the left antennule and the outer wall of that of the right have been removed to show the auditory sac. On the left the area of the sensitive membrane can be seen, and on the right a bristle has been inserted into the orifice of the auditory sac.

Numerous independent experiments leave little doubt that the "auditory organs" of Crustacea are statocysts,


c.c
e.o
c.c
4
n
tr
t.n
s.o
t.o
o
t.n'
c.c
n
c
g
tr
t.o
t
gr
2
c
o
g
t.o
tr
3.
g
n
c
e.c
e.o
1
c.c
c
c.c'

J. Green lith.

PLATE I.

Fig. 1. A single chordo-tonal organ from the subgenual organ of *Decticus verrucivorus*, × 360 *.

Fig. 2. Tibial chordo-tonal organs of *Decticus verrucivorus* seen from the outer side, × 95.

Fig. 3. Transverse section through the upper part of the auditory organ of a nearly adult *Locusta viridissima*, × 90.

Fig. 4. Distal termination of a chordo-tonal organ from Siebold's organ of *Decticus verrucivorus*, × 540.

Figs. 1, 2, and 4, after Schwabe †. Fig. 3, after Graber.

c., the membrane covering Siebold's organ ; *c.c.*, capping cells [=chordo-tonal ligaments (Graber)] in which the end organs are plunged; *c.c.'*, fibrous prolongation of the capping cells attached to the integument; *c.*, epidermis of the body-wall; *e.c.*, enveloping cells in which the terminal parts of the senso-neural cells lie; *e.o.*, end organs of the senso-neural cells; *g.*, senso-neural ganglion cells; *gr.*, groove between the anterior and posterior tracheal dilatations; *i.o.*, intermediate organ; *n.*, distal prolongations of senso-neural cells; *o.*, operculum ; *s.o.*, subgenual organ; *t.*, tympanic membrane; *t.n.*, nerve to tympanal organ; *t.n'.*, its branch to Siebold's organ ; *t.o.*, tracheal (Siebold's) organ; *tr.*, tracheal dilatations.

* This figure has been substituted for that of a larva (Graber, Arch. mikr. Anat. xx, Pl. 31, fig. 8) referred to in the text.

† Zoologica, Bd. xx., 1906.

concerned in equilibration and hardly if ever (e. g., *Mysis*, Hensen, Zeits. wiss. Zool., Bd. xiii. p. 393) possess any marked auditory function. The most striking results were perhaps those obtained by Kreidl (Sitz. Ak. wiss. Wien, Bd. cii. Abth. 3, p. 149) from experiments upon *Palæmon*, in which movements designed apparently to restore a supposed loss of equilibrium resulted from the action of an electro-magnet upon iron filings introduced into the auditory sac in place of the sand normally present there.

O. C. 1559 A *a a*. *Presented by Mr. R. Burton.*

Beer, Arch. f. Physiol., Bd. lxxiii. 1898, p. 1, & Bd. lxxiv. 1899, p. 364.

E. 214. The right antennule of a Crawfish (*Palinurus vulgaris*). A portion of the ventral wall of the basal segment of the protopodite has been removed to show the small flattened auditory sac. A bristle has been inserted into its orifice.

O. C. 1559 A *a*.

INSECTA.

*Graber, Arch. f. mikr. Anat., Bd. xx 1882, p. 506 ; & Bd. xxi. 1882, p. 65.

Nerve end organs of a special character and probably truly auditory in function occur in all orders of Winged Insects, and are disposed upon the most various parts of the body. They are known as chordo-tonal organs and in their simplest form, as found in many Larvæ (Pl. I. fig. 1), consist of senso-neural cells, enclosed either singly or in bundles within a fibrous tube (chordo-tonal ligament) which is stretched between two mutually stationary points of the inner surface of the exo-skeleton. The senso-neural cells terminate distally in stiff semichitinous rods or auditory hairs and are connected proximally with a peripheral ganglion of the nervous system, which is situated usually at some distance from either end of the chordo-tonal ligament.

E. 215. A New Zealand Cricket (*Deinacrida heteracantha*, Fam. Locustidæ). In each fore-limb, on the outer and inner surfaces of the tibia close to its articulation with

* A good summary will be found in Lowne's 'Anatomy . . . . of the Blow-Fly,' 1893–1895, vol. ii. p. 595, or in Lubbock's 'Senses of Animals,' p. 94.

the femur, the integument is thin and colourless over an oval area. In the interior of the limb in relation to this area is a special dilatation of a tracheal tube and a special nerve termination (chordo-tonal organ).

Among the Orthoptera tympanic auditory organs of this kind occur in several families either on the legs or abdomen. The chordo-tonal organs in connection with them are more complex than that shown in Pl. I. fig. 1, although with the same fundamental structure. They lie either near the margins of the drum membrane (Müller's and Graber's organs) or between the drum membrane and the tracheal dilatation (Siebold's organ). In this latter modification (Pl. I. figs. 2, 3, 4) the details of the histological arrangement are especially suggestive of a refined auditory function, for the chordo-tonal organs are arranged in linear series and regularly diminish in size from one end of the line to the other, while a corresponding regular alteration is noticeable in the size of a row of cubical cells within which the auditory hairs are imbedded.

O. C. 1559 A *c*.

Graber, Denkschr. Akad. wiss. Wien, Bd. xxxvi. 1876, p. 1.

E. 216. A specimen of *Hemiacrida* sp. The structure of the auditory organ is essentially the same as in the previous specimen, but in the centre of each drum-membrane is a longitudinal dark streak. O. C. 1559 A *b*.

E. 217. A female example of *Pseudophyllus* sp. On either side of the tibia of each fore-leg are thinnings of the cuticle similar to those seen in the two previous specimens; but in this case they are protected by an opercular forward growth of the thick integument of their posterior margins. Access to the drum membrane is through a narrow slit-like opening beneath the anterior edge of the operculum. Black paper has been inserted into these openings on the left leg. O. C. 1559 A *d*.

E. 218. A Locust (*Pachytylus migratorius*, Fam. Acridiidæ), dried. A red arrow points to a thin membranous area forming the front wall of a pit on the upper lateral surface of the first abdominal segment. A chordotonal organ is connected with this area of the integument.

O. C. 1559 A *f*.

E. 219. An example of *Rhomalea gigantea*, in spirit, showing a similar structure. The drum is however not sunk beneath the general surface of the body. O. C. 1559 A *e*.

E. 220. A Crane-fly (*Tipula gigas*). Behind the wings are a pair of knobbed appendages, which represent the hind wings in a highly modified condition. Each of these organs (known as Halteres or Balancers) consists of a slender stalk attached to the side of the metathorax by a thin triangular plate (scabellum) and terminates distally in a pear-shaped knob (capitellum).

Halteres are found in almost all Diptera and probably act as organs of equilibration and hearing. They are supplied by a peculiarly large sensory nerve and are provided at their base with large numbers of complex chordotonal organs. Their partial or complete removal disturbs or destroys the power of flight.

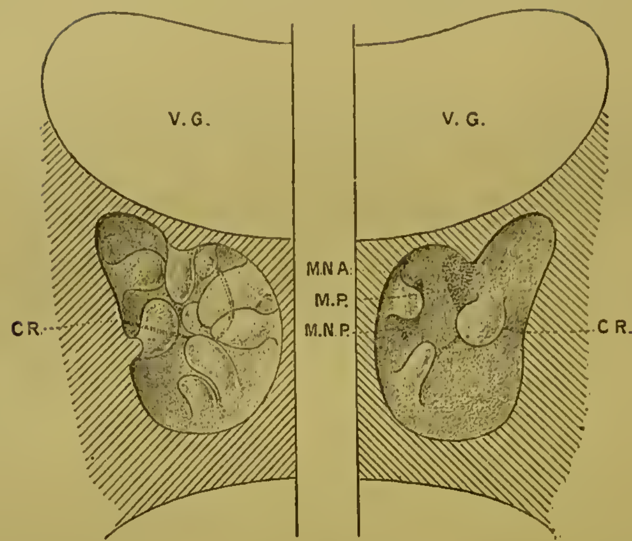
Lowne, Anatomy of the Blow-fly, 1893–95, vol. ii. p. 603.

MOLLUSCA.

E. 221. Two specimens of the statocysts of a Cuttle-fish (*Sepia officinalis*). The cartilaginous cranium has in each case been transversely divided to show the statocysts in section, in the upper specimen from in front and in the lower from behind. The section surface is as nearly as possible upon the same level in each.

The statocysts are a pair of rectangular chambers buried in the cartilage of the skull beneath the visceral ganglia. Their cavities are partly occupied by blunt processes (very constant in number and position) that project inwards from all sides and apparently serve to prevent the statolith which lies within the cavity of the cyst from touching the sensory areas of the lining membrane. The nerves to these areas appear to arise from the pedal ganglia, but in reality have their true origin, as in other Molluscs, in the cerebral ganglia.

Fig. 26 A. Fig. 26 B.



The right statocyst of *Sepia officinalis* in transverse section.

A, seen from in front; B, seen from behind (the positions of the maculæ inserted from Hamlyn-Harris).

CR. Crista statica. M.N A. Macula neglecta anterior. M.N.P. Macula neglecta posterior. M.P. Macula princeps. V.G. Visceral ganglion.

The statocyst in *Sepia* is stated (Hamlyn-Harris) to be lined by a low columnar epithelium, modified only in certain places to form sensory areas. These are four in number—three level areas (maculæ) upon the anterior wall and a ridge (crista) that runs almost horizontally from the inner margin of the anterior wall, along the outer and posterior walls, turning sharply upwards before its termination. The sense cells are large and columnar in form and appear to be senso-neural—*i. e.*, directly continuous proximally with an afferent nerve fibre. Distally they bear a number of short sense hairs.

From the experiments of Delage, there seems little doubt that the statocyst in Cephalopods is an organ of equilibration; the statocyst of *Nautilus* is shown in E. 1071. O. C. 1559 B.

Delage, Arch. Zool. Exp., sér. 2, T. v. 1887, p. 3 (*Physiol.*).

Hamlyn-Harris, Zool. Jahrb., Bd. xviii. 1903, p. 327 (*Anat.*).

VERTEBRATA.

Lee, Jour. of Physiol., vol. xv. 1894, p. 311; and vol. xvii. 1895, p. 192; and American Jour. Physiol., vol. i. 1898, p. 128.

Kreidl, Arch. f. Physiol., Bd. lxi. 1895, p. 450.

Ayers, Jour. of Morph. vol. vi. 1892, p. 1.

Retzius, Das Gehörorgan der Wirbelth., Stockholm, 1881–1884.

The organ of hearing and equilibration is developed as an integumentary inpushing on either side of the head behind the eyes, and probably has a common origin with the organs of the lateral line of aquatic forms. The originally simple invagination sinks into the tissues and becomes differentiated to form the various parts of the membranous labyrinth. Except among Cyclostomes where its form is somewhat peculiar, the general plan of the labyrinth is the same in all classes (*cf.* figs. 28, 31, 39, 40, 41). The main part consists of two chambers, the utricle above and the saccule below, which generally open into each other. Above and upon the outer side of the utricle and opening at either end into it are three semicircular canals disposed roughly one in the horizontal and the other two in the vertical planes of the head, the two latter lying in planes at right angles to each other and at angles of about 45° to the transverse plane of the head. Each canal has an enlargement (ampulla) near one end, situated in front in the case of the anterior and horizontal canals and behind in that of the posterior canal. The saccule, which only in Elasmobranchs retains an open connection with the exterior by means of the ductus endolymphaticus, is almost universally separable into two divisions —a saccule proper and a lagena. The latter in animals higher than Fishes forms the basis of the cochlea, and is gradually replaced by it.

The membranous labyrinth lies in the walls of the skull within a lymph-containing space which from the Amphibia upwards is a very definite chamber (perilymphatic space) lined by periosteum and in communication by the ductus perilymphaticus with the brain-cavity. The membranous labyrinth itself is filled with a fluid (endolymph), whose movements, due to alterations in the position of the head, or to vibrations, stimulate sensory cells upon certain special areas of the lining membrane and give rise to static, dynamic, and auditory sensations. These sensitive areas occur in the ampullæ of the canals (cristæ) and upon certain parts of the utricle, saccule and lagena (maculæ), and in a very special form in the cochlea of Mammals (organ of Corti).

The auditory nerve, by means of which the sensitive areas are connected with the brain, belongs to the same system as those that supply the organs of the lateral line. In the lowest groups, though usually divided into anterior and posterior rami for the innervation of the anterior and external ampullæ and the recessus, and of the saccule and posterior ampulla respectively, it is a single trunk, but in man and probably also in all vertebrates in which the cochlea or its rudiment is present, another independent nerve (ramus cochlearis) is added to it (Streeter, Am. Jour. Anat. vol. vi. 1907, p. 154). The transmission of vibrations to the labyrinth is frequently aided by various special modifications of the neighbouring parts of the body: in many Fishes by connections of different kinds with the swim-bladder, and in higher Vertebrates by a special oscillating (tympanic) apparatus developed in relation to the second visceral cleft. In most Mammals and some few Birds trumpet-shaped external ears further serve to concentrate sound vibrations upon the drum membrane of this apparatus, and to aid in locating the direction from which a sound proceeds.

Many points in the physiological action of the ear have yet to be explained. There is not much doubt that the organ combines two functions of which that of hearing is the latest to rise to importance, the other—equilibration—being its chief and almost only use in Fishes. Experiments (Lee) tend to show that in them all parts of the labyrinth, except probably the lagena and macula neglecta, are concerned in this function —the semicircular canals being the agents in dynamic equilibration (*i. e.*, response to alterations in direction and position when in motion), and the maculæ in the recessus and saccule in static equilibration (*i. e.*, response to change of position when at rest). The same functions are also probably performed by the semicircular canals and vestibule in other groups. Hearing in Fishes is apparently confined to perception of vibrations without any powers of discrimination between their different qualities ; although, from the experiments of Pieper and Hensen upon Teleosts, it seems highly probable that they do hear in the strict sense, though imperfectly. The presence of a pars basilaris lagenæ or cochlea which first appears amongst the lowest terrestrial Vertebrates seems, however, to be always accompanied by the power of true hearing, and probably also carries with it a certain capacity for the analysis of sound. In its highest development this part of the labyrinth becomes a chordotonal organ of extreme delicacy by which the musical qualities of complex sounds can be analysed, often with astonishing accuracy, and transmitted to the brain.

PISCES.

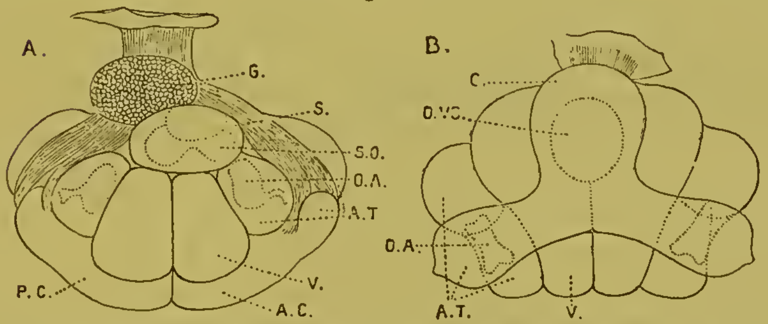
John Hunter, An Account of the Organ of Hearing in Fishes, Phil. Trans. vol. lxxii. 1782, p. 379 ; also, Works of Hunter, Palmer, vol. iv. p. 292.

CYCLOSTOMI.

E. 222. Head region of a Sea Lamprey (*Petromyzon marinus*). The brain and spinal cord have been exposed from above, and on the left side the dorsal wall of the periotic capsule has been removed to show the membranous labyrinth within.

In the River Lamprey (which probably in the structure

Fig. 27.



Right membranous labyrinth of *Petromyzon fluviatilis* (after Retzius).
A. Ventral aspect. B. Dorso-lateral aspect.

A.C. Anterior canal. A.T. Ampulla trifida. C. Commissure. G. Ganglion. O.A. Opening from ampulla to vestibule. O.VC. Opening from vestibule to commissure. P.C. Posterior canal. S. Saccular appendage. S.O. Its opening into the vestibule. V. Vestibule.
(A.C. & P.C. should be transposed.)

of its auditory organs resembles in essentials the Sea Lamprey) the membranous labyrinth consists of a single main chamber (vestibulum) and of two semicircular canals that correspond apparently to the anterior and posterior canals of other Vertebrates. The vestibule is partially divided into anterior and posterior halves by a prominent ridge (crista frontalis) and communicates above with a rounded chamber (commissure) into which open the upper ends of both semicircular canals. The canals are closely applied to the surface of the vestibule, and run outwards in anterior and posterior directions respectively towards its ventral surface. Below, each canal swells to form a trilobed ampulla, which opens into the lower parts of the vestibule. The floor of the vestibule is also dilated to form an asymmetrical pocket (saccular appendage). The auditory nerve divides into two main branches that run anteriorly and posteriorly to the ampullæ and saccular appendage to which they are mainly distributed. O. C. 1559 c.

Retzius, Das Gehörorgan der Wirbelthiere, Bd. i. p. 13.

ELASMOBRANCHII.

Retzius, Das Gehörorgan der Wirbelthiere, Bd. i. p. 105.

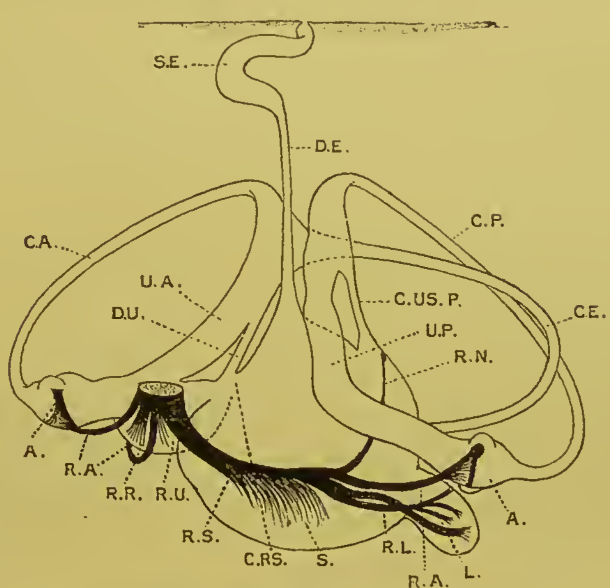
The membranous labyrinth (figs. 28, 29, 30) is completely buried within the cartilage of the skull, but still in most cases retains an open connection with the exterior through the ductus endolymphaticus, which sometimes (e. g., *Acanthias, Rhina*) is wide enough to allow the passage of sand into the saccule.

The utricle consists of two completely separate divisions—a utriculus anterior in connection with the anterior and horizontal canals and (by the ductus utriculi) with the recessus utriculi; and a utriculus posterior continuous at either end with the posterior canal. Each utricle opens into the sacculus either directly by the canalis utriculo-saccularis anterior and posterior (Sharks) or sometimes (in the case of the anterior utricle) indirectly only, through the recessus and the canalis recessu-saccularis (Rays). Upon the canalis utriculo-saccularis posterior lies a small macula neglecta—a similar nerve-ending marks the posterior limit of the single utriculo-sacculine canal in *Chimæra* and many Teleostea. The maculæ upon the walls of the recessus, saccule, and lagena are covered by loose masses of otoconia, embedded, at any rate as regards the saccule, in endolymph of gelatinous consistency.

Among the different groups and genera, variations are chiefly found in the amount of separation between the ascending arms of the utriculi, in the mode and extent of communication between the utricules and the saccule, and in the size and form of the saccule and lagena.

E. 223. The right membranous labyrinth of a Skate (*Raja batis*) with a portion of the dorsal cranial wall and skin of the head. The anterior utricle is in connection with the anterior and horizontal canals. Ventrally it is joined by a narrow

Fig. 28.



Right membranous labyrinth of *Raja batis.*

A. Anterior and posterior ampullæ. C.A., C.E., C.P. Anterior, external, and posterior semicircular canals. C.US.P. Canalis utriculo-saccularis posterior. D.E. Ductus endolymphaticus. D.U. Ductus utriculi. C.RS. Canalis recessu-saccularis. L. Lagena. R.A., R.L., R.N., R.R., R.S. Ramus ampullæ, lagenæ, neglectus recessus, sacculi. R.U. Recessus utriculi. S. Sacculus. S.E. Saccus endolymphaticus. U.A. Utriculus anterior. U.P. Utriculus posterior.

ductus utriculi (indicated by a red rod) to a rounded sac-like chamber—the recessus utriculi, which in turn opens by a small orifice (canalis recessu-saccularis), which is not shown in this specimen, into the sacculus. There is no direct connection between this utricle and the saccule. The posterior utricle, like the anterior, is a delicate thin-walled tube. It crosses the inner surface of the saccule and is continuous at either end with the posterior semi-circular canal, forming with it a complete ring, at the lower part of which lies the ampulla of the canal. Near its upper extremity it communicates with the saccule by a fine tube indicated by a green rod (canalis utriculo-saccularis posterior), close to the saccular opening of which lies the macula neglecta.

The sacculus is a large pear-shaped chamber, with its pointed upper extremity continued to the surface of the head as the ductus endolymphaticus. This duct lies between the ascending portions of the two utricles, and after traversing the skull dilates slightly and bends sharply forwards and backwards before opening to the exterior. At the hinder end of the saccule is a small oval appendage —the lagena.

The trunk of the auditory (vestibular) nerve divides into two chief branches, the anterior of which supplies the cristæ in the ampullæ of the anterior and horizontal canals after sending a large bundle of fibres to the macula of the recessus. The posterior branch innervates the macula of the saccule and gives off branches to the macula lagenæ and to the crista in the ampulla of the posterior canal. From this latter branch a small ramulus runs to the macula neglecta.

O. C. 1570 c.

Retzius, *l. c.*, p. 138.

E. 224. Part of the cranium of a Ray including the left auditory organ. The outer cranial walls have been cut away and the labyrinth filled with a black injection to show the natural position of the auditory organ within the skull and the perilymph cavities within which its various parts are suspended. The three semicircular canals lie, respectively, one in the horizontal and two in the vertical plane. The latter are set at right angles to one another and each at an angle of 45° to the transverse plane of the head. The saccule is almost horizontal, its broad outer and inner surfaces facing approximately upwards and downwards, and its free border outwards. The otoconia contained in the saccule and recessus utriculi show clearly in contrast to the dark injection.

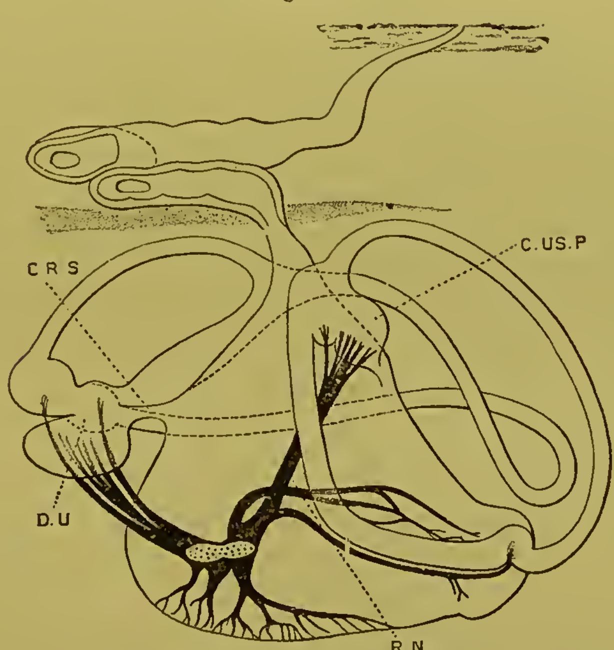
On the reverse of the specimen the cranial cavity is shown. It is completely cut off by cartilage from the perilymph cavities in which the labyrinth is contained, except at the point of passage of the auditory nerve.

A black bristle is inserted into the ductus endolymphaticus. O. C. 1570. *Hunterian.*

E. 225. The right membranous labyrinth of a Ray, filled with black injection. A bristle has been inserted into the external orifice of the ductus endolymphaticus. O. C. 1571. *Hunterian.*

E. 226. The right membranous labyrinth of a White Shark (*Carcharias lamia*) with part of the skull and overlying skin. When compared with the labyrinth of the Skate,

Fig. 29.



Right membranous labyrinth of *Carcharias lamia.*
C.RS Canalis recessu-saccularis. C.U.S.P. Canalis utriculo-saccularis posterior. R.N. Ramulus neglectus.

apart from a broad general resemblance, there are many important differences in detail. The recessus utriculi is set at some distance in front of the saccule owing to the great length of the horizontal portion of the anterior utricle. The posterior utricle is quite slender, and is united to the saccule by a relatively short canalis utriculo-saccularis posterior, which is narrow at its saccular end, but is inflated above, where it opens into a similar dilatation of the utricle. These two enlargements are innervated by a peculiarly large double ramulus maculæ neglectæ, which as usual is given off from the nerve that supplies the crista of the posterior ampulla. The saccule is of great size and has a definite lagena at its posterior end, separated from it by a slight constriction. The extra-cranial part of the ductus endolymphaticus is long and is bent acutely upon itself—the anterior end of the bend being also slightly convoluted. Bristles tipped with blue beads have been inserted into its external orifice and at its entry into the skull.

O. C. 1574 D.

C. Stewart, Jour. Linn. Soc., vol. xxix. 1906, p. 409.

E. 227. A similar preparation of the left labyrinth of the same Fish, in which parts of the external walls of the sacculus, anterior utriculus, and recessus utriculi have been removed. A black bristle has been passed from the horizontal canal along the anterior utricle into the anterior canal. The recessus is a simple dilatation of the ventral wall of the utricle and communicates with the sacculus by a long duct (canalis recessu-saccularis) which is closely adherent to the ventral wall of the utricle. This passage is marked by a red rod, and a green rod has been passed from the sacculus through the canalis utriculo-saccularis posterior into the posterior utricle. A blue rod and a blue-tipped bristle have been inserted into the ductus endolymphaticus.

O. C. 1574 C.

E. 228. The left membranous labyrinth of a Port Jackson Shark (*Cestracion philippi*) exposed in position within the skull and seen from the outer aspect. Relative to the size of the Fish, which was 3 ft. 4 in. (100 cm.) in length, the labyrinth

is very small. It is also curiously compressed antero-posteriorly in front, the normally horizontal portion of the utricle anterior to the recessus being bent up almost vertically. The saccule is exceptionally small and is prolonged below to form a blunt conical lagena. The nerves to the ampullæ are large. No otoconia were found in the labyrinth.
C. Stewart, *l. c.*, p. 440.

E. 229. The right membranous labyrinth of the same Fish, dissected from the inner side and with some of its cavities opened and a red rod passed through the canalis utriculo-saccularis anterior. The ductus endolymphaticus, into which a bristle has been passed, has apparently no opening to the exterior ; after passing through the skull in a channel 4 mm. in diameter (the fenestra vestibuli, *cf.* No. E. 234), it makes the usual forward bend and then ends abruptly.

E. 230. The right membranous labyrinth of a Greenland Shark (*Læmargus borealis*) with parts of the cranial walls and skin of the head. The ascending portions of the two utriculi touch above the saccule. The recessus is small and superficially appears to be rather a dilatation of the anterior end of the saccule than of the utricle, although it is in close contact with the ventral wall of the latter. The part of the anterior utricle between the recessus and the ampulla of the anterior canal has a slight ventral dilatation. The sacculus is extremely small. Its hinder end is prolonged downwards to form a blunt conical lagena, which however is not separated from the rest of the chamber by a constriction or other external mark. The ductus endolymphaticus is broad, and its extra-cranial portion is almost straight. The ramulus maculæ neglectæ is extremely delicate. The other branches of the auditory nerve have the usual arrangement, but those to the maculæ are relatively small. O. C. 1574 H.

Presented by W. Cowan, Esq.

Stewart, *l. c.*, p. 408.

E. 231. A similar specimen of the left membranous labyrinth of a Greenland Shark (*Læmargus borealis*) in which the outer walls of the anterior utricle, recessus utriculi, sacculus, and lagena have been in part removed. A red rod has been inserted into the canalis recessu-saccularis. The cavities of the utriculus and recessus utriculi appear to be separated by a membrane, the edge of which is seen in the specimen. The posterior half of this is the cut edge of the partition wall between the utricle and recessus, but the anterior half is the natural border of the ductus utriculi, leading from the utricle into the recessus. The canalis recessu-saccularis is large. A green rod has been passed through the short wide canalis utriculo-saccularis posterior and a black bristle into the ductus endolymphaticus. O. C. 1574 G.

Presented by W. Cowan, Esq.

E. 232. Part of the left side of the cranium of a Greenland Shark (*Læmargus borealis*) with the membranous labyrinth exposed from the outer aspect. In general form it is similar to the two previous specimens. The course of the horizontal canal is peculiar in being sinuous, making a dorsally convex curve as it passes backwards from the ampulla. The mesial and lateral walls of the ampullæ are thickened by masses of soft cartilage that project considerably from the general surface, forming flat oval bosses; an indication of similar thickenings can be seen in *Raja*, E. 223. The Fish from which this preparation was made measured 13 ft. (3·9 m.) and was much larger than that from which the two previous specimens were obtained.

The crystals of otoconia in this labyrinth were at least fifteen times as large as any found in the other Elasmobranchs examined.

E. 233. The ampullæ, with their nerves, from the right labyrinth of the same Fish, mounted side by side (those of the anterior, horizontal, and posterior canals in succession from left to right) to show respectively their ventral, lateral, and dorsal surfaces and the peculiar cartilaginous thickenings of their lateral walls.

E. 234. Part of the cranium and integument of a Spinous Shark (*Echinorhinus spinosus*) with the right membranous labyrinth exposed from the mesial aspect. The fish measured 7 ft. 6 in. (227 cm.) in length. It is similar in shape to that of *Læmargus*, and it should be noted that there is in both a similar ventral dilatation of the utricle in front of the recessus. The posterior utricle has been opened to show its communication with the saccule by a round aperture (2 mm. in diameter). A long slit in the floor of the anterior utricle (fissura utriculo-saccularis) forms a common means of connection between the cavity of this chamber and those of the recessus and saccule. The ductus endolymphaticus, as in *Læmargus*, takes an unusually straight course through the integument; a bristle has been passed along it from its external opening into the saccule and its dilated external portion has been opened. Close behind the channel in the skull through which the ductus endolymphaticus passes is a large oval fenestra (f. vestibuli) covered in nature by membrane. A similar aperture, though usually not quite so large, occurs in many Elasmobranchs (Howes, Jour. Anat. Physiol. vol. xvii. 1883, p. 188). In this specimen the trunks of the auditory nerve are also shown. The branches that supply the recessus and sacculus are relatively small. A large ramulus maculæ neglectæ is given off from the apex of an upward bend taken by the nerve that supplies the posterior ampulla.

C. Stewart, *l. c.*, p. 439.

E. 235. A similar specimen of the left membranous labyrinth of the same Fish seen from the outer aspect. In this preparation the general form of the labyrinth, the position and slenderness of the canals, and the nerve-branches to the recessus and ampullæ are shown; and through a hole in the wall of the saccule can be seen a mass of otoconia (in this species moderate in amount) embedded in mucin of gelatinous consistency.

E. 236. The right membranous labyrinth of *Notidanus griseus*, with parts of the cranial walls and overlying muscle. This specimen very closely resembles the membranous labyrinth of *Læmargus borealis*. The ascending portions of the utricles are however more closely applied to each other; the sacculus is slightly larger, and the lagena more globular and separated from the saccule by a distinct constriction. A bristle has been inserted into the ductus endolymphaticus.

O. C. 1574 F.

Presented by Dr. A. Günther.

Stewart, *l. c.*, p. 407.

E. 237. The left membranous labyrinth of the same Shark, in which parts of the outer wall of the anterior utricle, recessus utriculi, sacculus, and lagena have been removed. The anterior utricle opens directly by a large ductus utriculi (blue rod) into the recessus. Red and green rods have been passed as in the previous specimens from the recessus and posterior utricle respectively into the sacculus, and a black bristle into the ductus endolymphaticus. The extra-cranial part of this duct is dilated to form a saccus endolymphaticus

O. C. 1574 E.

Presented by Dr. A. Günther.

E. 238. The right membranous labyrinth of a Fox Shark (*Alopecias vulpes*) with parts of the cranial walls, and skin. The union of the ascending portions of the two utricles is so close that they appear to form a single vertical tube resembling the sinus superioris utriculi of higher Vertebrates. In reality they are completely separated by a septum. The rest of the labyrinth closely resembles that of *Læmargus*. Associated with the union of the ascending portions of the utricles, the ductus endolymphaticus lies in front of them. Its extra-cranial part is very long and considerably convoluted. O. C. 1574 B *a*.

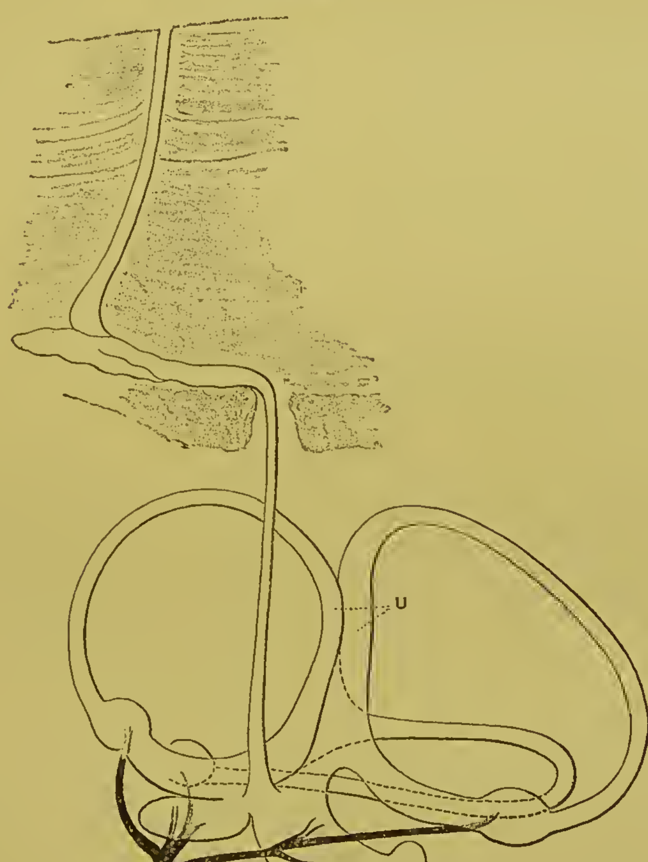
Stewart, *l. c.*, p. 408.

E. 239. A similar specimen of the left labyrinth in which the outer walls of the recessus and sacculus have been removed. The canalis recessu-saccularis has thus been opened and the long slit-like fissura utriculo-saccularis exposed. This opening connects the cavity of the utricle with that of the recessus by its anterior parts (ductus utriculi), with that of the canalis recessu-saccularis by its middle region, and with that of the sacculus by its posterior part (canalis utr.-sacc. anterior). A piece of black paper has been thrust from the sacculus up the ductus endolymphaticus. To the right of it in the upper wall of the sacculus can be seen the mouth of the short broad canalis utriculo-saccularis posterior.

O. C. 1574 B *b*.

E. 240. The right membranous labyrinth of a Porbeagle (*Lamna cornubica*) with part of the cranial roof. The ascending parts of the utricles are closely adherent and lie well behind

Fig. 30.



Right membranous labyrinth of *Lamna cornubica*.
L. Lagena. U. The fused ascending portions of the utricles.

the ductus endolymphaticus. The sacculus and lagena are peculiar in shape, the former being cylindrical and curving backward from the ductus endolymphaticus; its posterior and lower end is dilated to form the lagena. A black bristle has been inserted into the ductus endolymphaticus. The nerves have been removed. O. C. 1574 A.

Stewart, *l. c.*, p. 408.

E. 241. Another specimen of the right membranous labyrinth of *Lamna cornubica* with the nerves attached.

O. C. 1574 A *a*.

E. 242. Left membranous labyrinth of a Porbeagle (*Lamna cornubica*) with portions of the cranial roof. The outer walls of part of the anterior utricle, of the recessus utriculi and of the sacculus have been removed. The utricle opens by means of a long slit, as in *Alopecias*, into the recessus utriculi, canalis recessu-saccularis, and sacculus. Green and red rods have been inserted as in previous specimens. A pale blue rod has been passed from the anterior utriculus through the ductus utriculi into the recessus. A black bristle has been inserted into the ductus endolymphaticus.

O. C. 1574 B.

E. 243. The right membranous labyrinth of *Odontaspis americana* exposed in position within the skull. The general structure of the labyrinth is similar to that of *Lamna*, especially in the shape of the saccule and lagena and in the length of the horizontal parts of the utricles. The ascending parts of the utricles are however not so closely applied to each other, and the ductus endolymphaticus in consequence lies only just anterior to them. The recessus is also more flattened dorso-ventrally. The ductus endolymphaticus has no communication with the exterior. After passing through the skull it bends forward and dilates to form an elongated sac from whose upper surface a strand of fibrous tissue extends backwards and is lost upon the cranial roof above the fenestra. The semicircular canals are peculiarly thin.

E. 244. Part of the skull-wall and overlying skin of a Monk Fish (*Rhina squatina*) with the left membranous labyrinth shown from the outer side. In general form the labyrinth is remarkable for its appearance of dorso-ventral depression, this effect being almost entirely due to the shortness of the vertical portions of the utricles. The horizontal portions are, on the other hand, of considerable length and pass obliquely downwards, resting upon the dorsal and mesial surfaces of the large globular saccule. The hinder end of the saccule is separated by a constriction from a small finger-like lagena. The wall of the saccule has been removed to show a cake of sand applied to the inner wall. This sand, which takes the place of otoconia, is loosely cemented together by secretion and lies between the saccular wall and the gelatinous mucin with which the saccule is filled. No otoconia were found in any specimen examined, including embryos. The anterior utricle has also been opened above to show the slit by which it communicates with the saccule. A bristle has been inserted into the external opening of the ductus endolymphaticus.

C. Stewart, *l. c.*, p. 441.

E. 245. A similar specimen from a smaller individual, in which the saccular mouth of the canalis utriculi posterior has been exposed.

E. 246. A similar preparation from a larger individual, in which the labyrinth is unopened. The skin and extra-cranial part of the ductus endolymphaticus have been removed.

E. 247. The right membranous labyrinth of a Monk Fish (*Rhina squatina*) exposed from the mesial side. The sacculus has been opened and emptied to show the slit-like aperture (fissura) by which it communicates with the anterior utricle and the recessus. The canalis utriculo-saccularis posterior is shown in a similar way by the removal of the wall of the posterior utricle. A black bristle has been passed along the ductus endolymphaticus. Close beneath the skin the ductus is dilated to form a saccus endolymphaticus. The external aperture is large and opens backwards at the anterior limit of a shallow smooth depression. The chief branches of the auditory nerve are shown.

E. 248. A similar specimen, but from a larger Fish, in which the saccule has not been opened. The skin and extra-cranial parts of the ductus endolymphaticus have been removed.

E. 249. A piece of skin from the head of a Monk Fish (*Rhina squatina*), including the extra-cranial parts of the endo-lymphatic ducts. Upon the right side the saccus endo-lymphaticus has been opened and a bristle passed through it from the exterior and along the duct. Upon the reverse of the specimen the smooth depressions leading to the mouths of the ducts and no doubt facilitating the entry of sand into them are very clearly visible.

HOLOCEPHALI.

E. 250. The right and left membranous labyrinths of a Sea Cat (*Chimæra monstrosa*). The utriculus approaches in certain respects to the Teleostean type. Its ascending parts, which in Elasmobranchs are completely separate, are here fused to form a single tube (sinus superior utriculi) that opens below into the middle of a horizontal part that corresponds to the united horizontal portions of the two utricles of an Elasmobranch. The common utricular cavity opens by a single utriculo-sacculine passage into the sacculus in place of the two present in Elasmobranchs. Thus, instead of the long slit-like fissura utriculo-saccularis and the round canalis posterior of, for instance, *Alopecias* (E. 239), there is one long slit in the floor of the utricle the anterior part of which opens into the recessus and the posterior part into the sacculus. The macula neglecta, which is situated in Elasmobranchs at the mouth of the posterior canal, here borders the hinder end of the single large slit. In the specimen only the external features of the labyrinths are shown. The recessus lies between the utricle and saccule upon the outer surface. Its opening into the sacculus is not shown. The sacculus is of quite moderate size and is not separable into saccule proper and lagena. In the lower specimen a bristle tipped with blue has been inserted into the ductus endolymphaticus. O. C. 1574 I.

Retzius, *l. c.*, Bd. i, p. 102.

GANOIDEI.

E. 251. The right and left membranous labyrinths of a Sturgeon (*Acipenser sturio*). The utriculus conforms to the Teleostean type, and consists of a horizontal part lying above the saccule, and of a vertical sinus utriculi superior. The anterior end of the utricle is slightly dilated to form the recessus utriculi above which open the anterior and horizontal canals. The recessus has no direct connection with the sacculus (Retzius). In the floor of the utricle, directly below the sinus superioris, is a large oval canalis utriculo-saccularis (not shown in the specimen) leading into the saccule. The sacculus is of moderate dimensions. Posteriorly it is produced, and in this part, which is not superficially separable from the rest of the saccule, there is a separate macula lagenæ. A vestigeal ductus endolymphaticus runs upwards from the dorsal parts of the saccule nearly to the apex of the sinus utriculi superior, where it ends in a sharp-pointed extremity. Its middle part is dilated.. The nerves that supply the labyrinth are relatively very small, but have the usual branches with the exception of the ramulus maculæ neglectæ.

O. C. 1568 A.

Retzius, *l. c.*, Bd. i, p. 30.

E. 252. The otoconia from the right ear of a Sturgeon (*Acipenser sturio*) placed in the natural position upon a drawing of the labyrinth. In the sacculus the granules cohere to form an otolith of irregular shape. A separate saccular otolith is mounted below, showing its outer face. O. C. 1568 B.

Retzius, *l. c.*, Bd. i, p. 33.

E. 253. Two pieces of the skull of a Sturgeon (*Acipenser sturio*). The upper includes the whole of the membranous labyrinth and shows the distribution of branches of the auditory nerve to the recessus utriculi and sacculus. The lower piece shows the distribution of filaments of the same nerve to the ampullæ of the semicircular canals. It should be noticed that the semicircular canals are here inclosed in cavities of a corresponding shape excavated in the cartilaginous walls of the skull, but that the saccule and utricle are lodged in a mere depression in the side of the cranial cavity. O. C. 1568. *Hunterian.*

TELEOSTEA.

Retzius, Das Gehörorgan der Wirbelthiere, Bd. i. p. 38.

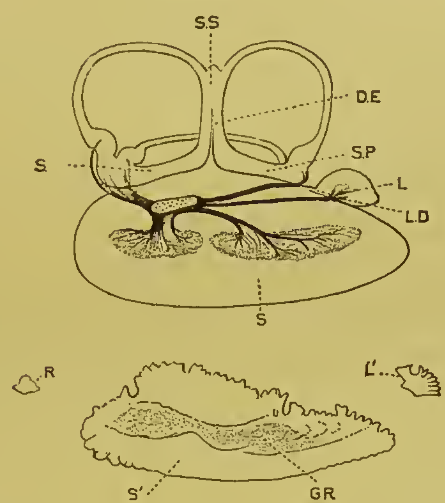
In Bony Fishes, although there are still vestiges of the deeper parts of the ductus endolymphaticus, the membranous labyrinth is completely cut off from the exterior and lies within the skull-wall in a bony encasement which is more or less imperfect towards the cranial cavity. The transmission to this organ of vibrations or variations in the pressure of the surrounding water is in many cases assisted by special connections between it and the swim-bladder, either by direct contact between the two or by the intermediation of a chain of specially modified parts of the skeleton.

The utricle, which is the least variable part of the labyrinth, is a singular tubular sac of ⊥-shape. Its three arms according to their position are known as the sinus anterior, posterior and superior, and correspond respectively to the horizontal and ascending parts of the two utriculi of Elasmobranchs and bear the same relations to the semicircular canals. The sinus anterior is dilated to form a recessus utriculi which, unlike that of Holocephali and most Elasmobranchs, has no communication with the sacculus. The utricle may or may not open into the sacculus, the position of the posterior limit of the opening being marked by the macula neglecta, when this nerve-ending is present.

The rest of the labyrinth is less constant and shows great variations in the size, shape and position of the saccule and lagena and in the length of the semicircular canals. The three chief maculæ in the utricle, saccule, and lagena respectively have otoliths of porcellaneous texture associated with them, that show considerable constancy in shape among the members of the minor taxonomic groups.

E. 254. Right and left membranous labyrinths of a Hake (*Merluccius vulgaris*) with the branches of the auditory nerve. This labyrinth shows well the general characters

Fig. 31.



The right membranous labryinth of *Merluccius vulgaris,* with the otoliths, separate, below.

D.E. Ductus endolymphaticus. GR. Groove in saccular otolith corresponding to macula sacculi. L. Lagena. L'. Otolith from lagena. L.D. Duct between lagena and saccule. R. Otolith from recessus. S. Saccule. S'. Otolith from saccule. S.A. (A omitted.), S.P., S.S. The sinus anterior, posterior and superior of the utricle.

typical of the Teleostea. Note should be made of the following special features :—The horizontal canal opens posteriorly into the hinder extremity of the utricle. The sacculus is almond-shaped and of large size, extending backwards considerably beyond the utricle. Upon its upper and posterior part lies a well-defined lagena, whose anterior extremity is connected with it by a narrow tubular orifice. O. C. 1567 H.

E. 255. The three otoliths from the sacculus, lagena, and recessus utriculi of the right and left ears of a Hake (*Merluccius vulgaris*). Those from the right ear are mounted within an outline-drawing of the labyrinth to show their relative positions. The large otolith in the saccule is convex internally, and has along this surface a longitudinal groove that overlies the macula. The groove may possibly serve to prevent actual contact with the underlying sensory cells. It is probably directly due to the fact that this area discharges less secretion than other parts, owing to the presence in it of large numbers of non-secreting sensory cells. The otolith of the lagena has a curious notch upon its upper border. The external surface of the otoliths is shown in the lower specimen.

O. C. 1567 I.

E. 256. The right membranous labyrinth of a Hake (*Merluccius vulgaris*) from which the otoliths and the inner wall of the recessus utriculi and of the anterior ampullæ have been removed, to show the maculæ acousticæ and cristæ, and their nerve supply. The trunk of the acoustic nerve divides into anterior and posterior divisions, the first of which supplies the two anterior ampullæ, the recessus and part of the macula sacculi, and the second the rest of the macula sacculi, the macula lagenæ and the posterior ampulla. In comparison with Elasmobranchs the several branches are more independent, particularly in the case of those going to the saccule and lagena. The primary separation of the main nerve trunk into anterior and posterior divisions is thus not very clear. O. C. 1567 J.

E. 257. The right and left membranous labyrinths of a Coal-fish (*Gadus virens*). The labyrinth is very similar to that of *Merluccius*, but the saccule is shorter posteriorly and the lagena forms its posterior termination. O. C. 1567 K.

E. 258. Part of the left side of the cranium of a Cod (*Gadus morrhua*) including the membranous labyrinth. The natural opening in the bony cranial wall between the labyrinth and the cranial cavity has been enlarged to show more fully the labyrinth and the large perilymph spaces by which its several parts are surrounded. The utriculus and semicircular canals have been injected with

a red material, which however has not penetrated to the sacculus. In the Cod there is stated (Retzius) to be no canalis utriculo-saccularis. O. C. 1560. *Hunterian.*
Retzius, *l. c.*, Bd. i. p. 72.

E. 259. Two specimens of the right membranous labyrinth of a Cod (*Gadus morrhua*). This closely resembles the labyrinth of *Merluccius.* In the upper specimen the saccule is much damaged. In both, the semicircular canals and the utricle have been injected with a red material, which in neither case has penetrated into the saccule.
O. C. 1565. *Hunterian.*

E. 260. Right and left membranous labyrinths of a Fishing Frog (*Lophius piscatorius*). The utricle is greatly extended in an antero-posterior direction and is dorso-ventrally depressed—the sinus anterior in particular being remarkably long, but the sinus superior very short and broad. The semicircular canals are long. The posterior end of the horizontal canal opens into the anterior end of the sinus posterior utriculi. The saccule is rounded and of moderate size. Above its hinder end lies a well-defined globular lagena connected with it by a narrow peduncle. There is no macula neglecta. Retzius also states that a canalis utriculo-saccularis is absent. O. C. 1567 c.
Retzius, *l. c.*, Bd. i. p. 60.

E. 261. Right and left membranous labyrinths of a Grey Mullet (*Mugil chelo*). The horizontal canal opens posteriorly into the lower extremity of the sinus superior utriculi. The floor of the utricle directly below the sinus superior is connected by a narrow neck (? canalis utriculo-saccularis) to the saccule. The latter has an oval form and is continuous posteriorly, without any marked intervening constriction, with a capacious rounded lagena.
O. C. 1567 L.

E. 262. The three otoliths from the recessus utriculi, sacculus, and lagena of the labyrinths of a Grey Mullet (*Mugil chelo*). Those of the right ear (upper specimen) are seen from the inner side. O. C. 1567 L *a*.

E. 263. The right membranous labyrinth and auditory nerves of a Halibut (*Hippoglossus vulgaris*) seen from the median aspect. In general form this labyrinth is just the reverse of that of *Lophius* (E. 260), being much extended dorso-ventrally and compressed antero-posteriorly. The anterior and posterior sinuses of the utricle are short, the sinus superior and semicircular canals extremely long. The recessus utriculi is larger and more prominent than in the previous specimens of Teleostea. The sacculus is oval, of quite moderate size, and bears upon its dorso-posterior aspect a sharply defined lagena. There is no macula neglecta. The nerve to the macula lagenæ is relatively very large, that to the saccule, on the contrary, small.

O. C. 1567 M.

E. 264. Left membranous labyrinth of a Halibut (*Hippoglossus vulgaris*) seen from the outer side, with the branches of the auditory nerve removed.

The saccule is attached to the floor of the utricle by a short and relatively slender peduncle. This probably is not the canalis utriculo-saccularis, which is stated to be absent in other Pleuronectids, but the saccular end of the aborted ductus endolymphaticus. Between this peduncle and the recessus utriculi the floor of the utricle is dilated to form a conical pouch—the remains, possibly, of the lost canalis utriculo-saccularis.

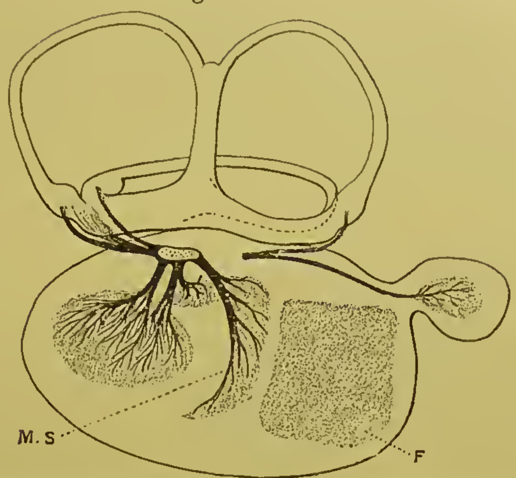
The hinder end of the horizontal semicircular canal opens into the extremity of the sinus posterior utriculi.

O. C. 1567 N.

Retzius (*Solea*), *l. c.*, Bd. i. p. 74.

E. 265. The right and left membranous labyrinths of an Albicore (*Sciæna aquila*). The saccules are very large and are fused together in the mid-line by the posterior half of their inner walls. As a result of this fusion, the hinder portion of the macula acoustica sacculi, instead of lying horizontally as usual, is rotated into a vertical position immediately in front of the fused area (*cf.* also the otoliths E. 458). The

Fig. 32.



Right membranous labyrinth of *Sciæna aquila.*

F. Area of fusion between the two saccules. M.S. The vertical part of the macula sacculi.

lagena forms a pear-shaped appendage attached by its pointed anterior end to the dorso-posterior wall of the saccule. O. C. 1567 U.

E. 266. Right and left membranous labyrinths of a John Dory (*Zeus faber*). The sacculus is much reduced in size. It bears a small lagena upon its dorso-posterior surface. There is said to be no canalis utriculo-saccularis. The horizontal semicircular canal is relatively very short; it opens posteriorly into the anterior end of the sinus posterior utriculi. The rami of the auditory nerve are unusually separate. Each gives off a large bundle to the macula sacculi. There is no macula neglecta. O. C. 1567 A.

Retzius, *l. c.*, Bd. i. p. 58.

E. 267. The otoliths from the right and left ears of a John Dory (*Zeus faber*). The saccular otolith has an exceptional, radiate, form. It consists of five radial bars: three of larger size, two of which are horizontal and one vertical, and two of smaller size lodged in the angles between them. There is a definite though very delicate otolith in the lagena (Retzius, *l. c.*, Bd. i. p. 59). O. C. 1567 B.

E. 268. The right and left membranous labyrinths of a Lump-fish (*Cyclopterus lumpus*). The semicircular canals, especially the horizontal canal, are very long and slightly tortuous. The sinus superior utriculi is short and broad. There is said to be no canalis utriculo-saccularis. The saccule and lagena are minute. The nerve-supply is small.
O. C. 1567 D.

Retzius, *l. c.*, Bd. i. p. 62.

E. 269. The right membranous labyrinth of another Lump-fish (*Cyclopterus lumpus*). The saccule is attached by a short and very slender pedicle (probably the saccular end of the ductus endolymphaticus) to the utricle.

Fig. 33.

Right membranous labyrinth of *Cyclopterus lumpus*.

D.E. Ductus endolymphaticus (?). R.N. Ramulus neglectus.

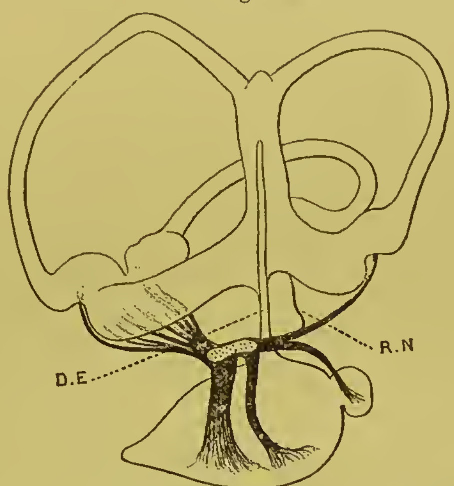
A very delicate ramulus neglectus can be seen in this specimen passing upwards from the ramus posterior of the acoustic nerve to the macula neglecta on the ventral border of the median wall of the utricle. O. C. 1567 E.

E. 270. Right and left membranous labyrinths of a Wolf-fish (*Anarrhichas lupus*). The nerves have been removed from the left labyrinth (lower specimen) to show clearly the wide separation of the saccule from the utriculus. The two chambers are connected by a narrow tube, which probably (Retzius, *l. c.*, p. 66) is not a patent canalis utriculo-saccularis, but consists in part of the aborted ductus endolymphaticus and in part of a conical process of the utricle floor—the vestige of the canalis utriculo-saccularis.

The saccule is oval, with a pointed anterior end. Posteriorly it bears a well-defined lagena.

The anterior ramus of the auditory nerve (upper specimen) supplies a large part of the macula sacculi. The

Fig. 34.



Right membranous labyrinth of *Anarrhichas lupus*.

D.E. Ductus endolymphaticus. R.N. Ramus neglectus.

posterior ramus gives off a small ramulus neglectus for the innervation of the macula neglecta, which lies on the utricle wall at the hinder limit of the conical process that accompanies the ductus endolymphaticus. O. C. 1567 F.

Retzius, *l. c.*, Bd. i. p. 66.

E. 271. The otoliths from the right and left ears of a Wolf-fish (*Anarrhichas lupus*). Those of the right side are mounted, with the median face exposed, within an outline of the labyrinth. O. C. 1567 G.

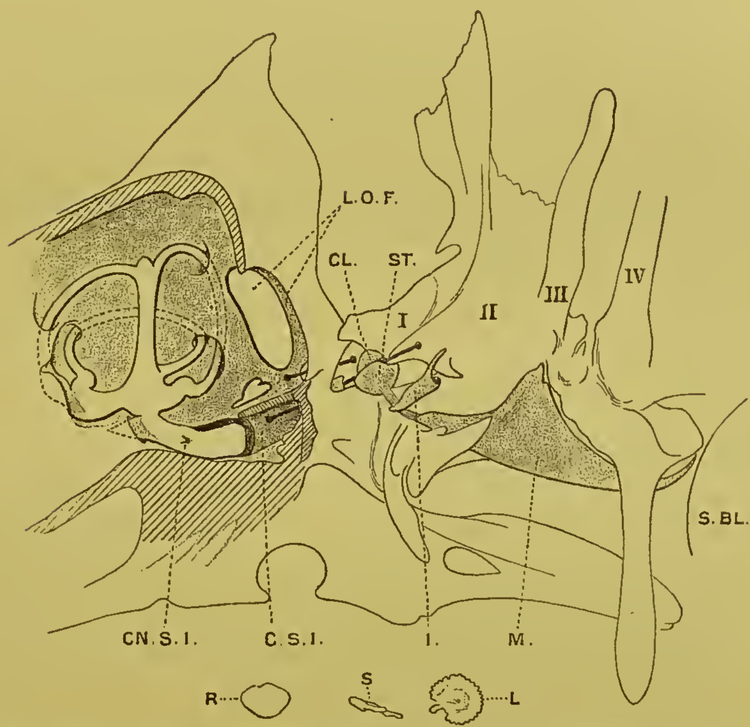
E. 272. The right and left membranous labyrinths of a Fresh-water Bream (*Abramis brama*). The whole length of the ventral wall of the sinus anterior utriculi is dilated to form an exceptionally large recessus. Immediately below the sinus superior is a wide canalis utriculo-saccularis. The sacculus is small and tubular in form. It lies behind the level of the anterior border of the sinus superior utriculi, and is pointed in front. Posteriorly it opens into a large, circular, laterally flattened lagena. A small rupture in the median wall of the saccule in the upper specimen shows where a delicate tube (canalis sinus imparis), by which the two saccules are in communication with each other, has been torn away. O. C. 1567 o.

Retzius, Anat. Untersuch., 1872, p. 59.

E. 273. The otoliths from the ears of a Freshwater Bream (*Abramis brama*). Those from the lagena (the asteriscus) and from the recessus utriculi are of great size, that from the saccule (sagitta) small and spine-like. O. C. 1567 P.

E. 274. Part of the skull with the anterior end of the vertebral column of a Freshwater Bream (*Abramis brama*), showing the chain of ossicles by means of which movements of the swim-bladder are transmitted to the membranous labyrinth. The ossicles (painted red) are hinged to the lateral parts of the three anterior vertebræ. The hindermost of them (malleus) is a triangular plate, hinged by its apex between the bodies of the second and third vertebræ, with its base directed outwards and downwards, and with the posterior angle produced into a hook-like process that curves behind a vertical plate formed by the fusion of the fourth pair of ribs and is there attached to the anterior surface of the swim-bladder. The anterior angle is united by ligament to the apex of a rod-shaped bone (incus) which is hinged by its other, forked, end to the body of the second vertebra. Another ligament connects the apex of the incus to a small cup-shaped ossicle (stapes) that partly blocks the foramen between the skull and the first vertebra with its concave surface. This opening is also partly closed by another ossicle (claustrum) that projects downwards and outwards from the broadened neural spine of the first vertebra into the cup-shaped cavity of the stapes. In the natural state the ossicles lie in a space which is continuous in front with the neural canal through the foramen in which lie the stapes and claustrum and also with the cranial cavity through the enormous lateral occipital foramina. The space enclosed within the claustrum and stapes (atrium sinus imparis) communicates in front with a large cavity (cavum sinus imparis) in the floor of the skull. A green bristle has been passed between the claustrum and stapes into this cavity. It is stated that in the Carp and other Cyprinoids the anterior part of the

Fig. 35.



Skull and part of the vertebral column of *Abramis brama,* showing the connection between the membranous labyrinth and swim-bladder. The otoliths are figured below.

CL. Claustrum. C.S.I.. Cavum sinus imparis. CN.S.I. Canalis sinus imparis. I. Incus. L. Otolith from lagena (asteriscus). L.O.F. Lateral occipital foramen. M. Malleus. R. Otolith from recessus. S. Otolith from saccule (sagitta). S.BL. swim-bladder. ST. Stapes. I., II., III., IV. The spines of the first four vertebræ. Rods are passed through the foramen magnum and from the atrium into the cavum sinus imparis.

cavus sinus imparis is occupied by an unpaired dilated part of the membranous labyrinth (sinus impar) the front of which is connected on either hand to each saccule by a delicate tube (canalis sinus imparis) upon the walls of which are special nerve-endings. These ducts and the sinus impar are probably modifications of the ductus and saccus endolymphaticus.

The cranial cavity, neural canal, cavum and atrium sinus imparis, and the space in which the ossicles lie are filled with an oily fluid, through which the movements of the stapes and claustrum are transmitted to the membranous labyrinth. The skull wall has been removed on the left side to the mid-line. Black bristles have been placed in the cavities that lodged the semicircular canals. O. C. 1567 Q.

Nusbaum, Zool. Anz., Bd. iv. 1881, p. 552.

E. 275. The three anterior vertebræ of a Freshwater Bream (*Abramis brama*) with the malleus, incus, stapes, and claustrum isolated. The ligaments between the malleus and incus and between the incus and stapes are painted blue. O. C. 1567 R.

E. 276. Otic portion of the skull of a Shad (*Clupea alosa*), a great part of which has been removed to expose the membranous labyrinth and two bony vesicles that lodge an extension of the swim-bladder. The anterior of the two vesicles lies below the forward extremity of the sinus anterior utriculi, the posterior in the space enclosed between the horizontal canal and the utricle. O. C. 1567 S.

E. 277. A Herring (*Clupea harengus*) dissected from the ventral aspect to show the relation of the swim-bladder to the ear. The swim-bladder is a fusiform elongated sac that extends from the skull to the vent. It opens to the exterior at the hinder end (black bristle) and is in communication with the stomach by means of a long ductus pneumaticus. Anteriorly it gives off two delicate cartilaginous tubes that pass upwards and forwards on either side of the skull and expand below the hinder end of each sinus utriculi posterior to form a fusiform vesicle that opens at its apex into two pear-shaped sacs. The whole of this triple vesicle is encased in a bony capsule. The posterior of the two pear-shaped chambers lies within the embrace of the horizontal canal, the anterior which is directed forwards and downwards is situated below and in front of the anterior ampulla. It is stated that there is direct contact between the membranous labyrinth and the anterior pear-shaped dilatation of the swim-bladder, owing to the intrusion into the bony encasement of this dilatation of a diverticulum of the recessus utriculi.

On the right side the membranous labyrinth has been removed. On the left, black paper has been placed beneath the tubular forward extension of the swim-bladder and between the horizontal canal and the posterior of the two pear-shaped vesicles. A red rod has been inserted into the ureter. O. C. 1567 S *a*.

Ridewood, Jour. Anat. & Phys., vol. xxvi. 1892, p. 26.

E. 278. The right and left membranous labyrinths of a Pike (*Esox lucius*). The inner wall of the sinus posterior utriculi, at the base of the sinus superior, gives origin to a pear-shaped appendix, which extends backwards within the cranial cavity. It has no special nerve-supply. The recessus utriculi is large. The hinder end of the horizontal canal opens into the short and wide sinus superior utriculi. The utricle is connected with the saccule by a wide patent (Retzius, p. 88) canalis utriculo-saccularis. The saccule is almond-shaped with the point in front. The greater part of it lies anterior to the level of the sinus superior utriculi. Its blunt hinder end forms a lagena, which is however not externally separable from it, but has its proper otolith and nerve supply. O. C. 1567 T *a*.

Presented by Dr. Corfield.

Retzius, *l. c.*, Bd. i. p. 84.

E. 279. Portion of the right side of the head and fore part of the trunk of a Pike (*Esox lucius*). The dura mater has been removed from the cranial wall, exposing the large open fossa in the skull wall in which lies the greater part of the membranous labyrinth. The appendix utriculi can be seen extending backward within the cranial cavity behind the posterior margin of the general auditory fossa nearly to the foramen magnum.

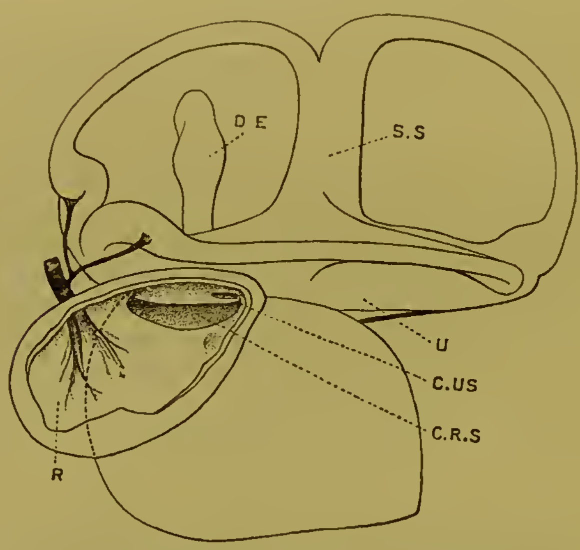
The branches of the auditory nerve to the anterior ampulla, recessus utriculi, sacculus, lagena, and posterior ampulla are shown. O. C. 1567 T.

Presented by Dr. Corfield.

DIPNOI.

E. 280. The right and left membranous labyrinths of a Barramunda (*Ceratodus forsteri*). The recessus utriculi forms a large flattened chamber projecting downwards upon the outer side of the labyrinth from the line of contact between the sinus utriculi anterior and the saccule. The sinus superior utriculi is short and broad and receives the hinder

Fig. 36.



Left membranous labyrinth of *Ceratodus forsteri.*

C.R.S. Canalis recessu-saccularis. C.U.S. Canalis utriculo-saccularis. D.E. Ductus endolymphaticus. R. Recessus-utriculi. S.S. Sinus superior utriculi. U. Horizontal part of utricle.

extremity of the horizontal canal into its lower part. The saccule is of moderate size and shows no externally distinguishable lagena. A dilated vestige of the ductus endolymphaticus arises from its antero-dorsal region. The auditory nerve and its branches have been retained in the upper specimen. The ramus recessus is very large. In the lower specimen the recessus and saccule have been opened. The recessus communicates with the saccule by a large oval canalis recessu-saccularis, indicated by a red rod. A black bristle has been passed through a small opening in the floor of the utricle close to the hinder part of the canalis recessu-saccularis by which the utricle is connected with both the sacculus and the recessus.

O. C. 1568 c.

Retzius, *l. c.*, Bd. i. p. 144.

E. 281. The otoliths from the recessus and sacculus of a Barramunda (*Ceratodus forsteri*). They are soft and granular in texture and not porcellaneous as in Teleostea, and are apparently formed by the cohesion of loose otoconia. Some free otoconia were also found in the labyrinths.

The otolith from the sacculus is broken. There is no separate otolith in the lagena. O. C. 1568 d.

AMPHIBIA.

Retzius, Das Gehörorgan, Bd. i. 1881, pp. 151, 219.

Harrison, Internat. Monthly Jour. Anat., vol. xix. 1902, p. 221 (*perilymph*).

In the Amphibia the membranous labyrinth consists of the same parts as in Fishes, but, except in the lowest forms, with the addition of an important sensory area in the lagena. This, which is known as the macula acoustica basilaris, is probably the rudiment of the cochlea (pars basilaris cochleæ). At first it is merely a separate portion of the macula lagenæ covering part of the wall of the labyrinth at the base of the lagena, but in Anura the underlying and neighbouring wall of the labyrinth undergoes an important change and forms an extremely thin sheet (membrana basilaris) stretched from the inner circumference of a cartilaginous ring-like thickening. A similar stretched membrane occurs in all forms of cochlea, and according to the Helmholtz theory of audition plays an essential part in the appreciation of differences in pitch (the Frog has lately been proved to have distinct powers of differentiating between sounds somewhat similar [Yerkes, Jour. Comp. Neurol., 1905]). In Mammals, and probably also in lower Vertebrates, the fibres of which the membrane is formed are tense in the direction of their own length and relatively slack in their connection with one another.

They are thus able to vibrate independently. According to the theory each fibre is tuned to vibrations of a certain rapidity and vibrates only in sympathy with them. The whole membrane thus forms an automatic analyser of mixed sounds and ensures

Fig. 37.

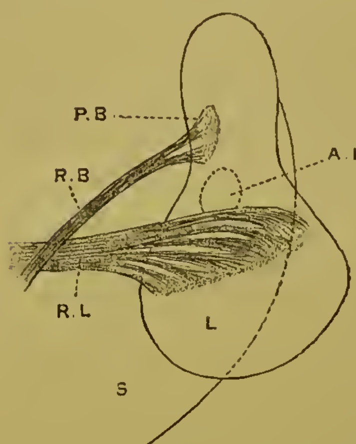


Fig. 38.

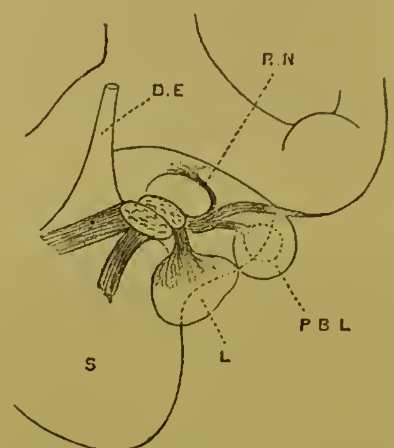


Fig. 37. Lagena of *Menopoma alleghanniense,* from the inner aspect (after Retzius).

Fig. 38. Lagena and surrounding parts of *Rana esculeuta,* from the inner aspect (after Retzius).

A.L. Apertura lagenæ. D.E. Ductus endolymphaticus. L. Lagena P.B. Papilla basilaris. P.B.L. Pars basilaris lagenæ. R.B., R.L., R.N. Ramus basilaris, lagenæ, neglectus. S. Sacculus.

the transmission of vibrations of one particular frequency to certain cells only of the overlying macula.

The saccus endolymphaticus, which is developed independently of the original communication between the ear and the exterior, is frequently much enlarged and extends into the cranial cavity, neural canal, and through the intervertebral foramina into the body cavity. The Amphibia are the lowest group in which the perilymphatic space forms a cavity lined by endothelium and in connection on the one hand with certain areas of the labyrinth and on the other with the cranial cavity by the ductus perilymphaticus. Within this group also a tympanic apparatus, due to modification of the hyoid cleft, is met with for the first time, and in its simplest form. When present, the cleft is usually a combined Eustachian tube and tympanic chamber that extends upwards from the mouth cavity and separates the otic region of the skull from the overlying tissues. The skin over this area is united to the mucous membrane of the tympanic chamber to form a flat drum-membrane suspended by its edges to a thickened cartilaginous ring (annulus membranæ tympani). A rod of cartilage and bone (columella auris) attached to the inner surface of the drum-membrane stretches across the tympanic cavity to an opening in the wall of the periotic capsule. By means of this apparatus sound-vibrations are transmitted by oscillations of the membrana tympani and columella to the perilymph and through it to the endolymph and sensory epithelium of the labyrinth, the necessary movements of the perilymph being made possible by the opening in the otherwise rigid walls of the periotic capsule, through which an enlargement of the perilymph sac projects into the cranial cavity. In Amphibia the membrana tympani lies unprotected flush with the general surface of the head.

E. 282. The right membranous labyrinth and the membrana tympani and columella auris of a Bull Frog (*Rana catesbiana*). In the specimen the saccule, lagena and utricle form an oval mass, in which the several parts are indistinguishable, surmounted by the semicircular canals and the sinus superioris utriculi. The membrana tympani is flush with the general surface of the head. It is stretched from the circumference of a ring of cartilage (the annulus membranæ tympani) which serves also to support the walls of the tympanic chamber. To the centre of the membrana tympani is attached the cartilaginous outer end (extrastapedial) of the columella auris. The inner end of the columella (interstapedial) is bound by fibrous tissue (the cut edge of which is shown in the specimen) to the edges of the fossa that leads to the fenestra ovalis. The upper border of the extrastapedial is attached to the deep margin of the tympanic ring. O. C. 1575 A.

Ecker's, Anat. des Frosches, Gaupp, 2nd Aufl., Abt. 3, 1904, pp. 679 & 736.

E. 283. Left half of the head of a Bull-Frog (*Rana catesbiana*). The posterior half of the membrana tympani has been removed leaving the annulus membranæ tympani and showing the connections and natural position of the columella auris and the communication between the tympanic chamber and the mouth through the Eustachian tube. The annulus is attached by its upper border to the squamosal and also has a slight connection in the same region with the columella auris. A black bristle has been passed to the anterior side of the columella and through the tympanum into the Eustachian tube. The membranous labyrinth has been exposed to show so far as possible the natural position of its different parts. O. C. 1575 B.

E. 284. The head of a Bull-Frog (*Rana catesbiana*) seen from the ventral aspect with the lower jaw removed. Upon the left side the posterior walls of the tympanum have been cut away to show the position of the columella auris and the inner surface of the membrana tympani. Upon the right side is shown the wide opening of the Eustachian tube into the mouth, and upon the reverse of the specimen the general appearance and the position of the tympanic membranes.
O. C. 1575. *Hunterian.*

E. 284 a. The head and trunk of a Frog (*Rana temporaria*) with the ventral body-walls removed. On either side of the backbone on a level with the intervertebral foramina are paired chalky masses (chalk-sacs) of irregular shape. These have been shown to be continuations of the endolymphatic ducts filled with otoconia. The two sacci endolymphatici are stated to be united around the hinder part of the brain to form a ring-like chamber from which a continuation made up of numerous fine tubes passes down the neural canal above the spinal cord and gives off laterally through each intervertebral foramen the "chalk-sacs" shown in this specimen. Similar extensions of the endolymphatic ducts into different parts of the body occur in some Lizards (see below).

Coggi, Anat. Anz., Bd. v. 1890, p. 177.

E. 285. Head of a Surinam Toad (*Pipa americana*). The Eustachian tubes open by a small common orifice in the mid-line of the roof of the mouth. A black bristle has been passed through this into the tympanic chamber and behind the extrastapedial cartilage of the columella. A red rod has been passed through the right nasal passage.

O. C. 1575 D.

E. 286. Skull of a Surinam Toad (*Pipa americana*), dried. Upon the left side a black bristle has been passed through the Eustachian tube and a green bristle into the fenestra ovalis. Upon the right the three divisions of the columella auris (represented by paper) have been painted different colours—the interstapedial and extrastapedial blue, and the mediostapedial red. O. C. 1575 C.

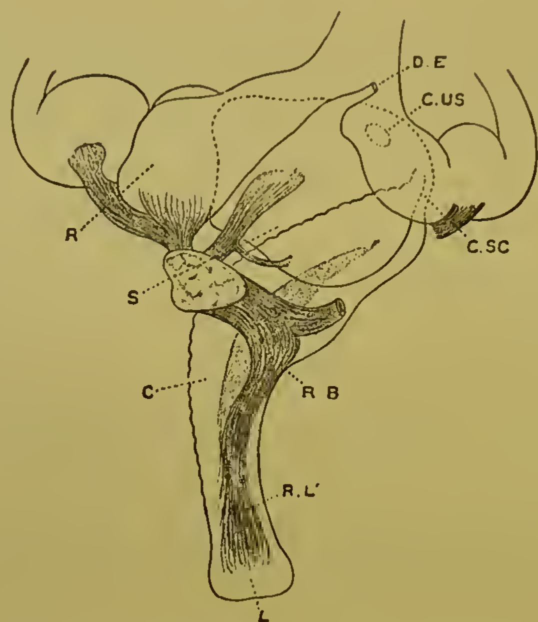
REPTILIA.

Retzius, Das Gehörorgan der Wirbelthiere, Bd. ii. 1884, pp. 3, 358.

As regards the membranous labyrinth, this is in some ways the most important of all the Vertebrate groups, for within it the transformation of the pars basilaris cochleæ can be traced from a rudiment upon the basal parts of the lagena to a large, lengthened, and slightly twisted tube to which the lagena forms a minute terminal appendage. In its lowest state of development (Chelonia, Ophidia) this cochlea differs little from that of a Urodele Amphibian, and in its highest (Crocodilia) is essentially the same as that of a Bird, but in no case is the minute structure of the papilla basilaris comparable in its details to that characteristic of the organ of Corti of Mammals, but is similar to that of the other maculæ of the labyrinth.

The rest of the membranous labyrinth consists of the same parts as in lower Vertebrates, with the same cristæ and maculæ acousticæ, including a small macula neglecta upon the ventral wall of the sinus utriculi posterior. The saccule, so far as investigated, is always in open communication with the utricle by a narrow canalis utriculo-saccularis, and with the cochlea by an opening which may be wide or may be drawn out into a relatively narrow tube (canalis reuniens). The ductus endolymphaticus, which is developed independently of the original connection between the labyrinth and the exterior, ends in a blind dilatation that sometimes, as in certain anurous Amphibia, extends (filled with otoconia) beyond the ear-capsule into the cranial cavity and other parts of the body.

Fig. 39.



Part of the right membranous labyrinth of *Alligator mississipiensis*, mesial aspect (after Retzius, modified).

C. Cochlea. C.SC. Canalis sacculo-cochlearis (reuniens). C.US. Canalis utriculo-saccularis. D.E. Ductus endolymphaticus. L. Lagena. R. Recessus utriculi. R.B., R.L. Ramus basilaris, and lagenæ. S. Sacculus.

Within this group also for the first time the perilymph space forms a definite channel that runs from the base to the apex of the cochlea applied to its roof-membrane forming the scala vestibuli, and thence as the scala tympani along the outer surface of the basilar membrane to an opening closed by membrane in the periotic capsule (fenestra rotunda) *. The flexible area provided by this opening in the rigid periotic wall allows the movements of the columella to be transmitted from the fenestra ovalis throughout the perilymph and thus to the endolymph and the sensory cells of the maculæ.

* Above Reptiles these three united passages are known as the cochlea, and the true cochlea as the scala media, or cochlear canal.

Although in some cases (Ophidia) the tympanic chamber is absent, it frequently has considerable complexity both in its shape and in its connections with the mouth. The tympanic membrane is often (Lacertilia) sunk below the level of the skin and is sometimes protected by an upstanding fold that faintly suggests a pinna.

RHYNCHOCEPHALIA.

E. 287. The skull of a Tuatara Lizard (*Sphenodon punctatus*) showing a direct connection between the extrastapedial cartilage of the columella auris and the upper end of the second visceral (hyoid) arch. This connection in *Sphenodon*, in addition to evidence derived from other animals, led Huxley to infer that the columella auris and (in Mammals) the incus and stapes are modifications of the upper end of the hyoid arch. But the primary character of the connection has been much questioned, and in consequence this view of the origin of the columella has not found many adherents. Latterly however it has been again brought forward (Howes and Swinnerton), supported by embryological evidence*. O. C. 1576 A.

Presented by F. E. Beddard, Esq.

Huxley, Proc. Zool. Soc., 1869, p. 391.
Gadow, Phil. Trans., vol. clxxix. 1889, p. 466.
Howes and Swinnerton, Trans. Zool. Soc., vol. xvi. 1903, p. 46.

LACERTILIA.

E. 288. Right half of the head of an Australian Scinc (*Tiliqua scincoides*). The membrana tympani is sunk below the general surface of the head at the bottom of a wide meatus auditorius externus. The cavity of the tympanum and its remarkably wide passage into the pharynx are shown upon the reverse of the specimen. O. C. 1605. *Hunterian.*

John Hunter, Essays and Observations, edit. R. Owen, vol. ii. 186, p. 368.

* A full review of this vexed question of the origin and homologies of the tympanic ossicles is given by Gaupp, Ergebnisse der Anat. u. Entwickl., Bd. viii. 1898, p. 990.

E. 289. Head of an Iguana (*Iguana tuberculata*). The membranous labyrinths are exposed from above, but parts of the semicircular canals only are visible. Upon the left side the tympanum has been opened from above to show the position of the long slender columella. The membrana tympani lies slightly below the general level of the skin and is protected to some extent by an integumentary fold along its posterior border. Upon the reverse of the specimen the cavity of the right tympanum and the openings of the Eustachian tubes are shown. O. C. 1576.
Hunterian.

John Hunter, Essays and Observations, edit. R. Owen, vol. ii. 1861, p. 367.

E. 290. Cranium of a Lizard (*Rhacodactylus leachianus*) belonging to the family Geckonidæ. The saccus endolymphaticus, as is usual in this family, is excessively enlarged, and protrudes—filled with otoconia—between the bones of the skull. Its chief expansions are irregularly nodular and can be seen projecting downwards between the two columellæ cranii towards the mouth cavity through the unossified alisphenoidal region of the skull. A smaller enlargement is visible between the supraoccipital and prootic bones, and there are also traces of otoconia between the supra-occipital and parietal bones and around the foramen magnum, that seem to be the cranial extremities of cervical sacs similar to those found in *Phyllodactylus*.
O. C. 1576 B.

Wiedersheim, Morph. Jahrb., Bd. i. 1876, p. 517.

EMYDOSAURIA.

E. 291. A transverse section through the otic region of the head of a Crocodile (*Crocodilus acutus*), showing the auditory organs from behind. The external meatus and tympanic chamber have been cut through on the right side, showing the position of the membrana tympani with the outer, convex, surface directed upwards and outwards, its connection by means of the columella with the internal ear, and its mode of protection from external injury by a moveable opercular flap of the integument that forms the dorsal wall of the meatus. This flap is probably raised when the animal is on land and depressed against the lower wall of the meatus (as shown on the left side of the specimen) when in the water. In the latter condition sound waves are conducted to the internal ear through the bones of the skull.

The columella auris is attached by its outer end to the membrana and extends obliquely downwards and inwards across the tympanic cavity to the fenestra ovalis—an aperture in the bony labyrinth situated opposite the base of the cochlea.

The tympanic chamber communicates with the mouth by a complex series of channels. In its ventral wall are two apertures: a posterior, marked by a black bristle, and an anterior marked by a yellow bristle. The duct in connection with the first passes inwards and downwards and soon forks in the transverse plane. The lateral branch of this fork runs directly downwards between the basisphenoid and basioccipital bones to the floor of the skull, and here bends abruptly inwards to open into the mouth in the mid-line behind the posterior nares by an aperture common to all the Eustachian canals. The median branch of the fork passes inwards and downwards and unites with its fellow of the opposite side to form a median canal (posterior median canal) that runs directly downwards to the common Eustachian opening. The anterior opening into the tympanum is in connection with a duct that runs towards the mid-line and unites with its fellow to form an "anterior median canal," which after a short ventral course opens into the anterior surface of the posterior median canal.

The tympanic chambers of either side are in open communication above the brain-case.

The membranous labyrinths have been exposed and show the position of the semicircular canals and their ampullæ, the general form of the utricle and saccule and (upon the left) the long cochlea stretching downwards with a slight backward curve from the posterior end of the saccule.

O. C. 1577 B.

Retzius, Das Gehörorgan, Bd. ii. 1884, p. 121.
Van Beneden, Arch. de Biol., t. iii. 1882, p. 497.

E. 292. A portion of the head of a young Crocodile (*Crocodilus acutus*), in which the organs of hearing are exposed from behind. The opercular flap for the protection of the membrana tympani is shown on the right as in the previous specimen; on the left it has been removed. The tympanic chambers have been opened and, upon the left side, the relation of the base of the columella to the fenestra ovalis is particularly well shown. Quills have been passed in front of each columella and along the communicating passage between the two tympana. Upon the right, one of the Eustachian canals has been opened and black bristles have been inserted into the cavities occupied by the horizontal and posterior semicircular canals. O. C. 1577.
Hunterian.

John Hunter, Essays and Observations, edit. R. Owen, vol. ii. 1861, p. 344.

E. 293. Left half of the head of a young Crocodile (*Crocodilus* sp.), showing the membrana tympani sunk slightly below the surface of the head at the bottom of a wide but shallow external meatus. The opercular flap shown in the two previous specimens has been removed. O. C. 1606.
Hunterian.

E. 294. The posterior part of the roof of the mouth of a Crocodile, showing the posterior nares and close behind them the common orifice of the Eustachian tubes. Black bristles have been inserted into the lateral and central passages of the Eustachian tubes. O. C. 1577 A.

CHELONIA.

E. 295. Part of the head of a Turtle (*Chelone mydas*), in which the auditory organ is displayed on both sides. The membrana tympani is covered externally by the cutis and by one of the horny epidermic scales. On the left side the two extremities of the long columella auris are exposed from above and bristles are placed beneath them. The tympanic cavity is separable into three parts: (*a*) An outer chamber of large size, just internal to the membrana tympani, into which opens the Eustachian tube—the tube upon this side (see reverse of specimen) has been slit up and a bristle passed along it into this part of the tympanic cavity. (*b*) A narrow median tubular part occupied completely by the shaft of the columella. This has not been opened in the specimen. (*c*) An inner chamber (antivestibulum), next the bony labyrinth, in which lies the foot of the columella. In the specimen this chamber has been opened and part of the wall of the labyrinth removed to show the foot of the columella lodged in the fenestra ovalis.

Upon the left side the membranous labyrinth has been exposed, but its several parts are retained in their true relations to the bony labyrinth and are still enveloped in the perilymphatic sheath, which in the Chelonia is readily detachable from the bony capsule. A white mass of otoconia can be seen through the transparent walls of the saccule.

Upon the right side the membranous labyrinth has been more fully isolated, showing the semicircular canals and their ampullæ. Upon the reverse the mouth of the right Eustachian tube is marked by a black bristle. O. C. 1578.

Hunterian.

John Hunter, Essays and Observations, edit. R. Owen, 1861, vol. ii. p. 354.

Hasse, Anat. Studien, Bd. i. 1870–73. p. 225.

E. 296. A small part of the right side of the head of a Turtle (*Chelone* sp.). The cutis and epidermic scales have been partly reflected to show the outwardly convex membrana tympani. The tympanic cavity has also been opened exposing the columella auris. The extreme narrowness of the central segment of the tympanum is well shown. The membranous labyrinth has been isolated from its bony coverings but is still surrounded by the perilymphatic sheath. The extension of this into the concavity of the foot of the columella is clearly seen. In this part there is a considerable space between the membranous labyrinth and the perilymphatic sheath. O. C. 1580 A.

E. 297. A small part of the left side of the head of a Turtle (*Chelone* sp.) from which the integument has been removed to show the membrana tympani. The tympanic cavity has been opened displaying the whole length of the columella auris, and the tympanal end of the Eustachian tube. The membranous labyrinth is also shown, still enveloped in its perilymphatic sheath. O. C. 1580 A *a*.

E. 298. Part of the left side of the head of a Turtle (*Chelone* sp.), in which the tympanic cavity and the bony labyrinth have been opened from below. The columella and the different parts of the membranous labyrinth are indicated by black bristles. The upper end of the Eustachian tube is shown opening into the outer chamber of the tympanum.
O. C. 1580. *Hunterian.*

E. 299. Part of the right side of the same head, with the columella auris and membrana tympani isolated. The foot of the columella is still lodged in the fenestra ovalis. The bony labyrinth has been opened showing fragments of the contained membranous labyrinth. O. C. 1579.
Hunterian.

E. 300. The columella auris and membranous labyrinth of the left side of a Turtle (*Chelone* sp.), isolated. The perilymphatic sheath has been partly removed, but the connection between it and the foot of the columella is still retained. O. C. 1580 c.

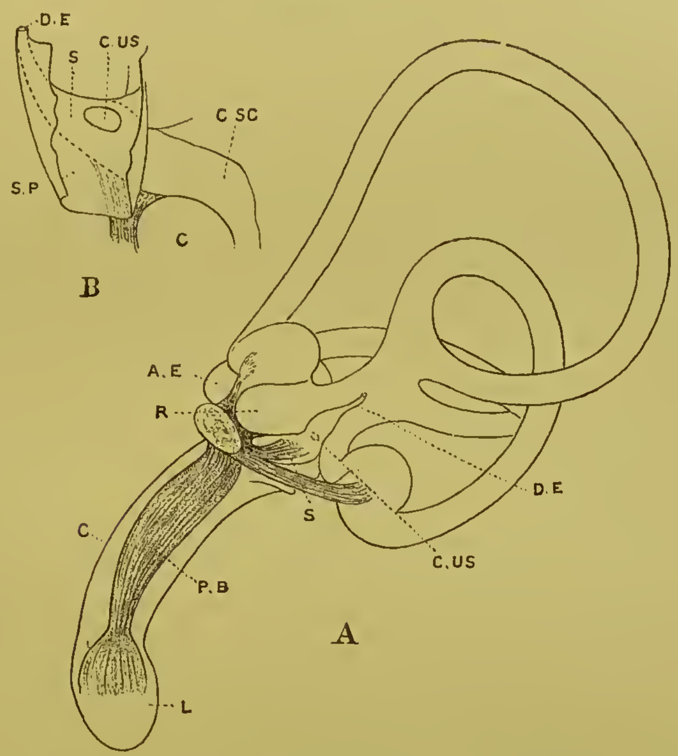
E. 301. Left half of the head of a Tortoise (*Testudo græca*). A bristle is inserted into the pharyngeal opening of the Eustachian tube. Upon the reverse of the specimen the membrana tympani is shown, exposed by the removal of the overlying horny scales. O. C. 1607. *Hunterian.*

AVES.

Retzius, Das Gehörorgan der Wirbelthiere, Bd. ii. 1884, pp. 139, 361.

The membranous labyrinth of Birds closely resembles that of the Crocodiles in the form and structure of the cochlea, which is long, narrow, slightly twisted, and attached to the saccule by a relatively narrow passage (canalis reuniens), and terminates in a small lagena with separate macula and nerve ramus. But the arrangement of the semicircular canals is of quite a peculiar type, the anterior vertical canal being of great length, and it and the posterior vertical being so placed that they cross each

Fig. 40.



A. Right membranous labyrinth of *Columba domestica*, mesial aspect.
B. Right utricle of the same opened from above, showing connection between it and the saccule and between the saccule and cochlea (both after Retzius, simplified).

A.E. Ampulla externa. C. Cochlea. C.SC. Canalis sacculo-cochlearis. C.US. Canalis utriculo-saccularis. D.E. Ductus endo-lymphaticus. L. Lagena. P.B. Papilla basilaris. R. Recessus utriculi. S. Sacculus. S.P. Sinus posterior utriculi.

other, the anterior above, and open into the apex of the sinus superior utriculi in reversed positions, *i. e.*, the posterior in front of the anterior. The deeper parts of the periotic capsule are made of peculiarly dense bone and form a thin encasement to the various parts of the membranous labyrinth. This dense "bony labyrinth" is probably in some way of assistance in audition, as a similar though more extensive condensation of the periotic capsule occurs also in Mammals. The tympanic chamber is complicated by extension into irregular cavities and trabeculated spaces in the skull which possibly act as resonators, and usually the membrana tympani lies below the level of the skin, at the bottom of a short external meatus and is further protected by feathers or integumentary flaps.

E. 302. Skull of a Goose (*Anser ferus*), with the bony labyrinths and tympana exposed. On both sides the columella is shown, stretching from the tympanic membrane to the fenestra ovalis. On the left the relative positions of the fenestræ ovalis and rotunda can be seen at the base of the cochlea, and on the right the bony labyrinth has been opened and the contained cavities painted black to show the form and position of the cochlea and the position of the fenestra ovalis opposite its base. The anterior and posterior canals cross one another before entering the sinus superior utriculi, but much less so than in some Birds. O. C. 1581 D.

E. 302 a. The head of a Capercaillie (*Tetrao urogallus*) with the external meatus of either side opened from above. The skin that lines the posterior wall of this passage is loose, forming an irregular cushion, and is separated by a considerable space from the deeper tissues. This space and the deeper parts of the cushion are traversed by slender trabeculæ and are stated to be in connection with the arterial system. During courtship and especially when the beak is wide open at the termination of the nuptial song these spaces become gorged with blood. The cushion swells and completely blocks the meatus, rendering the Bird for the time absolutely deaf.

Upon the right side of the specimen the cushion is contracted, upon the left it has been artificially inflated.

v. Graff, Zeits. wiss. Zool., Bd. xli. 1885, p. 107.

E. 303. Right half of the head of an Owl (*Bubo bubo*) showing the auditory organ. In the Owls the membrana tympani is sunk below the surface of the head at the bottom of a deep external meatus, whose mouth is protected by overhanging integumentary lips bordered by a circlet of feathers. The tympanic membrane is very delicate and is connected to the internal ear by a slender columella. The foramen ovale, in which its foot is lodged, is shown in section. The bony labyrinth has also been exposed and opened. Bristles have been passed into the pharynx through the anterior parts of the Eustachian tubes and the single opening common to them.

O. C. 1581. *Hunterian.*

E. 304. The right half of the head of a Barn Owl (*Strix flammea*), in which the external auditory meatus has been opened from below by a horizontal section. The margins of the opening into the meatus are produced as fleshy lips which are bordered by a circlet of feathers: thus a structure is formed analogous to the pinna of Mammalia.

O. C. 1581 A.

E. 305. Anterior part of the head of a Rook (*Trypanocorax frugilegus*), with the bony labyrinths exposed and with bristles inserted into the Eustachian tubes. The anterior semicircular canal is very much longer than the posterior and crosses above it before opening into the sinus superior utriculi. The position of the openings of the canals into this sinus is thus the reverse of that normal for other classes—the anterior canal opening into the posterior part of the sinus, the posterior into its anterior part.

O. C. 1581 C.

E. 306. The right halves of the skulls of two Corvine Birds. In one the bony labyrinth has been fully exposed *in situ* with a portion of its inner wall removed. An isolated left labyrinth and columella auris are mounted separately.

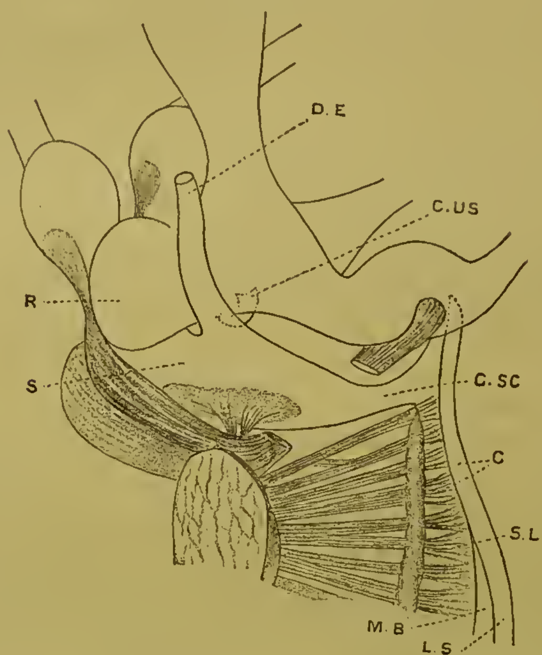
O. C. 1581 B.

MAMMALIA.

Middle and Internal Ear.

In all Mammalia, except Monotremes, the cochlea is much elongated and is twisted into a spire in which the number of coils varies considerably ($2\frac{1}{2}$, in Rabbit and Man, to nearly 5 in *Cœlogenys*). The thickened frame upon which the basilar membrane is stretched is transformed by this coiling from a circular or elongated oval form as seen in Amphibians, Reptiles and Birds to a spiral, its anterior and posterior sides forming respectively the lamina spiralis and ligamentum spirale of the

Fig. 41.



Part of the right membranous labyrinth of *Bos taurus* (fœtal), mesial aspect (after Retzius).

C. Cochlea. C.US. Canalis utriculo-saccularis. C.SC. Canalis sacculo-cochlearis (reuniens). D.E. Ductus endolymphaticus. L.S. Ligamentum spirale. M.B. Membrana basilaris. R. Recessus utriculi. S. Sacculus. S.L. Lamina spiralis carrying the rami basilares.

cochlea. The bony axis of the spire (Modiolus) consists mainly of the base of the lamina spiralis and gives passage to the cochlear branch of the auditory nerve. In all Mammals, even in Monotremes, the papilla basilaris, now known as the Organ of Corti, has a peculiar arrangement and differentiation of its histological elements, which is quite characteristic of the class, and is probably the structural expression of an increased sensitiveness to differences in rapidity of vibrations transmitted to it through the scalæ and basilar membrane*. The great

* Kretschmann, Arch. f. Physiol., Bd. cviii. 1905, p. 499.

development of the cochlea is accompanied by the loss of the lagena and macula lagenæ and of the macula neglecta. With these exceptions the rest of the labyrinth resembles in essentials that of lower forms, with however certain differences in detail, the most important of which are the length and narrowness of the canalis utriculo-saccularis and of the canalis reuniens. The labyrinth appears to differ relatively little in its general structure in such Mammals as have been examined *.

The tympanic apparatus is more specialised than in lower Vertebrates, the tympanum being enlarged by resonating air cavities, which either extend as irregular spaces into the substance of the mastoid part of the periotic bone (*e. g.* Man and Anthropoids) or occupy a "bulla" formed by the inflation of the tympanic or some other neighbouring bone of the skull, while the relatively simple columella is replaced by a chain of small ossicles, so hinged and attached together that each movement of the drum-membrane is reproduced in a diminished form at the fenestra ovalis. The membrana tympani, which may be set at various angles to the sagittal plane of the head, lies at the bottom of a deep meatus externus which in most cases is surrounded in its deeper parts by bone.

MONOTREMATA.

E. 307. The skull of a Duck-billed Platypus (*Ornithorhynchus anatinus*), in which the ventral wall of the right bony labyrinth has been removed to show the cochlea and the horizontal semicircular canal. The former is a short tube (about 6 mm. in length), of about equal diameter throughout, that runs forward in the petrous bone curving gently outwards for $\frac{1}{3}$ of a circle.

Examination of the membranous labyrinth (Pritchard) shows that the cochlea is essentially of the Mammalian type although "the acoustic apparatus of the organ of

* An excellent review of the whole question of the probable action of the various parts of the ear and particularly of the cochlea is given by M'Kendrick and Gray, in Schäfer's "Text-Book of Physiology," 1900, vol. ii. p. 1149, and an even fuller account with a more extensive bibliography of the subject will be found in "Die Lehren v. d. Funktionen der einzelnen Theile des Ohrlabyrinths," von Stein, trans. (German) C. v. Krzywicki, 1894.

Corti is not nearly so extensive as in typical Mammals nor do the various minute structures forming it appear to be so well developed." It however differs from the Mammalian cochlea in being coiled only at its tip, in being of nearly equal diameter throughout and in having at its apex a small lagena cochleæ.

Transferred from Osteol. Series, 3970.

Pritchard, Phil. Trans. vol. clxxii. 1882, p. 267.

E. 308. Skull of a Spiny Ant-eater (*Tachyglossus* [*Echidna*] *aculeatus*). Upon the right side the membrana tympani has been retained attached to the tympanic ring and malleus. It faces almost directly downwards. Upon the left the membrane has been removed to show the large tensor tympani muscle (painted red) passing directly outwards from the floor of the tympanum to the process by which the malleus is attached to the membrana tympani.

Transferred from Osteol. Series, 3957 A.

Peters, Monatsber. Ak. Wiss. Berlin, 1868, p. 779.

CETACEA.

John Hunter, Phil. Trans., vol. lxxvii. 1787, p. 430.

Beauregard, Jour. de l'Anat., T. xxx. 1894, p. 379, and T. xxix. 1893, p. 196.

E. 309. The organ of hearing of the left side of a Bottle-nose Whale (*Hyperoodon rostrata*) seen from the inner and lower aspect. The meatus auditorius externus is laid open throughout its whole length ; it is very narrow at its commencement where its lining membrane continues smooth for about an inch and a half (4 cm.) ; then the passage dilates a little and the orifices of many follicles analogous to the ceruminous glands, may be observed in it. Beyond this part the inner surface is slightly plicated longitudinally and afterwards is surrounded by a fibro-cartilaginous sheath and gradually expands to within an inch of the membrana tympani, where the cartilage terminates. Further on the passage again contracts to its termination, just before which it winds round a smooth mammilloid projection of the tympanic bone. The cavity of the tympanum is laid open showing its delicate lining membrane, the large tympanic plexus of vessels, and the strong triangular ligament which connects the membrana tympani with the malleus. The cut edge of the externally concave membrana tympani can be seen just below the mammilloid process of the tympanic bone. The cord of soft tissue issuing from the lower (anterior) part of the tympanic cavity is the end of the Eustachian tube. The petrous bone is preserved entire upon the right of the specimen. O. C. 1584. *Hunterian.*

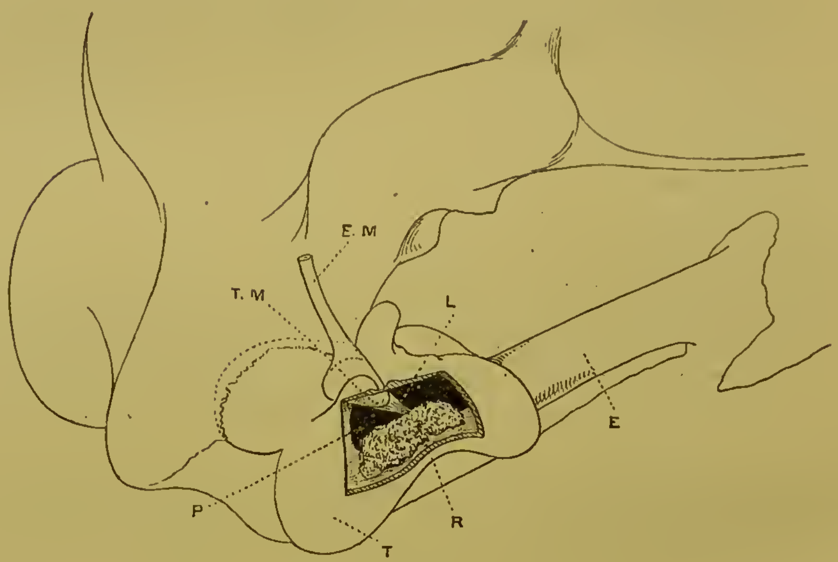
E. 310. Part of the nasal passage of the same Whale, including the opening of the Eustachian tube. The Eustachian tube is laid open to show its reticulated structure.
O. C. 1585. *Hunterian.*

E. 311. A similar specimen, showing the "termination of the Eustachian tube in a Whale." *Label* 1817.
O. C. 1586. *Hunterian.*

E. 312. Part of the head of a Porpoise (*Phocæna phocæna*), showing the auditory organ of the left side. The narrow winding external meatus is laid open from its small external orifice situated at a point about 4 cm. posterior to the eye to the tympanic membrane. The tympanum has been opened, showing the thick membrana tympani, the triangular ligament that connects it to the malleus, and the tympanic plexus of blood vessels. Bristles are passed from the tympanic cavity into the Eustachian tube and also into some of the sinuses described by Hunter (Phil. Trans., 1787, p. 431). These sinuses are filled with an Entozoon (*Strongylus minor*, Kuhn). The Eustachian tube, into which the stoutest bristle has been passed, is laid open through the greater part of its extent, showing the glandular structure of its pharyngeal end. Part of the skull wall has been removed to show the dense bony tympanic bulla and the petrous bone that contains the internal ear. The auditory nerve has been exposed.

O. C. 1582. *Hunterian.*

Fig. 42.



Right auditory organ of *Phocæna phocæna*, in position, lateral aspect.

E. Eustachian tube. E.M. External meatus. L. Ligament uniting tympanic membrane to malleus. P. Petrous bone. R. Rete. T. Tympanic bone. T.M. Tympanic membrane.

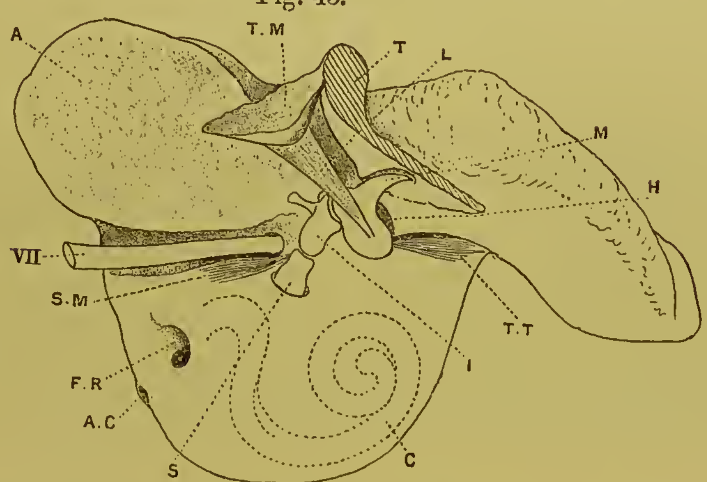
E. 313. Part of the floor of the cranium of a Porpoise (*Phocæna phocæna*), showing the right half of the nasal cavity. In the lateral wall of this, about 2 cm. in front of the hinder limit of the septum nasi, is a small orifice—the opening of the Eustachian tube. A bristle passed into this indicates upon the reverse of the specimen the continuity of the Eustachian tubes with certain sinuses described by Hunter (Phil. Trans. 1787, p. 431) in connection with the tympanum and Eustachian tube and compared by him with the guttural pouches of the Horse. The sinuses are infested by a number of thread worms (*Strongylus minor*).

O. C. 1587. *Hunterian.*

E. 314. The hinder part of the left side of the head of a Porpoise (*Phocæna phocæna*), showing the auditory organ *in situ* from in front and below. The specimen has been minutely injected and steeped in acid: the dense nature of the tympanic and especially of the petrous bone and the great amount of inorganic matter contained in them in comparison with the other bones of the cranium, is shown by their whiter and more chalky appearance. The cut edge of the tympanic plexus (*cf.* E. 309) can be seen in the groove between the tympanic and petrous bones. A black bristle has been placed in the wide Eustachian tube and into the internal meatus which is still filled by fibres of the auditory nerve. Upon the reverse of the specimen the narrow external meatus is shown, opened throughout its length; a bristle has been inserted into its orifice. O. C. 1588. *Hunterian.*

E. 315. Petrous and parts of the tympanic bones of the right side of a Porpoise (*Phocæna phocæna*), showing, from the

Fig. 43.



Right petrous bone and a fragment of the tympanic bone of *Phocæna phocæna*, lateral aspect.

A. Surface of articulation between petrous and tympanic bones. A.C. Aqueductus cochleæ. C. Cochlea. F.R. Foramen rotundum. H. Hollow lodging the swollen head of malleus. I. Incus. L. Ligament uniting tympanic membrane to malleus. M. Processus gracilis of malleus articulating with tympanic. S. Stapes. S.M. Stapedius muscle. T. Tympanic bone. T.M. Tympanic membrane. T.T. Tensor tympani. VII. The facial nerve.

ventral and inner aspect, the cavity of the tympanum and the ossicles with their ligaments and muscles. A small part of the membrana tympani is retained to show the strong triangular ligament (conspicuous for its glistening fibres) that connects its deep (convex) surface with the vestigeal manubrium of the malleus. From the apex of the blunt processus muscularis of the malleus a stout conical tensor tympani runs forward to the petrous bone. The articular surfaces of the malleus and incus have been slightly separated. The stapes can be seen extending from the incus to the fenestra ovalis, which lies at the bottom of a depression in the petrous bone. From the head of the stapes the stapedius muscle passes backwards and inwards to the petrous bone between the fenestra ovalis and fenestra rotunda.

The fenestra rotunda is divided transversely by a bony septum (*cf.* E. 324). O. C. 1590. *Hunterian.*

E. 316. A similar preparation of the right ear of a Porpoise, in which the form of the cochlea is displayed in addition to the parts shown in the preceding specimen. The scala tympani has been opened throughout its whole length from the fenestra rotunda showing the mode of coiling of the cochlear canal and scala vestibuli. These upon leaving the vestibule bend at first outwards in a left-handed direction and then suddenly inwards to form a right-handed spire of two and a half turns. O. C. 1591. *Hunterian.*

E. 317. The tympanum and labyrinth of the left ear of the same Porpoise, similarly prepared.
O. C. 1592. *Hunterian.*

E. 318. The right ear of a Dolphin (*Delphinus tursio*), dissected in a similar way to show the tympanum with the membrana tympani and the ossicles and their muscles, and parts of the internal ear. The general arrangement is similar to that seen in the Porpoise. The root of the auditory nerve has been exposed in the modiolus as far as the first turn of the lamina spiralis. O. C. 1593. *Hunterian.*

E. 319. The left internal ear of a Dolphin (*Delphinus tursio*), showing the cavities occupied by the semicircular canals and the cochlea. The canals have the same disposition as in other Mammals, but their size in proportion to the cochlea is much less. O. C. 1594. *Hunterian.*

E. 320. The right tympanic bone, with part of the fatty substance in which it is imbedded, of a Piked Whale (*Balænoptera acuto-rostrata*). The fatty tissue has been removed from the outer surface of the bone : the opposite involuted part is covered by a dense membrane continuous with the lining of the tympanum.

At the upper (anterior) end of the elongated fissure that leads into the cavity of the tympanum, the deep end of the external meatus and the membrana tympani are preserved. The latter, which has been slit along one side, is "projecting, and returns back into the meatus for above an inch in length, is firm in texture with thick coats, is hollow on its inside and its mouth communicating with the tympanum" (Hunter, Phil. Trans. 1787, p. 434).

O. C. 1596. *Hunterian.*

F. 321. The mass of fatty tissue that surrounds the tympanic bone, from the same Whale. O. C. 1597. *Hunterian.*

E. 322. The pouch-like membrana tympani of a Rorqual (*Balænoptera borealis*). From an animal taken in the River Crouch, Essex (Flower, Proc. Zool. Soc., 1883), 28 ft. 5 in. (8·66 m.) in length. O. C. 1598 c.

E. 323. A small portion of the tympanum of a young Whalebone Whale (*Balæna* sp.) including the membrana tympani and a part of the external meatus. The membrana tympani is attached in an elliptical form to the tympanic bone and bulges outwards in the form of a pouch into the external meatus.

The outer layer of the membrana tympani which is continuous with the lining of the meatus is in part removed, and in the same way a portion of the inner layer, which is continued from the lining of the tympanum, has been reflected, leaving the intermediate or proper layer of the membrana isolated and showing very clearly its fibrous structure. O. C. 1598 A.

E. 324. Left petrous bone and ossicula auditûs of the same animal seen from the ventral surface, with the posterior extremity to the right. The ossicles lie in their natural position, but the malleus has been detached from the tympanic bone. The tensor tympani and stapedius muscles can be seen passing respectively from the blunt processus muscularis of the malleus forwards and from the head of the stapes backwards and inwards to the petrous bone. Dorsal to the articulation between the incus and stapes lies the facial nerve. The triangular piece of cartilage in connection with the posterior part of the petrous bone (Home, Lectures, Pl. C, *n.*) is probably the upper end of the anterior cornu of the hyoid. The foot of the stapes and the fenestra ovalis are hidden behind the prominence of the petrous bone that contains the cochlea. The fenestra rotunda can be seen at the base of the scala tympani. It is closed by a membrane and is not divided by a transverse septum as in the Dolphins (E. 315). Both the scalæ of the cochlea and the intervening lamina spiralis are exposed in part of their gyrations, and the acoustic nerve is preserved where it enters the meatus auditorius internus. This specimen is figured by Home, Lectures on Comparative Anatomy, 1823, Pl. CI. O. C. 1598 B.

UNGULATA.

E. 325. Cranium of a Hyrax (*Procavia capensis*), showing on either side of the basioccipital below the otic region of the skull, a thin-walled membranous dilatation of the Eustachian tube. That on the right side has been cut open.

O. C. 1170 A *o*.

Peter, Arch. f. mikr. Anat., Bd. xliii. 1894, p. 359.

E. 326. Hinder part of the cranium of a Tapir (*Tapirus americanus*), showing from the ventral aspect a pair of membranous dilatations of the Eustachian tubes similar to those seen in the previous specimen. They are large and of irregular form, and occupy the space between the skull, the greater cornu of the hyoid, and the pharynx wall, meeting one another in the ventral mid-line. The dilatation on the left side has been opened and blue rods have been inserted into the pharyngeal openings of the Eustachian tubes. O. C. 1170 A *n*.

Peter, *l. c.*, p. 354.

E. 327. Posterior part of the left side of the head of an Ass (*Equus asinus*), showing from the mesial aspect, the dilated Eustachian tube and its opening into the hinder part of the nasal passage. This opening (indicated by a blue rod) has the form of a long oblique slit in the outer wall of the nasal passage. Its upper lip protrudes somewhat and forms a valve by which the orifice can be closed. Some 2 or 3 cm. from the pharyngeal opening the Eustachian tube dilates to form a large membranous sac (air-sac, guttural pouch) similar to those seen in the two previous specimens, and like them occupying a position between the floor of the skull, the pharynx wall, and the great cornu of the hyoid.

Above the anterior part of this dilatation, and in close contact with it, is a backwardly directed diverticulum of the nasal cavity. O. C. 1170 A *l*.

John Hunter, Essays and Observations, edit. R. Owen, vol. ii. 1861, p. 159.

Peter, *l. c.*, p. 328.

E. 328. The right Eustachian tube and neighbouring parts from the same animal, with the inner wall of the guttural pouch removed. A blue rod has been inserted into the tube and through the tympanum into the external meatus. The partial separation of the guttural pouch into an external and an internal chamber by the cornu of the hyoid is shown.

The function of the dilatations found upon the Eustachian tubes of some few Mammals has been the subject of many speculations, but at present without much result. They have been thought, amongst other things, to be resonating chambers to enforce or give some special tone to the voice, or to be a mechanism for ensuring a constant supply of warmed air to the tympanum, or to be a resonating chamber or microphone in which sounds too delicate to directly affect the drum are magnified and thus made audible. The latter suggestion harmonizes with the great keenness of hearing observed in the animals in which these dilatations occur. O. C. 1170 A *m.*

Peter, *l. c.*, p. 364.

RODENTIA.

E. 329. The cranium of a Jerboa (*Dipus sagitta*), showing the great bullate expansions of the tympanic cavities. These have the same form and position as in the Chinchilla shown and described in A. 198. Upon the right side the membrana tympani is preserved with the attachment of the malleus. On the left the tympanic chamber is laid open and the ossicula and cochlea exposed. The latter makes three entire turns and a half.

O. C. 1599. *Hunterian.*

CARNIVORA.

E. 330. A portion of the cranium of a young Lion (*Felis leo*) including the organ of hearing of the left side. The anterior wall of the external meatus and tympanum have been removed to show the membrana tympani (convex internally as in most Mammalia), with the handle of the malleus attached to it. A slit-like opening in the posterior wall of the tympanum leads into the enlarged tympanic bulla. The entry of the Eustachian tube into the anterior and inner part of the tympanum is also shown in section (*cf.* A. 201). O. C. 1600. *Hunterian.*

PRIMATES.

E. 331. The bony parts of the ear of a Fœtus, from both sides. The upper specimen shows the right squamosal and tympanic bones from within, with the membrana tympani and ossicula retained in their natural positions. Below is a similar specimen of the left ear without the membrana tympani and with the addition of the periotic bone. The cavities in the latter occupied by the cochlea and the semicircular canals have been partially opened. O. C. 1602 B.
From the Museum of Sir Astley Cooper.

E. 332. Skull of a Fœtus at the ninth month, showing upon the right side the membrana tympani and upon the left the cavity of the tympanum and the ossicula auditûs *in situ.* The tympanic membrane is almost horizontal in position. It is bordered by the horseshoe-shaped tympanic annulus, which is not yet of sufficient size to form a bony meatus.
O. C. 1602 B *a.*

E. 333. A horizontal section of part of a Human head, including the organ of hearing of the right side. The external meatus is laid open from above throughout its whole length, showing its direction and structure, and the oblique position of the membrana tympani facing outwards, downwards and slightly forwards. The cavity of the tympanum is also exposed with the ossicula retained in their natural positions. A large bristle is passed between the malleus and the processus longus of the incus, and a smaller one through the foramen of the stapes. The section also exposes part of the vestibular cavity, leaving entire the periosteal membrane covering the fenestra ovalis against which the foot of the stapes is applied. Portions of the cavities that enclose the semicircular canals are laid open together with the mastoid cells. O. C. 1601.
Hunterian.

E. 334. A vertical section of the left ear of the same head seen from behind. The section passes through the external

meatus, the tympanum, the vestibule and the internal meatns. The membrana tympani is shown more clearly than in the previons specimen. The eavity oecupied by the posterior semieireular eanal and its eonnection with the vestibnle are indieated by a blaek bristle. The auditory nerve is shown in the internal meatus. O. C. 1602.
Hunterian.

E. 335. The right tympanie bone with the eavity of the eoehlea opened and with the ossieles exposed in their natural position. O. C. 1602 A.

E. 336. Part of the hinder end of the nasal passage showing from below the lower extremities of the Eustaehian tubes and their openings into the nasal eavity. O. C. 1604.
Hunterian.

External Ear.

Sehmidt, Vergl.-anat. Untersueh. ü. d. Ohrmusehel, Berlin, 1902.

Baum u. Kirsten, Anat. Anzeig., Bd. xxiv. 1903, p. 33 (*muscles*).

The hinder and mesial margins of the opening into the external meatus are usually produeed to form an external ear or pinna, whieh when highly developed is trumpet-shaped and eapable of voluntary movements in different direetions. Its eavity ean thus be turned towards the point from whieh a sound proeeeds and it aets both as a eolleetor of sound vibrations and an instrument for locating their souree. In many Mammals, particularly in burrowing and aquatie speeies, the pinna is almost or quite absent, and in all groups its form and degree of development varies eonsiderably.

In the following deseriptions the different parts of the external ear and its supporting cartilages are named so far as possible in aceordanee with the usage of Human Anatomists, but as the external ear of Man is degenerate, a named diagram of the cartilages of the ear of a Fallow Deer (E. 358) is given here to assist in eomparison :—

Fig. 44.

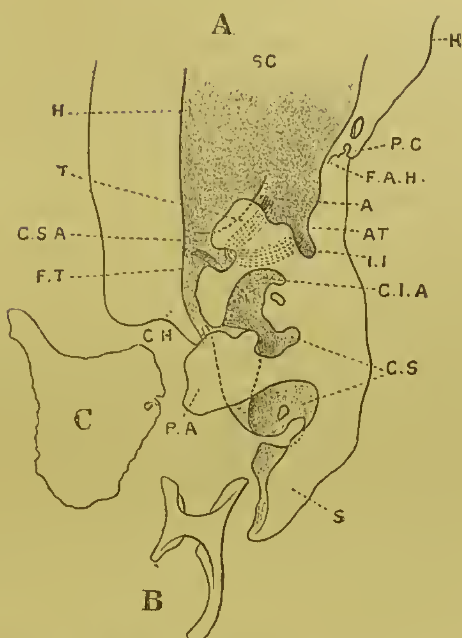


Diagram of ear cartilages of *Cervus dama.*

A. Proximal part of cartilage of pinna and concha.
B. Annular cartilage.
C. Scutellum.

A. Antihelix. A.T. Antitragus. C.H. Crus helicis. C.I.A. Crus inferius antihelicis. C.S. Clefts of Santorini. C.S.A. Crus superius antihelicis. F.A.H. Fissura antitrago-helicina. F.T. Fossa triangularis. H. Helix. I.I. Incisura intertragica. P.A. Processus aboralis. P.C. Processus caudatus. S. Styloid process. SC. Scapha. T. Tragus.

The part of the external ear distal to the meatus is termed the pinna. Its edge whether inturned or not is the helix. From this edge to the transverse ridge which represents the antihelix is the scapha. The base of the pinna between the antihelix and the meatus is the concha, forming a sort of vestibule to the meatus. Its hollow is the cavitas conchæ and the corresponding convexity on the mesial surface, the eminentia conchæ. The lower mesial part of the conch cartilage continues along the inner and posterior wall of the meatus and gives off a series of flat processes for the support of its outer wall. These are followed by a completely separate annular cartilage and represent rings which may be completely independent but here are partly fused together. The spaces between them form the clefts of Santorini.

The muscles proper to the pinna can be divided into two sets—extrinsic and intrinsic. The extrinsic consist of adductors inserted upon the anterior border of the pinna (attrahentes hom.), levators inserted upon its median surface (attollens hom.), abductors inserted upon its hinder and deep mesial parts (retrahentes hom.), a depressor inserted upon the antitragus, rotators passing backwards around the median surface to its hinder part, and a curious and variable muscle, the tragicus major, which passes upwards from the zygoma or some neighbouring part of the skull to the conch near the anterior edge of the tragus. In addition to these truly auricular muscles, there are several thin sheets (scutularis) that converge from the frontal and parietal parts of the skull to a loose plate of cartilage (scutellum) that lies in front of the pinna and serves as a point of origin for the adductors and certain other of the true extrinsic muscles. The intrinsic muscles are not so important as the extrinsic and are in lower Mammals essentially similar to those of Man. Among the following preparations of the auricular muscles, the specimen of the Dog has been described in detail to act as a standard of comparison for the rest.

MONOTREMATA.

E. 337. Right half of the head of a Duck-billed Platypus (*Ornithorhynchus anatinus*), showing the external auditory meatus. The meatus is of great length, and passes downwards and backwards from the external aperture, which is flush with the general level of the skin, to the point of the jaw, round which it curves inwards and forwards to reach the tympanic membrane. The whole length of the meatus is enclosed in a scroll-shaped sheet of cartilage which expands slightly near the external opening to form a small vestibule.

Ruge, Morph. Jahrb., Bd. xxv. 1898, p. 214.

E. 338. Right side of the head of a Spiny Ant-eater (*Tachyglossus* [*Echidna*] *aculeatus*), with the skin partly raised to show the external meatus and the muscles in connection with it. The meatus, which is in no part bony, is very long and assumes a twisted course between the external opening and the tympanic membrane, passing successively forwards, transversely inwards, backwards, and again forwards. Close within the external orifice it is spaceous forming a funnel-shaped vestibule comparable to the concha of other Mammals. Beyond the concha the tube gradually decreases in calibre towards the tympanum and is supported and kept open by a longitudinal strand of cartilage from which on either hand lateral processes are given off having the appearance of tracheal rings. The longitudinal cartilage is continuous distally with an expanded trumpet-shaped plate that supports the concha. The tympanic end of the meatus has been opened from below to show the tympanic membrane through which a bristle has been thrust along the Eustachian tube.

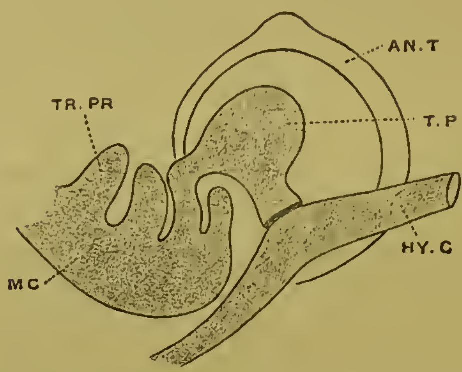
The concha is surrounded by powerful cutaneous muscles. One of these—a conspicuous bundle that passes backwards from the maxilla over the external surface of the conch—is attached in passing to its outer and anterior part, forming what resembles in many ways a combination of adductor externus and depressor conchæ. Inserted upon the mesial surface of the conch is a large and very definite levator auris that arises from the deeper parts of the skin in the mid-line behind the head. O. C. 1609 A *a*.

Ruge, Morph. Jahrb., Bd. xxv. 1898, p. 220 (*meatus*); also, Semon's Zoolog. Forschungsreise in Australien, Bd. ii, 1894–97, p. 144 (*muscles*).

E. 339. The left meatus of a smaller individual with the cartilages exposed, showing the transverse processes given off from the longitudinal cartilage of the meatus and the continuity of the latter with the anterior wing of the expanded cartilage of the conch. The large external orifice of the meatus is vertically lengthened and is bordered by a thickened fold of skin which is especially prominent along the posterior and upper margin, though not distinct enough to form a pinna.

E. 340. Parts of the skull of a Spiny Ant-eater (*Tachyglossus aculeatus*), showing a connection between the anterior hyoid cornu and the cartilage of the external meatus.

Fig. 45.



Connection between the hyoid cornu and meatal cartilage of *Tachyglossus aculeatus*.

AN.T. *Annulus tympanicus*. HY.C. Hyoid cornu. M.C. Longitudinal part of meatal cartilage. TR.PR. Its transverse processes. T.P. Tympanic plate.

The cornu, as it passes the tympanic annulus, gives off a process from its anterior border that expands to form a small plate (tympanic plate) situated directly ventral to the membrana tympani and continuous by its outer parts with one of the transverse processes of the longitudinal cartilage of the meatus. In this specimen the tympanic plate does not form a single piece with the cornu of the hyoid, but is jointed to it by the intervention of a thin layer of connective tissue.

Upon the left a bristle has been passed between the tympanic plate and the membrana tympani. On the right the tympanic plate is separated from the hyoid cornu.

This connection between the hyoid arch and the cartilage of the meatus has been thought to indicate that the latter is a derivative of the hyoid arch.

Ruge, Morph. Jahrb., Bd. xxv. 1897, p. 204.

MARSUPIALIA.

E. 341. Part of the skull with the cartilages of the left pinna o' a Bandicoot (*Peragale lagotis*). The cartilage of the conch and scapha is trumpet-shaped and is quite separate from the ring-like cartilages that support the meatus. The border of the helix is comparatively plain and is not inturned. It has apparently (*cf.* Kangaroo, E. 343) two crura—the outer of which forms a flat plate overlying the tragus and the inner is represented by a thin lamina that passes almost directly inwards into the cavity of the conch from the base of the outer crus. It is perforated by an aperture which in the natural state is filled by muscle tissue. Above and nearly parallel to the inner crus helicis is another thin lamina which is possibly the antihelix. By comparison with the Kangaroo it seems that the posterior border of the aperture of the conch is not formed by the antitragus but by an upward extension of the tragus to the processus caudatus. The true antitragus may, however, be represented by a vertical lamina projecting from the posterior wall of the pinna into the cavity of the conch. The posterior end of the lower border of the tragus gives off a long slender process, which probably corresponds to a much larger though similar bar in the Kangaroo, which supports the hinder part of the meatus. The cartilage of the scapha, as in the case of most large pinnæ, is irregularly perforated by holes.

The most distal of the three half rings that support the meatus is partly double, forming a single plate in front, but bifid behind. The two proximal half rings are single. There is no bony meatus. O. C. 1609 B A.

E. 342. The right ear of an Opossum (*Didelphys marsupialis*). The pinna is large, thin and leaf-like with bluntly rounded apex. The lower anterior border of the helix is inturned and divides below to form inner and outer crura. The inner crus continues the helix into the cavity of the conch. The outer crus projects from the convexity of the inturned border of the helix and joins the tragus to form the lower edge of the aperture of the conch. The antitragus is forked to form outer and inner crura. O. C. 1609 B.

E. 343. Part of the skull, with the ears, of a Black-faced Kangaroo (*Macropus melanops*). Upon the left side the cartilages of the pinna and meatus have been exposed. In spite of minor differences these compare well with those of *Peragale*. The anterior border of the helix is inturned at its lower end and has two clearly defined crura—an inner continuing the edge of the helix into the cavity of the conch, and an outer projecting outwards and downwards from the convexity of the helix-scroll to the anterior end of the tragus. Two low transverse ridges between the scapha and concha probably represent the antihelix. The antitragus is slight and is overhung by a very prominent processus caudatus of the posterior expansion of the scapha. A well defined thickened ridge continues the antitragus upwards and separates the main part of the scapha from its posterior expansion. The tragus bears upon its lower border a broad process which is united at its extremity with the first half-ring of the meatus (processus aboralis intermedius). The proximal half-ring of the meatus is free. There is no bony meatus.

Upon the right side the skin has been retained upon the pinna and several of the ear-muscles have been exposed. The most remarkable of these is a large sheet of muscle (A) that covers the mesial and posterior surface of the conch, it seems to represent a combination of the levator and abductor longus of the more typical arrangement. The other letters on the specimen signify the following muscles :—B. levator medius, C. levator brevis, E. adductor superior, F. adductor inferior, G. helicis, H. depressor conchæ, I. antitragicus. Between the levator medius and the adductor inferior lies a strong adductor medius passing downward and inwards from the fascia that represents the scutellum to the conch, and below the inferior adductor, between the meatus and the skull can be seen part of a peculiarly large tragicus major. This when entire consists of two parts—one inserted upon the skull above the temporo-maxillary joint, the other inserted by a long slender tendon to the mandible.

E. 344. The ears of a Native Bear (*Phascolarctus cinereus*). The right pinna is mounted below, hidden by the thick bushy fur that covers its outer surface and margins, above is the left ear with the hair clipped short to show its general form. It is short, erect, rather wider above than below and truncated at its apex. The prominences around the opening into the concha can be compared with those in the Opossum's ear, though their form and relative proportions are different. The inner crus of the antitragus is more conspicuous and encloses a deep upwardly directed pocket between itself and the wall of the conch. The outer crura of the helix and antitragus are very slight.

O. C. 1609 B *b*.

Presented by J. Abrahams, Esq.

EDENTATA.

E. 345. The ear of a Great Anteater (*Myrmecophaga jubata*) with the hair clipped close to show its small size, stoutness, and short rounded shape. O. C. 1609 D.

E. 346. The skin of the left side of the head of a Manis (*Manis longicauda*). There is no pinna. The opening to the external meatus is a long vertical slit, overlapped posteriorly by a thickened fold of skin. Compare with *Mydaus* and *Echidna*. O. C. 1609 E.

CETACEA.

E. 347. Part of the skin of the head of a Dolphin (*Delphinus tursio*) showing the external aperture and commencement of the external auditory meatus. The minute opening is situated behind the posterior angle of the eye and leads into a narrow tube enveloped in subcutaneous fat and with its walls stiffened by cartilage. The passage is large enough to admit an ordinary bristle only. There is no vestige of a pinna. The auditory aperture of *Platanista gangetica* is shown in E. 1147, in *Phocæna* in E. 312, and in *Hyperoodon* in E. 309. O. C. 1609 C.

Presented by F. T. Buckland, Esq.

E. 348. Part of the meatus auditorius externus of a Dolphin (*Delphinus tursio*). O. C. 1583. *Hunterian.*

UNGULATA.

HYRACOIDEA.

E. 349. The right ear of a Hyrax (*Procavia capensis*). The pinna is small and bluntly rounded at the apex. The anterior border of the helix is slightly inturned and is continuous below with the tragus. The cavity of the conch is separated from the scapha by a pair of prominences, one of which commences under the anterior inturned border of the helix, and runs backwards to meet the other which passes in the opposite direction from the antitragus. O. C. 1618 B.

PROBOSCIDEA.

E. 350. The cartilage of the pinna of an Elephant (*Elephas indicus*). It forms a plate of irregular form continuous and fairly thick in its proximal parts, but thinning out towards the margin and perforated here by holes of different sizes which at the extreme edge run together, leaving an irregular fringe of cartilage bars. O. C. 1618 A.

E. 351. The right pinna of a fœtal Indian Elephant (*Elephas indicus*) with the cartilage laid bare and some of the muscles shown. Upon the outer face may be seen: a large adductor superior, arising from the surface of the fibrous scutellum and inserted upon a ridge that forms the anterior lip of the apertura conchæ; the helicis and tragicus minor, which together form a thin sheet covering the outer surface of the meatus up to the border of the apertura conchæ; the depressor conchæ lying posterior to the meatus and inserted into the lower edge of the posterior expansion of the scapha. Between ~~the~~ adductor superior and the meatus lies a cylindrical muscle that runs from the deep end of the meatus to the base of the anterior surface of the conch. This is apparently the tragicus major.

Upon the reverse of the specimen the insertions of several muscles are shown. These are the levators and abductors, but in the condition of the specimen it is not wise to attempt any detailed comparison with those of other Mammals. In this view also can be seen a muscle (rotator auris or adductor medius) that passes backwards from the deep surface of the scutellum to the convexity of the conch; and between two of the insertions in the mid-line of the pinna are traces of a considerably developed transversus auris. O. C. 1618 A *a*.

Miall & Greenwood, Jour. Anat. & Physiol., vol. xii, 1878, p. 388.

PERISSODACTYLA.

E. 352. The cartilages of the right ear of a Horse (*Equus caballus*). The pinna is trumpet-shaped with long narrow pointed scapha. The anterior border is inturned below and continued into the cavity of the conch as the inner crus helicis. There is also a well marked outer crus helicis projecting from the convexity of the inturned helical border and covering the greater part of the tragus. This crus probably represents the spina helicis of man. It gives attachment to the superior adductor. The tragus is formed by the broadened end of the most distal of the half-rings that support the meatus. It is separated by a gentle depression from the antitragus. This latter prominence is formed by an inturning of the border of the apertura conchæ between the processus helicis caudatus and the incisura intertragica. In this case, however, it does not as usual support part of the actual edge of the apertura conchæ but projects into the cavity of the conch, the margin of whose aperture is formed by a band of cartilage that bridges over the incisura antitragico-helicina from the processus caudatus to the hinder limit of the incisura intertragica in a manner somewhat similar to that seen in *Peragale*. Below the tragus the cartilage of the meatus gives off anteriorly another broad process (processus aboralis intermedius), and is prolonged proximally in the form of a style (processus aboralis proximalis). The deep end of the meatus is supported by an annular cartilage which is quite independent and encircles the outer three-fourths of the tube. Deep down within the cavity of the conch is a transverse ridge that probably represents the antihelix.

In front of the ear, attached to it by the adductor superior, is a triangular plate of cartilage—the scutellum. This serves as a point of insertion and origin for certain skin muscles of the head (scutulares) and extrinsic muscles of the ear.

Schmidt, Vergl. anat. Untersuch. über d. Ohrmuschel versch. Säugethiere, 1902, p. 28.

E. 353. The cartilages of the right ear of a Horse (*Equus caballus*). O. C. 1617. *Hunterian.*

E. 354. The left ear of a Horse (*Equus caballus*), showing upon the convex surface of the concha, a mass of fat. This is always present even in individuals that have died of starvation and probably acts as a lubricant in the movements of the ear. O. C. 1617 B.

Presented by Prof. McFadyean.

E. 355. The cartilages of the left ear of an Ass (*Equus asinus*). O. C. 1618. *Hunterian.*

ARTIODACTYLA.

E 356. The right ear of a Peccary (*Tayassu tajaçu*). The pinna has a simple form, with broad base and pointed apex, and shows but slight indications of tragus and antitragus upon the borders of the apertura conchæ. The anterior border of the helix is strongly inturned, and within the cavity of the conch deep down towards the meatus can be seen a sharp crescentic fold enclosing an upwardly directed pocket. This is probably the inner crus helicis. In the hollow of the scapha are three longitudinal folds of the skin (plicæ auriculares longitudinales). O. C. 1618 C.

E. 357. The right ear of a Water Chevrotain (*Dorcatherium aquaticum*). The pinna has a simple bluntly rounded form, with very slight prominences upon its inner surface or around the margins of the conch aperture. Between the scapha and concha are two transverse folds. The lower of these, which is the most prominent, lies above the inner crus helicis and is probably the antihelix. The upper one is probably an integumentary fold merely, similar to the plicæ longitudinales seen in the previous specimen.

O. C. 1616 A.

Presented by Staff-Surgeon Thomas.

E. 358. The cartilages of the left ear of a Fallow Deer (*Cervus dama*). The pinna and external end of the meatus are supported by a long trumpet-shaped scroll of cartilage (the scapha and concha), similar in general form to that of the Horse. The anterior border of the helix is internal at its lower end forming a crus, but is not bifid as in the Horse. The antitragus resembles that of the Horse, but is not obscured by the filling in of the incisura intertragica. The tragus is formed as usual by the process representing the upper half-ring of the meatus. It is followed by two similar processes, the last of which corresponds to the base of the styloid process that projects down from the main cartilage in the Horse. In the cavity of the conch is a prominent transverse ridge representing the antihelix. The annular cartilage and scutellum are attached to the lower parts of the preparation. O. C. 1615. *Hunterian.*
Schmidt, *l. c.*, p. 32.

E. 359. A similar specimen of the proximal end of the cartilages of the right ear of the same animal. O. C. 1616.

Hunterian.

E. 360. The hinder part of the head of a Sheep (*Ovis aries*) with the muscles of the ears shown. On the right most of those belonging to the superficial layer have been cut and turned aside. The extrinsic muscles of the ear are very powerful and provide for the most varied movements. The most important are marked by letters as follows :—A. fronto-scutularis, B. levator medius, C. adductor superior, D. adductor externus, F. depressor conchæ, G. abductor longus, H. abductor brevis, I. levator longus, K. rotator auris, O. tragicus major. In addition to these there is a well marked levator brevis passing from the scutellum beneath the adductor superior to the median surface of the conch distal to the insertion of the levator longus. There is also a well defined though small adductor medius (best seen on the right side) which passes from the posterior edge of the scutellum across the deep surface of the levator brevis to the anterior edge of the helix under cover of the adductor superior. Broadly speaking, the adductors and the levator brevis correspond to the attrahens hom., the levators to the attollens hom., and the abductors to the retrahentes hom. In comparison with the Dog the size of the muscles is remarkable, and there are also many minor differences. A levator brevis is not present in the Dog, but is well developed in the Sheep. The adductor inferior of the Dog is represented in the Sheep by an adductor externus arising from the zygoma, not from the scutellum. The abductor is very much larger in the Sheep than in the Dog and arises to a great extent from the deep surface of the abductor longus. Its insertion extends around the anterior mesial and posterior surfaces of the base of the conch. The tragicus major of the Sheep is stouter and shorter than that of the Dog and takes origin from the base of the zygomatic process above the temporo-maxillary joint.

Baum u. Kirsten, Anat. Anzeig., Bd. xxiv. 1903, p. 33.

RODENTIA.

HYSTRICOMORPHA.

E. 361. The right ear of a Coypu Rat (*Myocastor coypus*). This is a small rounded ear with a greatly extended posterior and lower border. The anterior border of the helix is strongly inturned. The tragus and antitragus are not prominent. The entry to the meatus is protected by tufts of hair. O. C. 1614 B.

E. 362. The left ear of *Capromys pilorides*. The pinna is somewhat more pointed than in the Coypu. The anterior margin of the helix is strongly inturned, and there is a well developed crus helicis passing inwards towards the meatus. The tragus and antitragus are strongly marked, and between the latter and the expanded posterior border of the scapha is a distinct indication of a sulcus auris posterior (*cf.* Lemurs and Apes). O. C. 1614 D.

E. 363. The left ear of a Porcupine (*Hystrix javanica*). The pinna is small, erect, with a thickened, but not inturned, anterior border. The crus helicis passes deeply into the concavity of the conch ; just above it, is a rounded prominence that probably represents the crus antihelicis. The tragus and antitragns are well defined and are separated by a peculiarly deep and narrow incisura. The sulcus auris posterior is large and deep. O. C. 1614 C.

E. 364. Skin of the head of Cuvier's Chinchilla (*Lagidium cuvieri*) showing the external ears. They are larger and more membranous than in the foregoing Rodents. The general form is elongated, widening slightly towards the rounded tip. The anterior border of the helix is slightly inturned and is continuous ventrally with a very prominent and narrow crus that dips into the concavity of the concha. The tragus is scarcely perceptible, but the antitragus is very large and has the appearance of a flap of skin forming the anterior lip of a deep pocket—the sulcus auris posterior (?). A slight transverse ridge above the crus helicis is probably to be regarded as an antihelix.

O. C. 1614 D*a*.

Presented by Mr. S. Epprett.

E. 365. The right ear of a Viscacha (*Viscaccia maxima*). In its general form the pinna is very like that of a Pig, with straight anterior border inturned for nearly its whole length, pointed apex and broadly expanded posterior border. The outer crus helicis passes external to the tragus, separated from it by a deep sulcus auris anterior.

The inner crus is hidden by a tuft of hair. The tragus and antitragus are prominent and are separated by a deep and narrow incisura. The sulcus auris posterior is very extensive but otherwise resembles that of *Lagidium*.

O. C. 1614 A.

E. 366. The right ear of a Patagonian Cavy (*Dolichotis magellanica*). The pinna is large and closely resembles that of *Lagostomus* in general form; its anterior border is strongly inturned and originates below in a double inner and an outer crus. The latter is separated from the tragus by a well marked sulcus auris anterior. The chief limb of the inner crus continues the inturned edge of the helix into the conch; below it, above and behind the tragus, is another very sharply-marked crescentic fold, which appears to be a second limb to the inner crus helicis. The incisura intertragica is deep and narrow. The helix posterior to the antitragus is broad, but shows no indentation that can be considered a sulcus posterior comparable to those of *Lagostomus* and *Lagidium*. Above the inner crus helicis is a prominent transverse fold, probably the antihelix.

O. C. 1614 E.

LAGOMORPHA.

E. 367. The left pinna of a Rabbit (*Lepus cuniculus*), injected and with the hair removed. O. C. 1614. *Hunterian*.

E. 368. The cartilages of the right ear of a Rabbit (*Lepus cuniculus*). The concha is peculiarly long. The anterior border of the helix is strongly inturned, and in its lower part unites with the tragus to support the tragal prominence upon the margin of the entry to the concha. The tragus is remarkable for its length. Distally it is forked, one fork being applied to the anterior inturned helix, the other in a similar way to the posterior inturned helix or antitragus. Above the antitragus is a deep incisura antitragica helicina overhung by a pronounced processus caudatus. The meatus is supported by ~~two~~ half-ring~~s~~ partially con-
one

tinuous with the lower border of the tragus and by a free annular cartilage. There are no prominences between the scapha and the concha.

E. 369. The right side of the head of a Hare (*Lepus europæus*) with the muscles of the pinna shown. The several muscles have been lettered as in the preparation of those of the Dog (E. 379). The adductor inferior (D) (Krause's scutulo-auricularis superior posterior) is of very great size; beneath its upper end can be seen the extremity of the helicis major (tragicus major, Krause). The tragicus major (O) takes origin from the posterior process of the zygoma. There is apparently no adductor medius or adductor externus. The other muscles marked are A. fronto-scutularis, A.′ scutularis intermedius, C. adductor superior (scutulo-aur. sup. ant., Krause), F. depressor conchæ (parotideo-auric. ant. & post., Krause).

Krause, Anat. des Kaninchen, 1868, p. 133.

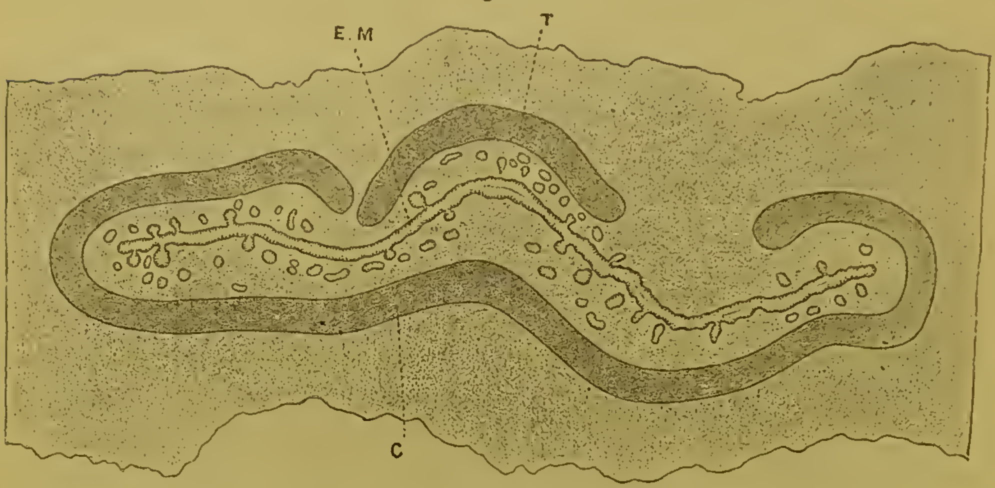
E. 370. Part of the head of a Hare (*Lepus europæus*) seen from the dorsal aspect to show the levator and abductor muscles of the ear and the several divisions of the scutularis. The transverse part of the scutularis is divided into two layers marked A′ and A″. The cervico-scutularis is small and forms a thin fan-shaped muscle converging from the ligamentum nuchæ to the hinder edge of the scutellum. The levators are represented by a levator longus (cervico-auric., Krause) (I) and a small levator brevis lying between it and the adductor superior (C). The abductors (G, H) (occip. auric. & helico-occip., Krause), and the rotator auris (K), are not in any way remarkable.

E. 371. Part of the skull and left ear of a Rabbit (*Lepus cuniculus*), with the superficial auricular muscles removed to show the helicis major (N) and the tragicus major. The latter consists of two parts: the first (O) (Krause's max. auric.) corresponds very closely to the tragicus major of the Sheep (E. 360) and runs from the posterior process of the zygoma to the hinder mesial edge of the pars anterior helicis;

the other (O′) (temporo-auric., Krause) lies upon the convexity of the inturned anterior part of the helix and passes thence to the upper border of the bony meatus.

E. 371 a. The head of a young Rabbit (*Lepus cuniculus*), one day old, showing the pinnæ. The lumen of the external meatus at this age is completely closed by the apposition and continuity of the lining epithelium. The position of the future

Fig. 46.



Transverse section through the upper part of the external meatus of a Rabbit, one day old.

C. Cartilage of the conch. E.M. Fused epidermal lining of the meatus. T. Cartilage of the tragus.

entry to the conch can, however, be traced by a narrow **V**-shaped line upon the lateral surface of the ear, bordered externally by thickened lips, that represent the inturned borders of the helix.

PINNIPEDIA.

E. 372. Part of the integument from the left side of the head of a Sea Lion (*Otaria* sp.) showing the small pointed external ear. Its size, shape and position are such as to present no impediment in swimming. The external meatus is shown upon the reverse of the specimen. It is long and tortuous, and its walls are supported by a series of oblong cartilages, moveably connected together. O. C. 1611. *Hunterian.*

E. 373. Right half of the head of a Seal (*Phoca vitulina*). There is no pinna. The external auditory meatus opens directly upon the surface surrounded by a slightly raised border of soft crinkled skin. It is very long (55 mm.) and runs backwards to the skull parallel to the dorsal border of the jugal process of the squamosal. The walls of the meatus are supported by two rings of cartilage—one, answering to the annular cartilage of other Mammals, lies close to the skull ; the other which is three times as large extends from the external border of the annular cartilage nearly to the skin upon the surface of the tube turned towards the skull ; it is continuous mesially, but upon the outer side is interrupted in its middle and again near the external opening by extensive membrane-covered lacunæ. In this specimen part of the Eustachian tube is also shown (indicated by a black bristle) as well as the eyelids and the globe of the eye with its muscles. O. C. 1611 A.

CARNIVORA.

ARCTOIDEA.

E. 374. The right ear of a Kinkajou (*Potos caudivolvulus*). The pinna is oblong, widening slightly towards its bluntly rounded apex. The inner crus helicis, the tragus and the antitragus are clearly marked. Within the cavity of the conch is a small but very prominent transverse projection which corresponds to a similar lamina in many other Carnivores ; it is probably the crus inferior of the antihelix. The posterior border of the helix is not cleft to form an integumentary pocket as in many Carnivora.

O. C. 1610 E.

E. 375. Left ear of a Grison (*Galictis vittata*). The ear is small, flat and rounded, lying close against the head. Upon the lower posterior border is a small integumentary cleft or pocket. The antitragus is prominent, and above it is a plica longitudinalis that closely resembles the body of the antihelix in Man. Close to the upper end of this plica are a pair of folds at right angles to the axis of the ear—the crura antihelicis. The upper of these is slight, but the lower is plate-like and remarkably prominent. O. C. 1610 A.

E. 376. The right ear of a Ferret (*Putorius furo*). The pinna has much the same shape as that of *Galictis*, but is slightly more pointed. The cleft or pocket upon the posterior border is larger, and more definite and regular in shape. The incisura intertragica is peculiarly deep and narrow and the tragus in consequence appears prominent. Between the cavity of the conch and the scapha are three parallel transverse ridges. The lowest of these is the inner crus of the helix, the middle one is the very pronounced lower crus of the antihelix and the upper its less prominent upper crus. O. C. 1610 B.

Presented by J. B. Perrin, Esq.

E. 377. Skin of the left side of the head of a Teledu (*Mydaus meliceps*). The external ear is quite vestigeal. It has the appearance of a lengthened vertical slit opening forwards and overhung slightly above behind and below by a thickened fold of skin fringed with hair. The pig-like form of the snout of this small burrowing Badger is also shown. O. C. 1610 G.

Presented by J. W. Clark, Esq.

E. 378. Part of the skin of the left side of the head of a Ratel (*Mellivora indica*) including the external ear. This is represented by a wide concavity sunk below the general level of the face, and bordered, except in front, by a thick slightly protuberant fold of skin. Within the concavity can be seen two folds—an upper that probably represents the crus antihelicis, and a lower and less prominent swelling—the internal crus helicis ; while upon the margin are slight indications of tragus and antitragus. In this animal, which burrows for temporary purposes, the projecting external ear is only so far developed as is compatible with subterranean progression. O. C. 1610. *Hunterian.*

CYNOIDEA.

E. 379. The head of a Dog (*Canis familiaris*), with the muscles of the pinna shown on both sides. The muscles can be separated into those that move the ear as a whole, and those that are proper to the pinna itself.

The former consist of :—the scutularis (A), a large sheet of muscle that covers the temporalis and is attached posteriorly to the scutellum ; its hinder part (A′) forms a separate muscle—the cervico-scutularis, which is more or less blended with the levator longus (I). The scutularis holds the scutellum in position, to act as a fixed point for the muscles that pass from it to the ear.

The adductors, comprising an adductor superior (C) from the scutularis and scutellum to the anterior border of the helix, an adductor inferior (D) from the scutularis to the antitragus, and an adductor medius from the scutellum to the antero-mesial border of the concha, above the tragus. These adductors draw the ear forward. The depressor conchæ (F), a long narrow slip taking origin in the skin muscles on the ventral surface of the neck and inserted upon the antitragus beneath the adductor inferior. This muscle depresses the ear and rotates it outwards. The abductors, comprising an abductor longus (G) and an abductor brevis (H), arising in the mid-line of the occiput and inserted respectively upon the posterior and median surfaces of the conch. They lift the ear and rotate it outwards. The levators, including the levator medius (attollens) (B), a muscle arising from the mid-line in front of the abductors and inserted partly into the deep surface of the scutellum and partly into the median surface of the conch ; and the levator longus (I) arising from the mid-line of the neck with the cervico-scutularis and inserted by two slips into the median surface of the conch. These muscles draw the pinnæ up towards the mid-line. The rotator auris (K), a small muscle that runs from the deep surface of the scutellum backwards upon the median surface of the conch. It twists the ear outwards and backwards. The tragicus major (O), a long slender muscle that takes origin from the angle of the jaw and is inserted upon the outer crus of the helix.

The intrinsic muscles include the transversus auris (L), a muscle-sheet applied longitudinally to the mesial surface of the conch, between the two insertions of the levator longus ; the helicis minor (M) filling in the groove between the two crura of the helix ; the helicis major (N) passing from the point of the outer crus helicis to the surface of the tragus. In action the transversus would stiffen the scapha and thus prick the ears, the helicis minor would increase the curvature of the anterior part of the helix, and the helicis major would assist this movement by approximating the border of the helix to the tragus.

E. 380. The cartilages of the right ear of a Dog (*Canis familiaris*). The helix terminates anteriorly in two well marked crura—an inner and an outer. The latter is expanded and overlaps the tragus in front. Posteriorly the tragus is continuous with a large triangular cartilage—the processus uncinatus or outer crus of the antitragus. The antihelix is represented by a transverse fold running backwards from the inner crus of the helix.

The meatus is supported by four half-rings. The upper three are almost completely united and are continuous with the conch. The free portion of the first half-ring forms the tragus. The fourth half-ring is independent, forming the annular cartilage.

AILUROIDEA.

E. 381. The right ear of a Ferret (*Genetta tigrina*). The pinna is elongated, erect, and with a rounded apex. Its posterior and lower margin is deeply incised with an irregular integumentary pocket, as in many other Carnivora. The helix, which is nowhere inturned, has outer and inner crura. The former is very slightly marked, but the inner crus is sharply prominent and extends backwards diagonally towards the meatus. The tragus is squarish in outline and is separated by a sulcus auris anterior from the outer crus of the helix and by a very slight incisura from the antitragus. The antitragus has inner and outer crura, the former of which overlies a longitudinal plica. The cavity of the conch is occupied by an abrupt rounded projection set transversely to the long axis of the ear. This corresponds to the lower of the two laminæ seen in *Crossarchus*, and probably is the crus inferius antihelicis. O. C. 1610 F.

Presented by St. George Mivart, Esq.

E. 382. The right ear of a Kusimanse (*Crossarchus obscurus*). This is a small ear of almost quadrangular outline, showing a considerable flat extension in front of the external crus helicis. The latter is weak, but the inner crus is strongly marked and runs deeply into the cavity of the conch, within which, above the crus, lie also two extremely prominent laminæ disposed parallel to one another and approximately at right angles to the long axis of the ear. They are strikingly similar to a pair of laminæ found in the ears of certain Lemurs, and probably represent the two crura of the antihelix in an exaggerated form. There is no cleft in the integument upon the posterior border of the helix.

O. C. 1610 D.

E. 383. The right ear of *Galidea elegans*. The pinna is bluntly pointed and is considerably broadened in front of the outer crus of the helix. There is a very large and regularly shaped integumentary cleft upon the posterior border of the helix, closely similar to that seen in the Ferret (E. 376). The prominences in and around the aperture of the conch are few and simple, the internal crus helicis and the crus antihelicis being the only two of any considerable size.

O. C. 1610 C.

INSECTIVORA.

E. 384. The anterior part of a Mole (*Talpa europæa*), showing the entrance to the external meatus unprovided with a projecting pinna, which would be an impediment in the act of burrowing and an unnecessary appendage.

O. C. 1609. *Hunterian.*

E. 385. The anterior part of a Mole (*Talpa europæa*), with the fur removed to show the external orifices of the ears and eyes, into which bristles have been placed.

O. C. 1608. *Hunterian.*

CHIROPTERA.

E. 386. The head of a Bat (*Megaderma lyra*). The external ears are of very great size, thin, elongated, and pointed. The anterior borders of their helices unite across the forehead, being supported in the mid-plane by a vertical triangular thickening. The tragus is also greatly developed, and stands up in front of the opening into the meatus in the form of a large leaf-like flap, terminating above in a pair of pointed processes. Behind the tragus upon the inner surface of the conch can be seen a well-marked plica longitudinalis.

The pinna in Bats not only serves to direct sound-waves into the meatus, but is also most probably extremely sensitive to tactile impressions, and in conjunction with the wing-membranes and the nasal appendage (when such is present) forms a touch-organ, by means of which the creature can direct its course in the dark. O. C. 1423 A.

PRIMATES.

LEMUROIDEA.

E. 387. Right ear of a Potto (*Perodicticus potto*). The helix is not inturned, but its anterior lower end is bent into the cavity of the conch and divides to form scarcely distinguishable inner and outer crura. The antihelix is weak, with the exception of its crus inferius, which is thin and remarkably prominent, and agrees in position and general appearance with the lower of the two transverse laminæ which occur in the ears of certain other Lemurs and Carnivora. O. C. 1612 A.

Presented by F. M. Skues, Esq.

E. 388. Right ear of a Slender Loris (*Loris gracilis*). The pinna is thin, erect, and delicately curved, but the helix is in no part inturned. The tragus is slight, but the antitragus more prominent. Both lie almost vertically, and form the anterior and posterior borders of a remarkably deep incisura intertragica. Behind the antitragus the scapha is hollowed out to form a deep concavity (sulcus auris posterior), which is also strongly developed in certain Monkeys and Rodents. From the antitragus a longitudinal ridge runs upwards between the scapha and the conch. This is the stem of the antihelix. Its crura are probably represented by two laminæ that stand out abruptly between the scapha and the cavitas conchæ transverse to the long axis of the ear. O. C. 1612. *Hunterian.*

E. 389. Right ear of a Calabar Potto (*Arctocebus calabarensis*). This differs in no important feature from the ear of *Loris gracilis*. O. C. 1612 B.
Presented by Andrew Murray, Esq.

ANTHROPOIDEA.

E. 390. The right ear of a Marmoset (*Midas œdipus*). The helix is inturned along its anterior and upper border. The apex is pointed and directed posteriorly. The antihelix has the same form as that of Man and other Anthropoidea and is fairly prominent. The tragus and antitragus are slight. O. C. 1619 A.

E. 391. Right ear of a Woolly Monkey (*Lagothrix humboldti*). The helix is inturned only in its ascending and horizontal parts. The descending part, although not inturned, is much reduced in comparison with that of Lemurs and most lower Mammals. The antihelix is prominent, with well-marked superior and inferior crura. The incisura intertragica is broader and shallower than in *Cebus*.
O. C. 1619 C.

E. 392. Right ear of a Sooty Mangabey (*Cercocebus fuliginosus*). The helix resembles that of *Cebus*, but the stem of the antihelix is less definite and is separated by the apex of the fossa triangularis from its crus inferius. The scapha terminates below in a rounded hollow (sulcus auris posterior) behind the antitragus, but this is less marked than in *Cebus*. O. C. 1619 E.

E. 393. Right ear of a Capuchin (*Cebus capucinus*). The helix originates in the cavity of the conch by a well-marked lamelliform crus, and although inturned along its whole circumference, borders a broad and well developed scapha. The tragus and antitragus are particularly prominent and are separated by a deep and narrow incisura. The lower end of the scapha forms a pit-like sulcus posterior. The antihelix is well developed and closely resembles that of Man. O. C. 1619 B.

E. 394. Ears of a Baboon (*Papio mormon*). These are of a lower and more animal type than those of the Monkeys previously described. The helix is inturned only along its anterior border and the pinna is pointed dorsally. The posterior part of the scapha is broad and slightly hollowed out, the hollow passing ventrally into a deep pit behind the antitragus. The antihelix (which apparently in Apes increases in importance as the scapha is reduced) is scarcely indicated except at either end. The tragus, antitragus, and incisura intertragica are strongly marked.

O. C. 1619. *Hunterian.*

E. 395. The cartilages of the right ear of a Baboon (*Papio babuin*). In comparison with those of the Human ear, the processes that support the tragus and antitragus are large and prominent, and it is specially worthy of note that the cartilages of the meatus are more separate and have retained more clearly signs of their annular origin. The antihelix is less marked, with the exception of its crus inferior, which is separate from the stem and of some size. The processus helicis caudatus is large and flat.

E. 396. Right ear of a Gibbon (*Hylobates lar*). The ascending, horizontal, and upper half of the descending parts of the helix are strongly inturned, and the lower posterior part though not inturned is greatly reduced. The antihelix is well developed. The crus inferius is separated from it by a depression. O. C. 1620. *Hunterian.*

E. 397. Right ear of an Orang-utan (*Simia satyrus*). The ear is of very small size and in general form very Human, but is without a lobule. The helix is inturned throughout. The antihelix is very prominent, but lacks the crus inferius. The incisura intertragica is remarkably broad and shallow. O. C. 1620 A.

E. 398. Part of the skull with the cartilage of the left ear of an Orang-utan (*Simia satyrus*). The meatal part of the cartilage is clearly separable into three half-rings, which are united into a single plate along their inner anterior border, but posteriorly and externally are separated by deep clefts of Santorini. The upper ring bears the tragus and antitragus and is continuous with the hinder part of the concha. The cartilage of the concha is very similar to that of Man, except for its small size, for the slight development of the crus inferius antihelicis, and for the greater acuteness of the stem of the antihelix.

E. 399. Left ear of a Chimpanzee (*Anthropopithecus troglodytes*). The pinna is large with strongly developed scapha, inturned along its entire helical border, although but slightly in its posterior and lower part. Towards the antitragus the scapha deepens into a slight hollow (sulcus auris posterior) that suggests the deep pit in the Baboon and other Apes. The antihelix is slight. The incisura intertragica resembles that of the Orang in being wide and shallow.

O. C. 1620 B.

E. 400. Part of the skull with the cartilages of the left ear of a Chimpanzee (*Anthropopithecus troglodytes*). The cartilages resemble those of the Human ear more nearly than do those of the Orang. In comparison with that of the Orang the crus helicis is large and bears upon its convexity a small spine (spina helicis) which represents the outer crus found in lower Mammals. The antihelix is very Human, with a broad shallow stem and well-defined crus inferius. The tragus is joined more completely to the second half-ring of the meatus than in the Orang, being continuous with it both in front and behind, but separated in the middle by a cleft of Santorini. The lowest half-ring is joined to the one above by only a very slender bar of cartilage.

E. 401. The right ear of a Negro. It is of large size and has no lobule. O. C. 1621. *Hunterian.*

Keith, Nature, vol. lxv. no. 1671, p. 16.

E. 402. The right ear of a Bushwoman. O. C. 1621 A.

E. 403. The left ear of a New Zealander. The lobule has been perforated to carry some heavy pendent ornament.
O. C. 1622. *Hunterian.*

E. 404. The ears of a Tahitan. There is no lobule.
O. C. 1622 A.

E. 405. The left ear of a European female. This shows well the "Orang type" of ear, in which the ear is small, with reduced and inturned helix. There is a small lobulus.
O. C. 1623. *Hunterian.*

E. 406. Right ear of a European male. The lobulus is large. This ear is of the "Chimpanzee" type, with flat expanded scapha. O. C. 1624. *Hunterian.*

E. 406 a. An ear, showing "Darwin's point," a small process upon the inturned edge of the helix at its upper and posterior part, which probably represents the pointed apex of the ear of lower Mammals.

E. 407. The supporting cartilage of the right ear. The cartilage conforms roughly to the external shape of the ear, but has no process corresponding to the lobule. The cartilage of the meatus is plate-like and shows its original formation from rings by two transverse fissures—the clefts of Santorini. The crus inferius antihelicis is strong and sharply prominent. On the anterior edge of the ascending helix is a small process (spina helicis). This answers to the external crus helicis of lower Mammals.
O. C. 1623 A.

OTOLITHS, OSSICULA AUDITUS, AND BONY LABYRINTHS*.

PISCES.

GANOIDEI.

E. 408. Otoliths from the right saccule of a Sturgeon (*Acipenser sturio*).

* Preserved in the Rail-case of Room V. (Lower Gallery).

TELEOSTEA *.

CLUPEIDÆ.

E. 409. Otolith of a Shad (*Clupea alosa*): from two individuals.

E. 410. Otoliths of a Herring (*Clupea harengus*): two from the left side and one from the right, from different individuals.

E. 411. Otoliths of a Pilchard (*Clupea pilchardus*).

SALMONIDÆ.

E. 412. Otoliths of a Salmon (*Salmo salar*).

E. 413. Otoliths of a Sea-Trout (*Salmo trutta*).

E. 414. Otoliths of a Grey Trout (*Salmo trutta,* var. *cambricus*).

E. 415. Otoliths of a Brook-Trout (*Salmo fario*).

E. 416. Otoliths of a Smelt (*Osmerus eperlanus*).

E. 417. Otolith of a Grayling (*Thymallus vulgaris*): from the right side.

CYPRINIDÆ.

E. 418. Otoliths of a Carp (*Cyprinus carpio*): from the lagena.

E. 419. Otoliths of a Roach (*Leuciscus rutilus*): apparently from two individuals. The upper specimen on the left and the lower on the right are from the lagena, the other two from the recessus utriculi.

SILURIDÆ.

E. 420. Otoliths of a Sheat-fish (*Silurus glanis*).

E. 421. Otoliths of Spix's Sheat-fish (*Hypophthalmus edentatus*).

E. 422. Otoliths of *Platystoma orbignianum.*

E. 423. Otolith of an Electric Silurus (*Malapterurus electricus*).

E. 424. Otoliths of a Hassar (*Callichthys asper*).

* These otoliths, except where otherwise stated, are from the sacculus.

ANGUILLIDÆ.

E. 425. Otoliths of an Eel (*Anguilla vulgaris*).

E. 426. Otoliths of a Conger Eel (*Conger vulgaris*).

E. 427. Otoliths of *Muræenesox talabon*.
Presented by W. Clarke, Esq.

ESOCIDÆ.

E. 428. Otolith of a Pike (*Esox lucius*) : from the left side.

CYPRINODONTIDÆ.

E. 429. Otoliths of a Star-gazer (*Anableps tetrophthalmus*).

SCOMBRESOCIDÆ.

E. 430. Otolith of *Scombresox saurus* : from the left side.

E. 431. Otoliths of a Gar-fish (*Belone vulgaris*).

E. 432. Otoliths of *Hemirhamphus intermedius*.

E. 433. Otoliths of a Flying-fish (*Exocœtus volitans*).

AMMODYTIDÆ.

E. 434. Otoliths of a Greater Sand-Launce (*Ammodytes lanceolatus*) : from two individuals.

E. 435. Otoliths of a Lesser Sand-Launce (*Ammodytes tobianus*).

MUGILIDÆ.

E. 436. Otoliths of a Grey Mullet (*Mugil capito*).

SPHYRÆNIDÆ.

E. 436 a. Otoliths of a Barracuda (*Sphyræna cameroonii*).

GADIDÆ.

E. 437. The otoliths (including those from the recessus utriculi and lagena) from the left ear of a Cod (*Gadus morrhua*), mounted in position upon an outline drawing of the membranous labyrinth.

E. 438. Otoliths of a Cod (*Gadus morrhua*).

E. 439. Otoliths of a Coal-fish (*Gadus virens*): from a young specimen.

E. 440. Otoliths of a Coal-fish (*Gadus virens*): from an adult.

E. 441. Otoliths of a Pollack (*Gadus pollachius*): two of the same size and shape, and one very much larger and smoother.

E. 442. Otoliths of a Bib (*Gadus luscus*): from two individuals of different ages.

E. 443. Two otoliths of *Gadus anglicus*, Koken, from the Coralline Crag, near Orford Castle.

E. 444. Otoliths of a Haddock (*Gadus æglefinus*): from different individuals, one from the right side and two from the left.

E. 445. Otoliths of *Gadus pseudæglefinus*, from the Coralline Crag, near Orford Castle.

E. 446. Three otoliths of *Gadus pseudæglefinus* = ? *G. luscus*, from the Coralline Crag, near Orford Castle: much worn.

E. 447. Otoliths of a Whiting (*Gadus merlangus*).

E. 448. Otoliths of *Gadus elegans*, from the Coralline Crag, near Orford Castle.

E. 449. Otoliths of a Hake (*Merluccius vulgaris*).

E. 450. Otoliths of a Common Fork-beard (*Phycis blennoides*).

E. 451. Otoliths of a Ling (*Molva vulgaris*).

E. 452. Otoliths of a Three-bearded Rockling (*Motella tricirrata*).

PERCIDÆ.

E. 453. Otoliths of a Bass (*Labrax lupus*).

E. 454. Otoliths of a Pope (*Acerina cernua*).

SERRANIDÆ.

E. 455. Otoliths of a Gaper (*Serranus cabrilla*).

E. 456. Otoliths of a Sea-Perch (*Serranus brunneus*).

E. 457. Otoliths of *Lutjanus annularis*.

SCIÆNIDÆ.

E. 458. Otoliths of an Albicore (*Sciæna aquila*).
Presented by E. T. Newton, Esq.

E. 459. Otoliths of *Sciæna belangerii*: from two individuals.

E. 460. Otoliths of *Otolithus argenteus*.

E. 461. Otoliths of a Sciænoid.

SPARIDÆ.

E. 462. Otoliths of a Sea-Bream (*Pagellus centrodontus*): from two individuals.

MULLIDÆ.

E. 463. Otoliths of a Red Mullet (*Mullus barbatus*).

LABRIDÆ.

E. 464. Otoliths of a Ballan Wrass (*Labrus maculatus*).

E. 465. Otoliths of a Striped Wrass (*Labrus mixtus*).

E. 466. Otolith of a Coral-fish (*Platyglossus dussumieri*).

CARANGIDÆ.

E. 467. Otoliths of a Horse-Mackerel (*Caranx trachurus*).

GERRIDÆ.

E. 468. Otoliths of *Equula nuchalis*.

ZEIDÆ.

E. 469. Otoliths of a John Dory (*Zeus faber*).

PLEURONECTIDÆ.

E. 470. Otoliths of a Turbot (*Rhombus maximus*).

E. 471. Otoliths of a Brill (*Rhombus lævis*) : from different individuals, one from the left side and two from the right.

E. 472. Otoliths of a Plaice (*Pleuronectes platessa*): from different individuals, one from the right side and two from the left.

E. 473. Otoliths of a Flounder (*Pleuronectes flesus*).

E. 474. Otoliths of a Dab (*Pleuronectes limanda*).

E. 475. Otoliths of a Sole (*Solea vulgaris*).

E. 476. Otoliths of *Plagusia bilineata*.

CALLIONYMIDÆ.

E. 477. Otoliths of a Dragonet (*Callionymus lyra*).

COTTIDÆ.

E. 478. Otoliths of a Father-lasher (*Cottus bubalis*).

E. 479. Otoliths of a Sea-Scorpion (*Cottus scorpius*).

PLATYCEPHALIDÆ.

E. 480. Otoliths of *Platycephalus scaber*.

TRIGLIDÆ.

E. 481. Otoliths of a Streaked Gurnard (*Trigla lineata*).

E. 482. Otoliths of a Grey Gurnard (*Trigla gurnardus*): from two individuals.

E. 483. Otoliths of a Piper (*Trigla lyra*).

E. 484. Otoliths of a Red Gurnard (*Trigla cuculus*).

TRACHINIDÆ.

E. 485. Otoliths of a Weever (*Trachinus draco*), including one from the lagena (mounted above).

AMPHIBIA.

URODELA.

E. 486. Menobranch (*Necturus maculatus*) : columella, of both sides.

E. 487. Spotted Salamander (*Salamandra maculosa*) : columella, of the left side.

ANURA.

E. 488. Surinam Toad (*Pipa americana*) : columella, of both sides.

E. 489. Tree-Frog (*Hyla arborea*) : columella, of both sides.

E. 490. Common Frog (*Rana temporaria*) : columella, of both sides.

E. 491. Noisy Frog (*Rana clamata*) : columella, of both sides.

E. 492. Bull-Frog (*Rana catesbiana*) : columella, of both sides.

REPTILIA.

RHYNCHOCEPHALIA.

E. 493. Tuatara Lizard (*Sphenodon punctatus*) : columella, of one side.

LACERTILIA.

E. 494. Indian Gecko (*Gecko verticillatus*): columella, of both sides.

E. 495. Egyptian Mastigure (*Uromastix spinipes*) : columella, of both sides.

E. 496. Iguana (*Iguana tuberculata*) : columella, of both sides, from a specimen one foot long.

E. 497. Naked-necked Iguana (*Iguana delicatissima*) : columella, of both sides, from a specimen measuring a few inches.

E. 498. Monitor Lizard (*Varanus griseus*) : columella, of one side.

E. 499. *Lacerta* sp., columellæ *in situ* in the skull. The position of the semicircular canals is also shown by bristles.

E. 500. Great Cyclodus (*Tiliqua gigas*): columella, of both sides.

E. 501. Common Chameleon (*Chamæleon vulgaris*): columella, of both sides.

OPHIDIA.

E. 502. *Python* sp.: columella, of both sides.

E. 503. Indian Cobra (*Naja tripudians*): columella, of both sides.

EMYDOSAURIA.

E. 504. Nilotic Crocodile (*Crocodilus niloticus*): columella, of one side, from No. 717 D, Osteol. Series.

E. 505. *Crocodilus niloticus*: columella, of both sides.

E. 506. *Crocodilus* sp.: columella, of both sides.

E. 507. False Gavial (*Tomistoma schlegelii*): columella, of the right side.

CHELONIA.

E. 508. Snapping Turtle (*Macroclemmys temminckii*): columella, of one side.

E. 509. European Tortoise (*Testudo græca*), both columellæ, with parts of the skull showing the cavities in the quadrate bones occupied by the outer chambers of the tympanum.
Max Hübrich Collection.

E. 510. *Chelone mydas*: columella, of both sides.

E. 511. *Chelone mydas*: columella, of both sides.

AVES.

RATITÆ.

RHEIFORMES.

E. 512. Rhea (*Rhea americana*): columella, of both sides.
* M.C., 2094.

APTERYGIFORMES.

E. 513. Kiwi (*Apteryx australis*): columella, of both sides.

* Original Manuscript Catalogue of the Collection of Auditory ossicula.

CARINATÆ.

TINAMIFORMES.

E. 514. Tinamou (*Tinamus solitarius*) : columella, of the right side. M.C., 2079.
Presented by Professor W. K. Parker.

GALLIFORMES.

E. 515. Brush-Turkey (*Catheturus lathami*) : columella. M.C., 2071.

E. 516. Black Grouse (*Lyrurus tetrix*) : bony labyrinth and columella, of both sides. M.C., 2007.
Max Hübrich Collection.

E. 517. Capercaillie (*Tetrao urogallus*) : bony labyrinth of both sides, and one columella. Part of the bony wall of the tympanic chamber is attached to the left labyrinth. M.C., 2003.
Max Hübrich Collection.

E. 518. Greek Partridge (*Caccabis saxatilis*) : bony labyrinth, of the right side and one columella. M.C., 2023 B.
Max Hübrich Collection.

E. 519. Partridge (*Perdix perdix*) : bony labyrinth, of the right side. M.C., 2021.
Max Hübrich Collection.

E. 520. Fowl (*Gallus gallus*, var. *domesticus*) : bony labyrinth and columella auris, of the right side. M.C., 1983.
Max Hübrich Collection.

E. 521. Golden Pheasant (*Chrysolophus pictus*) : bony labyrinth of both sides, and one columella. M.C., 1966 A.
Max Hübrich Collection.

E. 522. Turkey (*Meleagris gallopavo*) : bony labyrinth of both sides, and one columella. M.C., 2046.
Max Hübrich Collection.

COLUMBIFORMES.

E. 523. Stock-Dove (*Columba œnas*): bony labyrinth of the right side, and one columella. M.C., 628 A.
Max Hübrich Collection.

E. 524. Turtle-Dove (*Turtur turtur*): bony labyrinth and columella, of both sides. M.C., 662 A.
Max Hübrich Collection.

E. 525. Solitaire (*Pezophaps solitarius*): columella auris. From the series of bones collected by the Rev. H. H. Slater, 1874. M.C., 706.

RALLIFORMES.

E. 526. Corn Crake (*Crex crex*): bony labyrinth of both sides, and one columella. M.C., 1917.
Max Hübrich Collection.

PROCELLARIIFORMES.

E. 527. Wandering Albatross (*Diomedea exulans*): columella auris. M.C., 1524.
Presented by Alban Doran, Esq.

LARIFORMES.

E. 528. Tern (*Sterna fluviatilis*): bony labyrinth of the right side, and one columella. M.C., 1677.
Max Hübrich Collection.

CHARADRIIFORMES.

E. 529. Lapwing (*Vanellus vanellus*): bony labyrinth of the right, and columella of both sides. M.C., 1719.
Max Hübrich Collection.

E. 530. Curlew (*Numenius arquata*): bony labyrinth and columella auris, of both sides. M.C., 1813.
Max Hübrich Collection.

E. 531. Dunlin (*Pelidna alpina*): bony labyrinth, of the right side. M.C., 1769.
Max Hübrich Collection.

E. 532. Woodcock (*Scolopax rusticula*): bony labyrinth and columella auris, of both sides. M.C., 1751.
Max Hübrich Collection.

ARDEIFORMES.

E. 533. Heron (*Ardea cinerea*): bony labyrinth and columella auris, of both sides. M.C., 1295 A.
Max Hübrich Collection.

E. 534. Bittern (*Botaurus stellaris*): bony labyrinth and columella auris, of both sides. M.C., 1321.
Max Hübrich Collection.

ANSERIFORMES.

E. 535. Wild Goose (*Anser ferus*): bony labyrinth of the right side, and one columella. M.C., A 1388.
Max Hübrich Collection.

E. 536. Bean-Goose (*Anser fabalis*): bony labyrinth of the left side, and one columella. M.C., 1380 A.
Max Hübrich Collection.

PELECANIFORMES.

E. 537. Cormorant (*Phalacrocorax carbo*): bony labyrinth and columella auris, of both sides. M.C., 1253.
Max Hübrich Collection.

CATHARTIDIFORMES.

E. 538. Black Vulture (*Catharistes urubu*): columella, of both sides. M.C., A 885.

ACCIPITRIFORMES.

E. 539. Griffon Vulture (*Gyps fulvus*): columella, of the right side. M.C., 914.
Presented by Professor W. K. Parker.

E. 540. Hen-Harrier (*Circus cyaneus*): bony labyrinth and columella, of both sides. M.C., 933.
Max Hübrich Collection.

E. 541. Sparrow-Hawk (*Accipiter nisus*): bony labyrinth, of both sides, and one columella. M.C., 959.
Max Hübrich Collection.

E. 542. Buzzard (*Buteo buteo*): bony labyrinth and columella, of the right side. M.C., 966.
Max Hübrich Collection.

E. 543. Harpy Eagle (*Thrasaëtus harpyia*): columella, of both sides. M.C., A 983.

E. 544. Golden Eagle (*Aquila chrysaëtus*): right bony labyrinth and surrounding parts of the skull. The semicircular canals and vestibule have been opened and their cavities marked by black bristles. M.C., 975.

E. 545. Golden Eagle (*Aquila chrysaëtus*): part of the left side of the skull, showing the air-spaces in connection with the tympanum. M.C., 975 A.

E. 546. Golden Eagle (*Aquila chrysaëtus*): columella, of both sides. M.C., 975 B.

E. 547. Rough-legged Buzzard (*Archibuteo lagopus*): bony labyrinth and columella, of both sides. M.C., 970 A.

E. 548. Bateleur Eagle (*Helotarsus ecaudatus*): columella, of both sides. M.C., 985 A.

E. 549. Peregrine Falcon (*Falco peregrinus*): bony labyrinth and columella, of both sides. M.C., 1023 A.
Max Hübrich Collection.

E. 550. Merlin (*Falco merillus*): bony labyrinth of the left side, and one columella. M.C., 1032 A.
Max Hübrich Collection.

STRIGIFORMES.

E. 551. Long-eared Owl (*Asio otus*): bony labyrinth and columella, of both sides. M.C., 1072.
Max Hübrich Collection.

E. 552. Great Eagle-Owl (*Bubo bubo*): bony labyrinth and columella, of both sides. M.C., 1052.
Max Hübrich Collection.

E. 553. Barn-Owl (*Strix flammea*): bony labyrinth, of the left side. M.C., 1100.

PSITTACIFORMES.

E. 554. Rose-crested Cockatoo (*Cacatua moluccensis*): columella, of both sides. M.C., A 1140.

E. 555. Blue-and-Yellow Macaw (*Ara ararauna*): columella, of both sides. M.C., 1148.

CORACIIFORMES.

E. 556. Kingfisher (*Alcedo ispida*): bony labyrinth and columella, of both sides. M.C., 752.
Max Hübrich Collection.

E. 557. White-beaked Hornbill (*Anthracoceros convexus*): one columella auris. M.C., 856.
Presented by Prof. W. K. Parker.

E. 558. Red-necked Hornbill (*Rhytidoceros plicatus*): one columella auris. M.C., 867 A.

E. 559. Hoopoe (*Upupa epops*): bony labyrinth of both sides, with one columella. M.C., 616.
Max Hübrich Collection.

E. 560. Swift (*Cypselus apus*): bony labyrinth and columella, of the left side. M.C., 788.
Max Hübrich Collection.

TROGONES.

E. 561. Cuckoo (*Cuculus canorus*): bony labyrinth and columella, of the right side. M.C., 720 A.
Max Hübrich Collection.

PICIFORMES.

E. 562. Green Woodpecker (*Gecinus viridis*): bony labyrinth and columella, of the left side. M.C., 556.
Max Hübrich Collection.

PASSERIFORMES.

E. 563. Swallow (*Hirundo rustica*): bony labyrinth and columella, of both sides. M.C., 514.
Max Hübrich Collection.

E. 564. Wren (*Anorthura troglodytes*): bony labyrinth and columella, of both sides. M.C., 444.
Max Hübrich Collection.

E. 565. Blackbird (*Merula merula*): bony labyrinth and columella, of the left side. M.C., 425.
Max Hübrich Collection.

E. 566. Nightingale (*Aedon luscinia*): bony labyrinth and columella, of both sides. M.C., 427.
Max Hübrich Collection.

E. 567. Robin (*Erythacus rubecula*): bony labyrinth and columella, of both sides. M.C., 430.
Max Hübrich Collection.

E. 568. Redstart (*Phœnicurus phœnicura*): bony labyrinth and columella, of both sides. M.C., 434.
Max Hübrich Collection.

E. 569. Blackcap (*Sylvia atricapilla*): bony labyrinth and columella, of both sides. M.C., 394.
Max Hübrich Collection.

E. 570. Red-backed Shrike (*Enneoctonus collyrio*): bony labyrinth and columella, of the left side. M.C., 367.
Max Hübrich Collection.

E. 571. Blue Titmouse (*Cyanistes cœruleus*): bony labyrinth and columella, of both sides. M.C., 344.
Max Hübrich Collection.

E. 572. White Wagtail (*Motacilla alba*): bony labyrinth and columella, of the right side. M.C., A 288.
Max Hübrich Collection.

E. 573. Skylark (*Alauda arvensis*): the bony labyrinths partly separated from the cranium. M.C., 277.

E. 574. Crossbill (*Loxia curvirostra*): bony labyrinth and columella, of both sides. M.C., 253.
Max Hübrich Collection.

E. 575. Canary (*Serinus canaria*): bony labyrinth and columella, of both sides. M.C., 241.
Max Hübrich Collection.

E. 576. Canary (*Serinus canaria*): bony labyrinths partly separated from the cranium. M.C., 242.

E. 577. House-Sparrow (*Passer domesticus*): bony labyrinth and columella, of the right side. M.C., 232.
Max Hübrich Collection.

E. 578. Siskin (*Chrysomitris spinus*): bony labyrinth and columella, of the right side. M.C., 217.
Max Hübrich Collection.

E. 579. Goldfinch (*Carduelis carduelis*): bony labyrinth and columella, of both sides. M.C., 212.
Max Hübrich Collection.

E. 580. Starling (*Sturnus vulgaris*): bony labyrinth and columella, of both sides. M.C., 87.
Max Hübrich Collection.

E. 581. Magpie (*Pica pica*): bony labyrinth and columella, of the left side. M.C., 51.
Max Hübrich Collection.

E. 582. Nutcracker (*Nucifraga caryocatactes*): bony labyrinth and columella, of the right side. M.C., 49.
Max Hübrich Collection.

E. 583. Hooded Crow (*Corone cornix*) : bony labyrinth of both sides, with one columella. M.C., 33.
Max Hübrich Collection.

E. 584. Jackdaw (*Colœus monedula*): bony labyrinth and columella, of the left side. M.C., 27.
Max Hübrich Collection.

E. 585. Raven (*Corvus corax*): bony labyrinth and columella, of both sides. M.C., 20.
Max Hübrich Collection.

MAMMALIA.

* Doran, Morphology of the Mammalian ossicula auditûs, Trans. Linn. Soc., ser. 2, vol. i. 1879, p. 371.

MONOTREMATA.

Doran, *l. c.*, p. 492.

ORNITHORHYNCHIDÆ.

E. 586. Duck-billed Platypus (*Ornithorhynchus anatinus*) : ossicula of both sides. The mallei are joined to the tympanic bones. M.C., 3972 A.

Doran, *l. c.*, p. 491.

ECHIDNIDÆ.

E. 587. Spiny Anteater (*Tachyglossus* [*Echidna*] *aculeatus*) : ossicula of both sides, with the mallei attached to the tympanic bones. M.C., 3960 A.

Doran, *l. c.*, p. 488.

E. 588. Spiny Anteater (*Tachyglossus aculeatus*). The right ossicula, with the stapes still attached to the processus longus of the incus. The shrivelled remains of the tensor tympani muscle and tendon are painted red. The tympanic bone is placed below the ossicula. M.C., 3960 B.

* A separate copy of the paper (which is a descriptive account of this collection) is kept in the Museum.

MARSUPIALIA.

Doran, *l. c.*, p. 486.

POLYPROTODONTIA.

DASYURIDÆ.

E. 589. Common Dasyure (*Dasyurus viverrinus*): left malleus and incus, and the right stapes.
Osteol. Series, 3899; M.C., 3899.
Presented by Ronald Gunn, Esq.

E. 590. *Dasyurus* sp.: malleus of both sides. M.C., 3899 A.

E. 591. Tasmanian Devil (*Sarcophilus* [*Dasyurus*] *ursinus*): ossicles of the right side, with the malleus of the left.
M.C., 3910.
Doran, *l. c.*, p. 483.

E. 592. Tasmanian Wolf (*Thylacinus cynocephalus*): left malleus and incus (Osteol. Series, 3930) with the left stapes from another individual (Osteol. Series, 3928). M.C., 3928.
Doran, *l. c.*, p. 482.

E. 593. *Phascologale* sp.: ossicula of both sides. The left malleus is attached to the tympanic bone. M.C., A 3881.
Doran, *l. c.*, p. 483.

E. 594. Marsupial Anteater (*Myrmecobius fasciatus*): ossicula of both sides. M.C., 3879.
Doran, *l. c.*, p. 483.

PERAMELIDÆ.

E. 595. Long-eared Bandicoot (*Peragale lagotis*): ossicula of both sides. The malleus is of a peculiarly low type. From an adult, 18 inches (460 mm.) long. M.C., 3862 A.
Doran, *l. c.*, p. 486.

E. 596. Long-eared Bandicoot (*Peragale lagotis*): right tympanic bone with the malleus attached, and left tympanic bone, with the incus and stapes, isolated. M.C., 3862 B.

E. 597. *Peragale* sp.: left malleus and incus. M.C., 3862 C.

E. 598. Pig-footed Bandicoot (*Chœropus castanotis*): ossicula of the right side. M.C., 3877.
Doran, *l. c.*, p. 486.

DIDELPHYIDÆ.

E. 599. Virginian Opossum (*Didelphys marsupialis*): ossicula of both sides. M.C., 3947 A.
Doran, *l. c.*, p. 480.

E. 600. Virginian Opossum (*Didelphys marsupialis*): ossicula of both sides. The malleus and incus of the left side are articulated. M.C., 3947 B.

E. 601. Four-spotted Opossum (*Didelphys opossum*): the ossicula of both sides. The tympanic bone is still connected to the right malleus. M.C., A 3947.
Doran, *l. c.*, p. 482.

DIPROTODONTIA.

MACROPODIDÆ.

E. 602. Great Kangaroo (*Macropus giganteus*): right tympanic bone, with membrana tympani and ossicles in position. The left malleus and incus and right stapes mounted separately below. Osteol. Series, 3708; M.C., 3708.

E. 603. Great Kangaroo (*Macropus giganteus*): mallei. M.C., 3713.
Doran, *l. c.*, p. 478.

E. 604. Bennett's Wallaby (*Macropus ruficollis*): right ossicles. From a young specimen two inches (50 mm.) in length without the tail. M.C., 3731 B.
Doran, *l. c.*, p. 479.

E. 605. Bennett's Wallaby (*Macropus ruficollis*): ossicles of both sides and right tympanic bone. The malleus and tympanic bone are united. M.C., 3731 C.

E. 606. Red Kangaroo (*Macropus rufus*): ossicles of the right side. M.C., 3722 A.

E. 607. A Hare-Kangaroo (*Macropus* sp.): malleus and incus of both sides and two right mallei. M.C., 3739.

E. 608. Gaimard's Rat-Kangaroo (*Bettongia gaimardi*): ossicula of both sides. M.C., 3812 A.

E. 609. Gaimard's Rat-Kangaroo (*Bettongia gaimardi*): malleus and incus of the left side. M.C., 3812 B.

E. 610. Kangaroo-Rat (*Potorous tridactylus*): ossicula of both sides. M.C., 3808 A.
Doran, *l. c.*, p. 480.

PHASCOLOMYIDÆ.

E. 611. Hairy-nosed Wombat (*Phascolomys latifrons*): left malleus, with right incus and stapes. M.C., 3649.
Doran, *l. c.*, p. 485.

E. 612. Common Wombat (*Phascolomys ursinus*): right malleus, left incus and stapes, and a slightly imperfect left malleus. M.C., 3632 A.
Doran, *l. c.*, p. 485.

PHALANGERIDÆ.

E. 613. Vulpine Phalanger (*Trichosurus vulpecula*, var. *fuliginosa*): ossicula of both sides. M.C., 3665.
Doran, *l. c.*, p. 483.

E. 614. Cook's Phalanger (*Pseudochirus peregrinus*): ossicula of the left side. M.C., 3688.
Doran, *l. c.*, p. 484.

E. 615. Great Flying Phalanger (*Petaurus australis*): ossicula of the right side. Osteol. Series, 3693; M.C., 3693.

E. 616. Taguan Flying Phalanger (*Petauroides volans*): right malleus. Osteol. Series, 3692; M.C., 3692.
Doran, *l. c.*, p. 484.

E. 617. Koala (*Phascolarctus cinereus*): ossicula of the right side, and the malleus (attached to the tympanic ring) and incus of the left. M.C., 3652 A.

E. 618. Koala (*Phascolarctus cinereus*): ossicula of the right side (the malleus and incus articulated), and the left malleus and incus. M.C., 3652 B.

E. 619. Koala (*Phascolarctus cinereus*): left malleus and incus. M.C., 3652 C.

Doran, *l. c.*, p. 484.

EDENTATA.

Doran, *l. c.*, p. 476.

XENARTHRA.

BRADYPODIDÆ.

E. 620. Three-toed Sloth (*Bradypus tridactylus*): ossicula of both sides. M.C., 3423 B.

E. 621. Three-toed Sloth (*Bradypus tridactylus*): ossicula of both sides, lacking the right malleus. From a young specimen. The aperture between the crura of the stapes is wider than in the adult. M.C., 3433.

E. 622. Three-toed Sloth (*Bradypus tridactylus*): right malleus and incus. M.C., 3423 A.

Doran, *l. c.*, p. 470.

E. 623. Two-toed Sloth (*Cholœpus didactylus*): the ossicula of the right side (in the middle), the right and left malleus and incus (above), and the left incus (below). M.C., 3438 B.

E. 624. Two-toed Sloth (*Cholœpus didactylus*): ossicula of the left side. From a new-born specimen. M.C., 3438 C.

Doran, *l. c.*, p. 471.

MEGATHERIDÆ.

E. 625. *Grypotherium listai* : ossicula of the right side. The ossicles of *Grypotherium* closely resemble those of existing Sloths, especially of *Cholœpus didactylus*.
Presented by Dr. F. P. Moreno.
Smith Woodward, Proc. Zool. Soc. 1900, p. 69, pl. vi. fig. 4.

E. 626. *Grypotherium listai*: ossicula of the left side, from the same individual as the preceding. The malleus and incus are still united. In this individual (Smith Woodward's skull No. 1) the malleus articulates with the incus not only by the head, but also by a small facette situated below the head. *Presented by Dr. F. P. Moreno.*

E. 627. *Grypotherium listai* : right malleus and incus.
Presented by Dr. F. P. Moreno.

E. 628. *Grypotherium listai* : ossicula of the left side.
Presented by Dr. F. P. Moreno.

MYRMECOPHAGIDÆ.

E. 629. Great Anteater (*Myrmecophaga jubata*): the malleus and incus of both sides, with the left stapes of another individual. M.C., 3543.
Doran, *l. c.*, p. 475.

E. 630. Tamandua Anteater (*Tamandua tetradactyla*) : right malleus and incus, and a left malleus.
Osteol. Series, 3547 ; M.C., 3547.
Doran, *l. c.*, p. 475.

E. 631. Tamandua Anteater (*Tamandua tetradactyla*) : right malleus and incus, and left malleus.
Osteol. Series, 3548 ; M.C., 3548.

E. 632. Prehensile-tailed Anteater (*Cycloturus didactylus*) : ossicula of the right side. M.C., 3552.
Doran, *l. c.*, p. 475.

E. 633. Prehensile-tailed Anteater (*Cycloturus didactylus*): left malleus and incus. M.C., 3552 A.

LORICATA.

DASYPODIDÆ.

E. 634. Six-banded Armadillo (*Dasypus sexcinctus*): ossicula of the right side. Osteol. Series, 3567; M.C., 3567.
Presented by the Zoological Society.
Doran, *l. c.*, p. 472.

E. 635. Hairy Armadillo (*Dasypus villosus*): ossicula of the right side. M.C., 3573.

E. 636. Hairy Armadillo (*Dasypus villosus*): ossicula of the left side, from a fully developed fœtus. M.C., 3573 A.

E. 637. Little Armadillo (*Zaëdyus minutus*): ossicula of the right side. Osteol. Series, 3576; M.C., 3576.

E. 638. Great Armadillo (*Priodontes giganteus*): the ossicula of the left side, and the malleus of the right. M.C., 3580.
Doran, *l. c.*, p. 473.

E. 639. Three-banded Armadillo (*Tolypeutes conurus*): ossicula of the right side. Osteol. Series, 3581; M.C., 3581.
Presented by Charles Darwin, Esq.
Doran, *l. c.*, p. 473.

E. 640. Nine-banded Armadillo (*Tatusia novemcincta*): malleus and incus of both sides, one stapes, and an imperfect cast of the bony labyrinth. M.C., 3553
Max Hübrich Collection.
Doran, *l. c.*, p. 473.

E. 641. Seven-banded Armadillo (*Tatusia hybrida*): ossicula of the right side, from a fœtus at full term. M.C., 3565 A.

NOMARTHRA.

MANIDÆ.

E. 642. Chinese Pangolin (*Manis aurita*): ossicula of the left side. The stapes is peculiarly sauropsidan. M.C., 3615.
Doran, *l. c.*, p. 474.

E. 643. Chinese Pangolin (*Manis aurita*): right malleus and incus. M.C., 3615 A.

E. 644. Javan Pangolin (*Manis javanica*): ossicula of the left side. Osteol. Series, 3618; M.C., 3618.
Howship Collection.

E. 645. Long-tailed Pangolin (*Manis tetradactyla*): ossicula of both sides, from a young specimen.
Osteol. Series, 3621; M.C., 3621.
Brookes Collection.

E. 646. Long-tailed Pangolin (*Manis tetradactyla*): malleus and incus of the left side.

E. 647. White-bellied Pangolin (*Manis tricuspis*): ossicula of the right side. M.C., A 3621.

ORYCTEROPIDÆ.

E. 648. Aard-Vaark (*Orycteropus afer*): right tympanic bone and ossicula, from a new-born example. M.C., 3625 A.
Doran, *l. c.*, p. 476.

E. 649. Aard-Vaark (*Orycteropus afer*): left malleus (the processus gracilis was firmly anchylosed to the tympanic bone as in the Kangaroos), with the right stapes and incus from another specimen. M.C., 3623.

CETACEA.

Doran, *l. c.*, p. 463.

ODONTOCETI.

DELPHINIDÆ.

E. 650. *Delphinus* sp.: ossicula of the left side. Note the enlarged stapedial crus of the incus, characteristic of Delphinidæ. M.C., 3031.
Doran, *l. c.*, p. 459.

E. 651. *Delphinus* sp.: ossicula of the left side, from a fœtus.

E. 652. *Clymenia obscurus* : right malleus and stapes, and left malleus. The latter is attached to the tympanic bone.
M.C., 3030.
Presented by Captain Almond.

E. 653. Sharp-nosed Dolphin (*Lagenorhynchus acutus*) : malleus and incus of the right side and stapes of the left.
M.C., 3025.
Doran, *l. c.*, p. 460.

E. 654. Tasmanian Dolphin (*Globicephalus* sp.) : ossicula of the eft side. M.C., 2994.
Doran, *l. c.*, p. 460.

E. 655. Tasmanian Dolphin (*Globicephalus* sp.) : ossicula of both sides, lacking the left incus. The right incus and malleus are articulated together. M.C., 2995.

E. 656. Tasmanian Dolphin (*Globicephalus* sp.) : three right mallei, a right incus, and three stapedes. M.C., 2996.

E. 657. *Pseudorca crassidens* : ossicula from both sides. The malleus and incus are from Osteol. Series, 2983.
M.C., 2983.
Presented by W. L. Crowther, Esq.
Doran, *l. c.*, p. 461.

E. 658. *Pseudorca crassidens* : right malleus and incus.
Osteol. Series, 2986 ; M.C., 2986.
Presented by W. L. Crowther, Esq.

E. 659. Grampus (*Orca* sp.) : ossicula of the right side, and the malleus and stapes of the left. M.C., 2979 A.
Doran, *l. c.*, p. 461.

E. 660. Killer (*Orca orca*) : both stapedes and the left malleus.
M.C., 2979.

E. 661. Porpoise (*Phocæna phocæna*) : ossicula of the left side and the right stapes, from a young individual.
M.C., 2972 A.
Doran, *l. c.*, p. 460.

E. 662. Porpoise (*Phocœna phocœna*): ossicula of the left side.
M.C., 2972.

E. 663. Beluga (*Delphinapterus leucas*): ossicula of both sides The left malleus and incus are articulated.
Osteol Series, 2958; M.C., 2958.

Doran, *l. c.*, p. 460.

E. 664. Beluga (*Delphinapterus leucas*): ossicula of both sides. The membrana tympani and tensor tympani are preserved in connection with the left malleus. From a fœtal skull.
Osteol. Series, 2964; M.C., 2964.

E. 665. Narwhal (*Monodon monoceros*): ossicula of the right side. The membrana tympani and the tendon of the tensor tympani are preserved in connection with the malleus. M.C., 2944 A.

Doran, *l. c.*, p. 461.

E. 666. Narwhal (*Monodon monoceros*): left stapes from an adult female. It was not ankylosed to the fenestra ovalis.
M.C., 2944.

E. 667. Narwhal (*Monodon*) (?): malleus of the right side, attached to the tympanic bone. M.C., 2944 B.

PLATANISTIDÆ.

E. 668. Soosoo (*Platanista gangetica*): ossicula of the right side, and the malleus and incus (articulated) of the left.
M.C., 2936 A.

Doran, *l. c.*, p. 462.

E. 669. Soosoo (*Platanista gangetica*): ossicula of the left side. The membrana tympani is still adherent to the malleus.
M.C., 2936 B.

E. 670. Soosoo (*Platanista gangetica*): the right malleus and incus. M.C., 2936 C.

PHYSETERIDÆ.

E. 671. Arnoux's Xiphoid Whale (*Berardius arnouxi*) : ossicula of the left side, and the right stapes. Note the extreme modification of the malleus in the Physeteridæ.
M.C., 2909.

Doran, *l. c.*, p. 457.

E. 672. *Mesoplodon grayi* : ossicula of the left side, and the right stapes. Osteol. Series, 2903 ; M.C., 2903.
Presented by Dr. Julius von Haast.

Doran, *l. c.*, p. 458.

E. 673. Bottle-nosed Whale (*Hyperoodon rostratus*) : ossicula of the right side. Osteol. Series, 2899 ; M.C., 2899.

Doran, *l. c.*, p. 457.

E. 674. Bottle-nosed Whale (*Hyperoodon rostratus*) : ossicula of the left side. Osteol. Series, 2899 ; M.C., 2899 A.

E. 675. Sperm-Whale (*Physeter macrocephalus*) : ossicula of both sides, from an adult. M.C., 2860.

Doran, *l. c.*, p. 456.

E. 676. Sperm-Whale (*Physeter macrocephalus*) : right malleus of an adult (Osteol. Series, 2361), and the right incus from another individual. M.C., 2861.

MYSTACOCETI.

BALÆNIDÆ.

E. 677. Rudolphi's Rorqual (*Balænoptera borealis*) : ossicula of the right side. M.C., 2762 C.

E. 678. Rudolphi's Rorqual (*Balænoptera borealis*) : ossicula of the left side. M.C., 2762 D.

E. 679. Rudolphi's Rorqual (*Balænoptera borealis*) : stapes.
M.C., 2762 B.
Presented by Professor Turner.

E. 680. Piked Whale (*Balænoptera acuto-rostrata*) : ossicula of the right side, from a nearly adult male.
Osteol. Series, 2757 ; M.C., 2757.
Presented by J. H. Gurney, Esq.
Doran, *l. c.*, p. 453.

E. 681. Greenland Whale (*Balæna mysticetus*) : ossicula of the left side, articulated. From a young specimen.
M.C., 2742 A.
Doran, *l. c.*, p. 450.

E. 682. Greenland Whale (*Balæna mysticetus*) : right incus, top of the right stapes, and base of the left stapes. From an adult female. Osteol. Series, 2742 ; M.C., 2742.

SIRENIA.

Doran, *l. c.*, p. 469.

MANATIDÆ.

E. 683. African Manatee (*Trichechus* [*Manatus*] *senegalensis*) : malleus of the left side.
Osteol. Series, 2735 ; M.C., 2736 A.
Presented by Captain Harris.
Doran, *l. c.*, p. 468.

E. 684. African Manatee (*Trichechus* [*Manatus*] *senegalensis*) : left incus and stapes. Osteol. Series, 2735 ; M.C., 2736 B.
Presented by Captain Harris.

E. 685. African Manatee (*Trichechus* [*Manatus*] *senegalensis*) : ossicula of the right side.
Osteol. Series, 2735 , M.C., 2736 C.
Presented by Captain Harris.

E. 686. African Manatee (*Trichechus* [*Manatus*] *senegalensis*) : left malleus and stapes. M.C., 2736 D.

E. 687. American Manatee (*Trichechus manatus*) : malleus and incus of the left side. Osteol. Series, 2729 ; M.C., 2729.
Presented by Henry Christy, Esq.
Doran, *l. c.*, p. 467.

HALICORIDÆ.

E. 688. Dugong (*Halicore dugong*) : ossicula of the right side.
Osteol. Series, 2697 ; M.C., 2697.
Presented by Lieut. Helpman, R.N.

Doran, *l. c.*, p. 465.

E. 689. Dugong (*Halicore dugong*) : ossicula of the right side.
Osteol. Series, 2698 ; M.C., 2698.

E. 690. Steller's Sea-Cow (*Rhytina gigas*) : left malleus.
M.C., 2728 A.
Presented by Professor d'Arcy Thompson, C.B.

Doran, *l. c.*, p. 469, and Jour. Linn. Soc., vol. xvii. 1883, p. 366.

E. 691. Steller's Sea-Cow (*Rhytina gigas*) : left incus and stapes.
M.C., 2728 B.
Presented by Prof. D'Arcy Thompson, C.B.

UNGULATA.

Doran, *l. c.*, p. 431.

HYRACOIDEA.

PROCAVIIDÆ.

E. 692. Cape Hyrax (*Procavia capensis*) : ossicula of the right side.
M.C., 2236 A.

Doran, *l. c.*, p. 432.

E. 693. Tree-Hyrax (*Dendrohyrax dorsalis*) : malleus and incus of both sides, with the stapes of the left side. The right malleus and incus are firmly articulated (Osteol. Series, 2240). The left malleus and incus are from Osteol. Series, 2239.
M.C., 2240.

E. 694. Tree-Hyrax (*Dendrohyrax dorsalis*) : ossicula of the left side.
M.C., 2240 A.

PROBOSCIDEA.

ELEPHANTIDÆ.

E. 695. Indian Elephant (*Elephas indicus*): ossicula of the right side. Taken from a female Elephant which lived in the Zoological Gardens from 1851 to 1875. M.C., 2264 B.
Doran, *l. c.*, p. 430.

E. 696. The left ossicula from the same individual. M.C., 2264 C.

E. 697. Indian Elephant (*Elephas indicus*): right malleus and incus, with the left stapes from another individual. M.C., 2264 A.

E. 698. Indian Elephant (*Elephas indicus*): ossicula of the right side, from a young individual. M.C., 2264 D.

E. 699. The left ossicula of the same specimen. M.C., 2264 E.

E. 700. African Elephant (*Elephas africanus*): left malleus and stapes, from a young specimen. M.C., 2496.
Doran, *l. c.*, p. 431.

PERISSODACTYLA.

TAPIRIDÆ.

E. 701. Baird's Tapir (*Tapirus bairdi*): the left malleus and incus, and right malleus. M.C., 1973 A.
Doran, *l. c.*, p. 420.

E. 702. Baird's Tapir (*Tapirus bairdi*): mutilated malleus and incus of both sides, from a young individual.
Osteol. Series, 1973; M.C., 1973.

RHINOCEROTIDÆ.

E. 703. Two-horned Rhinoceros (*Rhinoceros bicornis*): left ossicula, from a very large skull. The malleus is of a peculiarly low type. Osteol. Series, 2149; M.C., 2149.
Doran, *l. c.*, p. 419. *Hunterian.*

E. 704. Sumatran Rhinoceros (*R. sumatrensis*) : right malleus and stapes, with the left malleus.
Osteol. Series, 2141 ; M.C., 2141.
Presented by Sir T. Stamford Raffles.
Doran, *l. c.*, p. 420.

E. 705. Sondaic Rhinoceros (*R. sondaicus*) : malleus and incus of the right side. Osteol. Series, 2134 ; M.C., 2134.
Doran, *l. c.*, p. 420.

EQUIDÆ.

E. 706. Horse (*Equus caballus*) : ossicula of both sides, from a foal six days old. M.C., 2071.
Doran, *l. c.*, p. 420.

E. 707. Horse (*Equus caballus*) : ossicula of the right side, from a large cart-horse. M.C., 2029 A.

E. 708. Horse (*Equus caballus*) : malleus and stapes of the right side. M.C., 2071 A.

E. 709. Zebra (*Equus zebra*) : ossicula of the left side, with the malleus and stapes of the right.
Osteol. Series, 2115 ; M.C., 2115.
Doran, *l. c.*, p. 421.

E. 710. Ass (*Equus asinus*) : ossicula of the left side.
M.C., 2102 A.
From the Collection of the late Mr. Swan.
Doran, *l. c.*, p. 421.

E. 711. Ass (*Equus asinus*) : a rough preparation of the internal bony ear and the tympanum of the right side.
M.C., 2102 B.

ARTIODACTYLA.

SUIDÆ.

E. 712. Pig (*Sus scrofa*) : ossicula of both sides, from a fœtus.
Osteol. Series, 1794 ; M.C., 1794.
Doran, *l. c.*, p. 422.

E. 713. Pig (*Sus scrofa*) : ossicula of the right side and a cast of the cavity of the bony labyrinth. M.C., 1765.
Max Hübrich Collection.

E. 714. Babirussa (*Babirussa babirussa*) : ossicula of the right side, and the malleus and stapes of the left. M.C., 1831 A.
Doran, *l. c.*, p. 423.

E. 715. Babirussa (*B. babirussa*) : left malleus.
Osteol. Series, 1831 ; M.C., 1831.
Presented by T. H. Stewart, Esq.

E. 716. Wart-Hog (*Phacochœrus æthiopicus*) : ossicula of the right side, and malleus and incus of the left. M.C., 1852.
Doran, *l. c.*, p. 422.

E. 717. Collared Peccary (*Tayassu tajaçu*) : ossicula of the right side. Osteol. Series, 1741 ; M.C., 1741.
Doran, *l. c.*, p. 423.

HIPPOPOTAMIDÆ.

E. 718. Hippopotamus (*H. amphibius*) : ossicula of both sides. M.C., 1858.
Doran, *l. c.*, p. 421.

E. 719. Hippopotamus (*H. amphibius*) : ossicula of the right side, from a specimen two days old born in the Zoological Gardens, Feb. 21, 1871. Osteol. Series, 1872 ; M.C., 1872.

CAMELIDÆ.

E. 720. Camel (*Camelus dromedarius*) : the ossicula of both sides. The stapedes are damaged. The stapedius tendons are extensively ossified. M.C., 1696.
Doran, *l. c.*, p. 424.

E. 721. Camel (*Camelus dromedarius*) : right and left malleus. M.C., 1696 A.

E. 722. Llama (*Lama glama*) : ossicula of the left side, and the malleus and incus of the right. M.C., 1698.
Doran, *l. c.*, p. 424.

E. 723. Alpaca (*Lama pacos*) : right malleus. M.C., 1704.

TRAGULIDÆ.

E. 724. Javan Chevrotain (*Tragulus javanicus*) : ossicula of both sides. The stapedes are from an adult, the rest from a young animal. M.C., 1673.
Doran, *l. c.,* p. 423.

E. 725. Javan Chevrotain (*Tragulus javanicus*) : ossicula of the right side. M.C., A 1682.
Doran, *l. c.*, p. 424.

E. 726. Napu Chevrotain (*Tragulus napu*) : ossicula of both sides. M.C., 1682 A.

E. 727. Napu Chevrotain (*Tragulus napu*) : malleus and incus of the left side. M.C., 1682 B.

CERVIDÆ.

E. 728. Musk-Deer (*Moschus moschiferus*) : ossicula of the right side. M.C., 1445.
Doran, *l. c.*, p. 430.

E. 729. Musk-Deer (*Moschus moschiferus*) : ossicula of the left side. M.C., 1445 A.
Presented by the Zoological Society.

E. 730. Chinese Water-Deer (*Hydropotes inermis*) : ossicula of the left side and a second left incus. M.C., 1651.
Doran, *l. c.*, p. 430.

E. 731. Indian Muntjac (*Cervulus muntjac*) : ossicula of the left side, and the stapes of the right.
Osteol. Series, 1455 ; M.C., 1455.
Doran, *l. c.*, p. 430.

E. 732. Axis Deer (*Cervus axis*) : malleus and incus of both sides. Osteol. Series, 1490 ; M.C., 1490.
Doran, *l. c.*, p. 429.

E. 733. Red Deer (*Cervus elaphus*) : ossicula of the right side, from an adult male. M.C., 1492.

E. 734. Red Deer (*Cervus elaphus*) : ossicula of the left side.
Osteol. Series, 1494 ; M.C., 1494.
Presented by N. E. Vaughan, Esq.

E. 735. Fallow-Deer (*Cervus dama*) : malleus of both sides and the right stapes, from a fawn.
Osteol. Series, 1571 ; M.C., 1527.

E. 736. Roe (*Capreolus caprea*) : tympanic bone, bony labyrinth, and ossicula of the left side. M.C., 1636.
Max Hübrich Collection.

E. 737. Mexican Deer (*Cariacus mexicanus*) : malleus of both sides and the right stapes.
Osteol. Series, 1662 ; M.C., 1662.

E. 738. Pudu Deer (*Pudu pudu*) : malleus of both sides.
Osteol. Series, 1668 ; M.C., 1668.

GIRAFFIDÆ.

E. 739. Giraffe (*Giraffa camelopardalis*) : ossicula of both sides, from a young male. M.C., 1437.
Doran, *l. c.*, p. 429.

E. 740. Giraffe (*Giraffa camelopardalis*) : left ossicula, from a young individual. M.C., 1440.

ANTILOCAPRIDÆ.

E. 741. Prong-horn Antelope (*Antilocapra americana*) : ossicula of the right side. M.C., 1424.
Doran, *l. c.*, p. 424.

E. 742. Prong-horn Antelope (*Antilocapra americana*) : malleus and stapes of the left side. M.C., 1419.

BOVIDÆ.

E. 743. Bubal (*Bubalis boselaphus*) : ossicula of the right side, with the malleus and incus of the left. M.C., C 1406.
Doran, *l. c.*, p. 429.

E. 744. Tora (*Bubalis tora*) : left malleus. M.C., A 1406.

E. 745. Sassaby (*Damaliscus lunatus*) : left malleus.
M.C., 1408.
Presented by Sir Victor Brooke, Bt.
Doran, *l. c.*, p. 429.

E. 746. Bontebok (*Damaliscus pygargus*) : both mallei.
M.C., 1407 A.
Presented by Sir Victor Brooke, Bt.
Doran, *l. c.*, p. 429.

E. 747. White-tailed Gnu (*Connochætes gnu*) : both mallei and the right stapes. Osteol. Series, 1412 ; M.C., 1412.
Doran, *l. c.*, p. 429.

E. 748. Brindled Gnu (*Connochætes taurinus*) : right malleus and left stapes. Osteol. Series, 1414 ; M.C., 1414.

E. 749. Maxwell's Duiker (*Cephalophus maxwelli*) : ossicula of both sides. Those of the left side from another and larger specimen. M.C., 1391 C.
Presented by Sir Victor Brooke, Bt.
Doran, *l. c.*, p. 428.

E. 750. Common Duiker (*Cephalophus grimmi*) : both mallei.
Osteol. Series, 1394 ; M.C., 1394.
Presented by B. Travers, Esq.

E. 751. Four-horned Antelope (*Tetraceros quadricornis*) : ossicula of the left side. Osteol. Series, 1399 ; M.C., 1399.
Presented by R. C. Beavan, Esq.
Doran, *l. c.*, p. 428.

E. 752. Klipspringer (*Oreotragus saltator*) : right malleus.
M.C., H 1387.
Doran, *l. c.*, p. 428.

E. 753. Zanzibar Antelope (*Nesotragus moschatus*) : two left mallei, and a right malleus. M. C., B 1390.
Doran, *l. c.*, p. 428.

E. 754. Royal Antelope (*Neotragus pygmæus*) : ossicula of the right side. M.C., F 1387.

Presented by Sir Victor Brooke, Bt.

Doran, *l. c.*, p. 428.

E. 755. Abyssinian Ourebi (*Ourebia montana*) : ossicula of the right side. M.C., E 1387.

Doran, *l. c.*, p. 428.

E. 756. Common Water-buck (*Kobus ellipsiprymnus*) : left malleus and incus. M.C., 1387.

Presented by Sir Victor Brooke, Bt.

Doran, *l. c.*, p. 428.

E. 757. Black Buck (*Antilope cervicapra*) : right malleus and stapes. M.C., 1376.

Doran, *l. c.*, p. 428.

E. 758. Saiga (*Saiga tatarica*) : ossicula of the right side, and the malleus of the left. M.C., 1369.

Presented by Sir Victor Brooke, Bt.

Doran, *l. c.*, p. 428.

E. 759. Dorcas Gazelle (*Gazella dorcas*) : ossicula of both sides. M.C., 1361.

Doran, *l. c.*, p. 428.

E. 760. *Gazella* sp. (probably *dorcas*) : ossicula of both sides. M.C., 1361 A.

E. 761. Indian Gazelle (*Gazella bennetti*) : ossicula of the left side. M.C., 1364.

E. 762. Tibetan Gazelle (*Gazella picticauda*) : mallei and left incus. M.C., A 1735.

E. 763. *Gazella lævipes* : right malleus and incus. M.C., A 1364.

E. 764. Harnessed Antelope (*Tragelaphus scriptus*) : left malleus and incus. M.C., 1345 B.

Presented by Sir Victor Brooke, Bt.

Doran, *l. c.*, p. 429.

E. 765. Chamois (*Rupicapra tragus*) : ossicula of both sides. M.C., 1327.

Doran, *l. c.*, p. 427.

E. 766. Himalayan Goral (*Nemorrhædus goral*) : right malleus and the incus of both sides. M.C., 1317.

E. 767. Cambing-utan (*Nemorrhædus sumatrensis*) : right malleus and stapes. M.C., 1323.

Doran, *l. c.*, p. 428.

E. 768. Goat (*Capra hircus*) : tympanic bone, bony labyrinth, and ossicula of the left side; and a cast of the cavity of a cochlea. The malleus is preserved in position. M.C., 1300.

Max Hübrich Collection.

Doran, *l. c.*, p. 427.

E. 769. Markhoor (*Capra megaceros*) : ossicula of the left side, with the malleus and incus of the right. M.C., 1310 A.

Presented by Sir Victor Brooke, Bart.

E. 770. Grecian Ibex (*Capra hircus*) : ossicula of the left side. Osteol. Series, 1304 ; M.C., 1304.

Presented by W. H. Colvill, Esq.

E. 771. Alpine Ibex (*Capra ibex*) : the mallei. M.C., 1286.

E. 772. Sheep (*Ovis aries*) : ossicula and bony labyrinth of both sides, from a lamb. M.C., 1244.

Max Hübrich Collection.

Doran, *l. c.*, p. 425.

E. 773. Sheep (*Ovis aries*) : the tympanic bone of the right side. M.C., 1244 A.

Max Hübrich Collection.

E. 774. Sheep (*Ovis aries*) : ossicula of both sides, from an adult. M.C., 1223 A.

Doran, *l. c.*, p. 425.

E. 775. Sheep (*Ovis aries*) : right malleus. M.C., 1223.

E. 776. Nahoor (*Ovis nahoor*) : ossicula of the right side.
Osteol. Series, 1278 ; M.C., 1278.
Presented by General R. Strachey.
Doran, *l. c.*, p. 427.

E. 777. Musk-Ox (*Ovibos moschatus*) : ossicula of both sides.
M.C., 1213.
Doran, *l. c.*, p. 429.

E. 778. Anoa (*Anoa depressicornis*) : ossicula of the left side.
Osteol. Series, 1173 ; M.C., 1173.
Presented by Dr. B. C. Henderson.
Doran, *l. c.*, p. 429.

E. 779. Ox (*Bos taurus*) : ossicula of both sides, from a specimen six weeks old. M.C., 1310.
Doran, *l. c.*, p. 425.

E. 780. Ox (*Bos taurus*) : the left tympanic bone and bony labyrinth, with the ossicula of both sides, lacking one stapes, from a calf. M.C., 1127 A.
Max Hübrich Collection.
Doran, *l. c.*, p. 426.

E. 781. Ox (*Bos taurus*) : ossicula of the left side, from a full-term fœtus. Osteol. Series, 1133 ; M.C., 1131.

E. 782. Ox (*Bos taurus*) : ossicula of the left side, from a large adult skull. M.C., 1131 A.

E. 783. Zebu (*Bos taurus*) : ossicula of the right side.
Osteol. Series, 1149 ; M.C., 1149.
Doran, *l. c.*, p. 427.

RODENTIA.

Doran, *l. c.*, p. 418.

SCIUROMORPHA.

ANOMALURIDÆ.

E. 784. Fraser's Scaly-tailed Squirrel (*Anomalurus fraseri*) : ossicula of the right side, with the left malleus and incus.
Osteol. Series, 3065 ; M.C., 3065.
Presented by Capt. R. Burton.
Doran, *l. c.*, p. 408.

PEDETIDÆ.

E. 785. Cape Jumping-Hare (*Pedetes caffer*): a mutilated malleus and a stapes. M.C., 3199.

Doran, *l. c.*, p. 414.

SCIURIDÆ.

E. 786. Common Squirrel (*Sciurus vulgaris*): tympanic bone, bony labyrinth, and ossicula of the right side (the malleus and incus articulated), with the left malleus, from a young skull. M.C., 3072.

Max Hübrich Collection.

Doran, *l. c.*, p. 408.

E. 787. Malabar Squirrel (*Ratufa indica*): ossicula of both sides. Osteol. Series, 3075 ; M.C., 3075.

Presented by Capt. Gideon.

Doran, *l. c.*, p. 407.

E. 788. Jelerang Squirrel (*Sciurus bicolor*): ossicula of the right side. Osteol. Series, 3073 ; M.C., 3073.

Doran, *l. c.*, p. 408. *Hunterian.*

E. 789. Bristly Ground-Squirrel (*Xerus capensis*): ossicula of both sides. M.C., 3086.

E. 790. Chipping-Squirrel (*Tamias asiaticus*): ossicula of the right side. M.C., 3088 B.

Doran, *l. c.*, p. 408.

E. 791. Flying Squirrel (*Pteromys nitidus*): ossicula of the right side. Osteol. Series, 3066 ; M.C., 3066.

Doran, *l. c.*, p. 409.

E. 792. Prairie Marmot (*Cynomys ludovicianus*): ossicula of the left side. M.C., 3093 A.

Doran, *l. c.*, p. 409.

E. 793. Alpine Marmot (*Arctomys marmotta*): ossicula of the right side. M.C., 3096 A.

E. 794. European Souslik (*Spermophilus citillus*): ossicula of both sides. Osteol. Series, 3090; M.C., 3090.
Presented by the Zoological Society.
Doran, *l. c.*, p. 408.

CASTORIDÆ.

E. 795. European Beaver (*Castor fiber*): ossicula of the left side. M.C., 3104.
Doran, *l. c.*, p. 410.

E. 796. European Beaver (*Castor fiber*): part of skull, showing tympanic chamber and bony labyrinth of the right side. M.C., 3105.

E. 797. Canadian Beaver (*Castor canadensis*): ossicula of the right side. Osteol. Series, 3122; M.C., 3122.
Hunterian.

MYOMORPHA.

MYOXIDÆ.

E. 798. Fat Dormouse (*Myoxus glis*): ossicula of both sides. Osteol. Series, 3130; M.C., 3130.
Doran, *l. c.*, p. 409.

E. 799. Common Dormouse (*Muscardinus avellanarius*): ossicula of the right side. Osteol. Series, 3131; M.C., 3131.
Presented by Miss V. J. Flower.

E. 800. Golden-bellied Beaver-Rat (*Hydromys chrysogaster*): ossicula of the left side. Osteol. Series, 3132; M.C., 3132.
Doran, *l. c.*, p. 411.

E. 801. Hamster (*Cricetus cricetus*): right malleus and incus. Osteol. Series, 3138; M.C., 3138 A.
Presented by the Zoological Society.
Doran, *l. c.*, p. 412.

E. 802. Field-Mouse (*Microtus agrestis*): bony labyrinth and ossicula of both sides. M.C., 3178 A.
Max Hübrich Collection.
Doran, *l. c.*, p. 411.

E. 803. Field-Mouse (*Microtus agrestis*): tympanic bone, bony labyrinth, and ossicula of the right side. The malleus is attached to the tympanic bone. M.C., 3178.
Max Hübrich Collection.

E. 804. Field-Mouse (*Microtus agrestis*): skull, showing the tympanic bullæ. M.C., 3178 B.
Max Hübrich Collection.

E. 805. Water-Vole (*Arvicola terrestris*): ossicula of the left side. M.C., 3176.
Doran, *l. c.*, p. 411.

E. 806. Musquash (*Fiber zibethicus*): ossicula of the right side. M.C., 3171.
Doran, *l. c.*, p. 411.

E. 807. *Ellobius talpinus*: ossicula of the right side (the malleus and incus are united), and the left malleus and incus.
Osteol. Series, 3180; M.C., 3180.
Presented by Professor Peters.
Doran, *l. c.*, p. 412.

E. 808. Black Rat (*Mus rattus*): bony labyrinth of both sides, with two tympanic bones and two sets of ossicles from the right side. One malleus is in its natural position. There is a well marked orbicular apophysis on the malleus.
M.C., 3142.
Max Hübrich Collection.

E. 809. Norway Rat (*Mus decumanus*): right malleus and incus.
Osteol. Series, 3147; M.C., 3147.
Presented by Professor Owen.
Doran, *l. c.*, p. 410.

E. 810. House-Mouse (*Mus musculus*): tympanic bone, bony labyrinth, and ossicula of the left side. The malleus is in its natural position. M.C., 3160.
Max Hübrich Collection.

E. 811. House-Mouse (*Mus musculus*): tympanic bone and malleus and incus of the left side. The malleus is in position. M.C., 3160 A.

E. 812. Mitchell's Hapalote (*Conilurus mitchelli*): ossicula of both sides, lacking the right stapes. M.C., A 3166.
Doran, *l. c.*, p. 411.

SPALACIDÆ.

E. 813. Mole-Rat (*Spalax typhlus*): ossicula of the right side.
Osteol. Series, 3181; M.C., 3181.
Doran, *l. c.*, p. 412.

E. 814. Bay Bamboo-Rat (*Rhizomys badius*): ossicula of the right side. M.C., 3184.
Doran, *l. c.*, p. 412.

BATHYERGIDÆ.

E. 815. Coast Rat (*Bathyergus maritimus*): ossicula of the right side. The malleus and incus are united.
Osteol. Series, 3186; M.C., 3186
Presented by Thomas Keate, Esq.
Doran, *l. c.*, p. 413.

GEOMYIDÆ.

E. 816. Pouched Gopher (*Geomys bursarius*): ossicula of the right side. M.C., 3192.
Doran, *l. c.*, p. 413.

DIPODIDÆ.

E. 817. Egyptian Jerboa (*Dipus sagitta*): ossicula of both sides, lacking the left stapes. M.C., 3194.
Doran, *l. c.*, p. 414.

E. 818. Egyptian Jerboa (*Dipus sagitta*): ossicula of both sides. The malleus and incus are united. M.C., 3195.

HYSTRICOMORPHA.

OCTODONTIDÆ.

E. 819. Cuming's Octodon (*Octodon degus*): ossicula of both sides, from a very young skull. The left incus is malformed.
Osteol. Series, 3205; M.C., 3205.
Presented by Professor Flower.
Doran, *l. c.*, p. 415.

E. 820. Fournier's Capromys (*Capromys pilorides*): ossicula of the left side, with the right malleus and incus from another individual. The malleus and incus are articulated.

M.C., 3210.

Doran, *l. c.*, p. 415.

E. 821. Ground-Rat (*Thryonomys swindernianus*): ossicula of the left side. Osteol. Series, 3214; M.C., 3214.

Presented by R. J. Garden, Esq.

Doran, *l. c.*, p. 415.

COENDIDÆ.

E. 822. Guianan Tree-Porcupine (*Coendu insidiosus*): ossicula of the right side. The malleus and incus are articulated.

M.C., 3216.

Doran, *l. c.*, p. 415.

HYSTRICIDÆ.

E. 823. Crested Porcupine (*Hystrix cristata*): ossicula of the right side. The malleus and incus are articulated.

Osteol. Series, 3224; M.C., 3224.

Doran, *l. c.*, p. 414.

E. 824. Javan Porcupine (*Hystrix javanica*): ossicula of the right side. The malleus and incus are articulated.

Osteol. Series, 3231; M.C., 3232 A.

Presented by the Zoological Society.

Doran, *l. c.*, p. 415.

LAGOSTOMIDÆ.

E. 825. Chinchilla (*Chinchilla lanigera*): ossicula of the right side. The malleus and incus are articulated. The head of the malleus is extremely developed.

Doran, *l. c.*, p. 416.

DASYPROCTIDÆ.

E. 826. Golden Agouti (*Dasyprocta aguti*): right periotic and tympanic bones, with the floor of the auditory bulla removed, showing the prominence of the periotic that encloses the cochlea. M.C., 3249 B.

E. 827. Golden Agouti (*Dasyprocta aguti*): left tympanic and periotic bones, prepared in a similar way, but with the cochlea laid open. The stapes is retained in position.
M.C., 3249 A.

E. 828. Golden Agouti (*Dasyprocta aguti*): ossicula of the right side, with the malleus and incus articulated. M.C., 3249 C.
Doran, *l. c.*, p. 416.

E. 829. West-Indian Agouti (*Dasyprocta cristata*): malleus and incus of the left side (articulated) and stapes of the right. M.C., A 3250.
Doran, *l. c.*, p. 416.

E. 830. Spotted Cavy (*Agouti paca*): left malleus and incus, articulated. Osteol. Series, 3255; M.C., 3255.
Doran, *l. c.*, p. 416.

CAVIIDÆ.

E. 831. Guinea-Pig (*Cavia porcellus*): tympanic bone, bony labyrinth, and ossicula of both sides. The left stapes is in position. The mallei and incudes are articulated.
M.C., 3267 A.
Max Hübrich Collection.
Doran, *l. c.*, p. 417.

E. 832. Guinea-Pig (*Cavia porcellus*): portions of the skull, prepared to show the cochlea of both sides. The left has been opened. M.C., 3267 B.

E. 833. Patagonian Cavy (*Dolichotis magellanica*): ossicula of the right side, with the malleus and incus articulated.
Osteol. Series, 3268; M.C., 3268.
Doran, *l. c.*, p. 416.

E. 834. Capybara (*Hydrochœrus capybara*): the ossicula of both sides, from an individual eight days old.
Osteol. Series, 3276; M.C., 3276.
Doran, *l. c.*, p. 417.

LAGOMORPHA.

LEPORIDÆ.

E. 835. Hare (*Lepus europæus*): three specimens of the tympanic bone, with the bony labyrinth of the right side, the left cochlea in section, and the ossicula. M.C., 3281 C.
Max Hübrich Collection.
Doran, *l. c.*, p. 417.

E. 836. Hare (*Lepus europæus*): bony labyrinth and ossicula of the right side. M.C., 3281 B.
Max Hübrich Collection.

E. 837. Hare (*Lepus europæus*): bony labyrinth and ossicula of the left side. M.C., 3281 A.
Max Hübrich Collection.

E. 838. Hare (*Lepus europæus*): part of the right side of the skull, showing the tympanic membrane and cavity, and the various parts of the internal ear in section. A bristle is passed behind the tensor tympani muscle and the stapes. M.C., 3281 D.
Max Hübrich Collection.

E. 839. Rabbit (*Lepus cuniculus*): tympanic bone, bony labyrinth, and ossicula of both sides. The left ossicles are in their natural position. The processus muscularis mallei is situated on the inner edge of the manubrium at some distance from its root. M.C., 3316 A.
Max Hübrich Collection.
Doran, *l. c.*, p. 418.

E. 840. Rabbit (*Lepus cuniculus*): ossicula of the left side. The processus muscularis mallei is situated on the root of the manubrium. M.C., 3316 B.

PINNIPEDIA.

Doran, *l. c.*, p. 407.

OTARIIDÆ.

E. 841. Falkland-Island Sea-Lion (*Otaria australis*): ossicula of both sides. Note the small size of the ossicles compared with those of Phocidæ. M.C., 983.
Doran, *l. c.*, p. 401.

E. 842. Steller's Sea-Lion (*Otaria stelleri*); ossicula of the left side, with the right malleus.
Osteol. Series, 979; M.C., 979.
Doran, *l. c.*, p. 400.

E. 843. Californian Sea-Lion (*Otaria californiana*): ossicula of both sides. From a young specimen once living in the Southport Aquarium. M.C., 981.

E. 844. Southern Sea-Lion (*Otaria jubata*): left incus, from a young specimen. M.C., 978.
Doran, *l. c.*, p. 400.

E. 845. Walrus (*Odobœnus rosmarus*): ossicula of both sides.
M.C., 1008 A.
Doran, *l. c.*, p. 401.

E. 846. Walrus (*Odobœnus rosmarus*): incus and stapes of the left side. M.C., 1008 B.

PHOCIDÆ.

E. 847. Grey Seal (*Halichœrus grypus*): ossicula of the left side. The ossicles closely resemble those of *Phoca barbata*.
M.C., 1061.
Doran, *l. c.*, p. 406.

E. 848. Grey Seal (*Halichœrus grypus*): right incus.
Osteol. Series, 1060; M.C., 1060.

E. 849. Common Seal (*Phoca vitulina*): ossicula of both sides.
M.C., 1066.
Doran, *l. c.*, p. 404.

E. 850. Common Seal (*Phoca vitulina*): ossicula of both sides. The left malleus and incus are united, to show their double articulation. M.C., 1068.

E. 851. Harp Seal (*Phoca grœnlandica*): ossicula of the left side. Osteol. Series, 1079; M.C., 1079.
Doran, *l. c.*, p. 405.

E. 852. Ringed Seal (*Phoca fœtida*) : ossicula of both sides.
Osteol. Series, 1074; M.C., 1074.
Doran, *l. c.*, p. 406.

E. 853. Bearded Seal (*Phoca barbata*) : ossicula of both sides. The right malleus and incus are from Osteol. Series, 1086; the remainder from Osteol. Series, 1087. M.C., 1086.

E. 854. Bearded Seal (*Phoca barbata*) : malleus and incus of both sides. The left malleus and incus are united. There is no second articulation, as in *Phoca vitulina*.
M.C., 1087 A.
Doran, *l. c.*, p. 406.

E. 855. Monk-Seal (*Monachus albiventer*): left malleus and incus. The malleus resembles that of *Phoca*, for the neck is not elongated as in *Cystophora*, nor so very short with a conspicuously short manubrium as in *Stenorhynchus*, *Lobodon*, or *Macrorhinus*. There is no extra articular process as in *P. vitulina*, a trace of a processus muscularis exists. The manubrium forms an angle with the body as wide as in *Phoca*; that is, midway between the wider angle of *Cystophora* and the sharper angle in *Macrorhinus* and the *Stenorhynchina*. The incus has decided tendencies to the *Stenorhynchus* type. It is larger and bulkier than that of *Phoca* or *Halichœrus*, and the development of the posterior part of the body and the deep grooved pit internal to the facets strongly remind one of the *Stenorhynchina*; in *Phoca* the groove internal to the facets is far shallower.
Osteol. Series, 1088; M.C., 1088.
Hunterian.

E. 856. Leopard-Seal (*Stenorhynchus leptonyx*) : ossicula of both sides. The left malleus and incus are articulated.
M.C., 1096.
Presented by Thomas Chevalier, Esq.
Doran, *l. c.*, p. 403.

E. 857. Leopard-Seal (*Stenorhynchus leptonyx*): malleus and incus of both sides from Osteol. Series, 1095, with the right stapes from Osteol. Series, 1092. M.C., 1095.

E. 858. Hooded Seal (*Cystophora cristata*): ossicula of both sides. M.C., 1105.
Doran, *l. c.*, p. 403.

E. 859. Elephant-Seal (*Macrorhinus leoninus*): right ossicula of a young specimen. Osteol. Series, 1107; M.C., 1107.
Doran, *l. c.*, p. 402.

E. 860. Elephant-Seal (*Macrorhinus leoninus*): ossicula of the left side. From the same individual as the preceding.
Osteol. Series, 1107; M.C., 1107 A.

E. 861. Elephant-Seal (*Macrorhinus leoninus*): right incus of an adult. M.C., 1106.

CARNIVORA.

Doran, *l. c.*, p. 406.

ARCTOIDEA.

URSIDÆ.

E. 862. Polar Bear (*Ursus maritimus*): ossicula of both sides.
M.C., 945.
Doran, *l. c.*, p. 399.

E. 863. American Black Bear (*Ursus americanus*): ossicula of the right side. M.C., 818.

E. 864. Spectacled Bear (*Tremarctos ornatus*): ossicula of the left side. Osteol. Series, 815; M.C., 815.
Doran, *l. c.*, p. 399

E. 865. Himalayan Black Bear (*Ursus thibetanus*): right and left malleus, and right stapes. M.C., 831.
Doran, *l. c.*, p. 399.

E. 866. Himalayan Black Bear (*Ursus thibetanus*): right malleus and incus. M.C., 831 A.

E. 867. Sloth-Bear (*Melursus ursinus*): right and left malleus.
M.C., 954.
Doran, *l. c.*, p. 399.

E. 868. Panda (*Ailurus fulgens*): right malleus and incus.
Osteol. Series, 806; M.C., 806.
Doran, *l. c.*, p. 398.

PROCYONIDÆ.

E. 869. Racoon (*Procyon lotor*): ossicula of the left side.
Osteol. Series, 782; M.C., 782.
Doran, *l. c.*, p. 397.

E. 870. *Bassariscus astutus*: malleus and incus of both sides.
M.C., 799.
Presented by Sir Victor Brooke, Bt.
Doran, *l. c.*, p. 398.

E. 871. Coati Mundi (*Nasua nasua*): ossicula of the right side.
M.C., 791 A.
Presented by Mr. James Flower.
Doran, *l. c.*, p. 397.

E. 872. Coati Mundi (*Nasua nasua*): ossicula of the left side.
Osteol. Series, 791.

E. 873. Kinkajou (*Potos caudivolvulus*): ossicula of both sides.
M.C., 800.
Doran, *l. c.*, p. 398.

MUSTELIDÆ.

E. 874. American Badger (*Taxidea americana*): right malleus and incus. M.C., 746.
Doran, *l. c.*, p. 397.

E. 875. Badger (*Meles meles*): ossicula of the right side.
Osteol. Series, 754; M.C., 754.
Doran, *l. c.*, p. 397.

E. 876. Badger (*Meles meles*): malleus and incus of both sides.
Osteol. Series, 752; M.C., 752.

E. 877. *Helictis orientalis*: malleus of both sides and the left incus. Osteol. Series, 741; M.C., 741.
Presented by R. C. Beavan, Esq.
Doran, *l. c.*, p. 397.

E. 878. African Skunk (*Ictonyx zorilla*): ossicula of the right side. Osteol. Series, 740; M.C., 740.

Doran, *l. c.*, p. 396.

E. 879. Tayra (*Galera barbara*): ossicula of both sides.
M.C., 737.

E. 880. Weasel (*Putorius vulgaris*): the tympanic bone, bony labyrinth, and ossicula of both sides. M.C., 713.
Max Hübrich Collection.

Doran, *l. c.*, p. 396.

E. 881. Stoat (*Putorius ermineus*): three tympanic bones (two left and one right), of which two have the membrana tympani and malleus still attached; the bony labyrinth of both sides; the right ossicula; and the left stapes.
Max Hübrich Collection.

E. 882. Pole-Cat (*Putorius putorius*): tympanic bone and ossicula of both sides, with the right bony labyrinth.
M.C., 696.
Max Hübrich Collection.

E. 883. American Mink (*Putorius vison*): ossicula of the left side. M.C., 727.

Doran, *l. c.*, p. 396.

E. 884. Pine-Marten (*Mustela martes*): the tympanic bone and ossicula of both sides, with part of the right bony labyrinth.
M.C., 677.
Max Hübrich Collection.

E. 885. American Sable (*Mustela americana*): malleus and incus of both sides. Osteol. Series, 687; M.C., 687.
Presented by the Smithsonian Institution.

E. 886. Glutton (*Gulo luscus*): ossicula of the right side.
Osteol. Series, 730; M.C., 730.
Hunterian.

Doran, *l. c.*, p. 396.

E. 887. Common Otter (*Lutra lutra*) : part of the right side of the skull with the tympanum and internal ear exposed. The floor of the bulla has been removed to show the partial separation of the tympanum into median and outer chambers. The membrana tympani and ossicles have been retained in their natural position. M.C., 761 A.

E. 888. Common Otter (*Lutra lutra*), young : the left tympanic bone, bony labyrinth, and ossicula. The right malleus and stapes from another individual have been mounted below.
M.C., 761.
Max Hübrich Collection.
Doran, *l. c.*, p. 397.

E. 889. Common Otter (*Lutra lutra*) : bony labyrinth of the left side with its cavities partly exposed. M.C., 761 B.

E. 890. Common Otter (*Lutra lutra*) : ossicula of the left side.
Osteol. Series, 771 ; M.C., 771.

E. 891. Javan Otter (*Lutra cinerea*) : right malleus and incus.
M.C., A 777.

E. 892. Sea-Otter (*Enhydra lutris*) : ossicula of both sides.
M.C., 779.
Doran, *l. c.*, p. 397.

CYNOIDEA.

CANIDÆ.

E. 893. Indian Wild Dog (*Canis indianensis*) : left malleus and incus, and right malleus. Osteol. Series, 537 ; M.C., 537.
Presented by Mrs. J. P. H. Walker.

E. 894. Dog (*Canis familiaris*) : tympanic bone and ossicula of both sides, with the right bony labyrinth and an imperfect cast of the cavity of the left. The malleus is retained in position upon the right tympanic bone. M.C., 564.
Max Hübrich Collection.
Doran, *l. c.*, p. 394.

E. 895. Dog (*Canis familiaris*): tympanic chamber and bony labyrinth of the left side. The membrana tympani has been preserved and the tympanic bulla laid open.
M.C., 564 A.

E. 896. Dog (*Canis familiaris*): portion of the right internal ear, with the malleus in position. A left malleus is mounted separately. M.C., 564 B.

E. 897. Dog (*Canis familiaris*): ossicula from the skull of a very large young individual. M.C., 564 C.

E. 898. Common Wolf (*Canis lupus*): left tympanic bone and bony labyrinth, with the right ossicula. M.C., 623.
Max Hübrich Collection.

E. 899. Wolf (*Canis lupus*): right bony labyrinth, with the left malleus and stapes. M.C., 623 A.
Max Hübrich Collection.

E. 900. Fox (*Vulpes vulpes*): bony labyrinth and ossicula of the right side. M.C., 654 A.
Max Hübrich Collection.

Doran, *l. c.*, p. 395.

E. 901. Red Fox (*Vulpes fulva*): ossicula of the right side.
M.C., 656.

Doran, *l. c.*, p. 395.

E. 902. Arctic Fox (*Vulpes lagopus*): right malleus and incus, and left stapes. Osteol. Series, 660; M.C., 660.
Doran, *l. c.*, p. 395.

E. 903. Arctic Fox (*Vulpes lagopus*): malleus and incus of both sides. M.C., 660 A.

E. 904. Cape Hunting-Dog (*Lycaon pictus*): malleus and incus of both sides. M.C., 531.
Doran, *l. c.*, p. 395.

E. 905. Bush-Dog (*Speothos venaticus*): ossicula of both sides.
Osteol. Series, 533; M.C., 533.

E. 906. Long-eared Fox (*Otocyon megalotis*) : right malleus and incus. Osteol. Series, 673 ; M.C., 673.
Doran, *l. c.*, p. 395.

AILUROIDEA.

HYÆNIDÆ.

E. 907. Aard Wolf (*Proteles cristatus*) : malleus and incus of both sides. M.C., 509.
Doran, *l. c.*, p. 392.

E. 908. Spotted Hyæna (*Hyæna crocuta*) : ossicles of the right side, and the left malleus. M.C., 524.
Doran, *l. c.*, p. 391.

E. 909. Striped Hyæna (*Hyæna hyæna*) : malleus of the right side. M.C., 516.

VIVERRIDÆ.

E. 910. African Civet Cat (*Viverra civetta*) : ossicula of the right side, from a young individual.
Osteol. Series, 454 ; M.C., 454.
Doran, *l. c.*, p. 393.

E. 911. Rasse (*Viverra malaccensis*) : ossicula of both sides. The malleus and incus from Osteol. Series, 458 ; the stapes from another individual. M.C., 458.
Doran, *l. c.*, p. 393.

E. 912. Common Genet (*Genetta vulgaris*) : left malleus, right incus, and stapes. M.C., 468.
Doran, *l. c.*, p. 393.

E. 913. Two-spotted Paradoxure (*Nandinia binotata*) : malleus and incus of the right side.
Osteol. Series, 473 ; M.C., 472.
Doran, *l. c.*, p. 393.

E. 914. Gray's Paguma (*Paradoxurus grayi*) : right malleus and incus. M.C., A 478.
Doran, *l. c.*, p. 393.

E. 915. Musanga Paradoxure (*Paradoxurus hermaphrodyta*): right malleus and incus (Osteol. Series, 479), with the right malleus from another specimen. M.C., 479.
Doran, *l. c.*, p. 393.

E. 916. *Parodoxurus* sp.: ossicula of the left side. The stapes is imperfect. Osteol. Series, 482; M.C., 481.
Presented by Bryan H. Hodgson, Esq.

E. 917. Binturong (*Arctictis binturong*): right incus and stapes (Osteol. Series, 486), with the right malleus of another individual. M.C., 486.
Doran, *l. c.*, p. 393.

E. 918. *Cynogale bennetti*: right ossicula. M.C., 489.
Doran, *l. c.*, p. 393.

E. 919. *Eupleres goudoti*: ossicula of the right side and the left malleus. M.C., 490.
Doran, *l. c.*, p. 393.

E. 920. Grey Ichneumon (*Herpestes griseus*): ossicula of the right side. Osteol. Series, 494; M.C., 493.
Presented by W. Crozier, Esq.
Doran, *l. c.*, p. 394.

E. 921. Grey Ichneumon (*Herpestes griseus*): right malleus and incus. Osteol. Series, 495; M.C., 494.
Presented by W. Crozier, Esq.

E. 922. Nepalese Ichneumon (*Herpestes auropunctatus*): ossicula of the right side. M.C., 499.
Doran, *l. c.*, p. 394.

E. 923. Marsh-Ichneumon (*Herpestes galera*): left malleus and right incus and stapes. Osteol. Series, 503; M.C., 503.

E. 924. Dusty Ichneumon (*Herpestes pulverulentus*): ossicula of the right side and the left malleus and incus.
M.C., A 492.
Doran, *l. c.*, p. 394.

E. 925. Banded Ichneumon (*Crossarchus fasciatus*) : ossicula of both sides. M.C., A 501.

E. 926. Suricate (*Suricata tetradactyla*) : ossicula of the left side, and the right malleus. Osteol. Series, 508 ; M.C., 508.
Doran, *l. c.*, p. 394.

FELIDÆ.

E. 927. Foussa (*Cryptoprocta ferox*) : ossicula of the right side. Osteol. Series, 450 ; M.C., 450.
Doran, *l. c.*, p. 394.

E. 928. Cheetah (*Cynælurus jubatus*) : right malleus. M.C., 439.
Doran, *l. c.*, p. 391.

E. 929. Northern Lynx (*Felis lynx*) : malleus and incus of both sides. Osteol. Series, 436 ; M.C., 436.
Doran, *l. c.*, p. 391.

E. 930. Persian Lynx (*Felis caracal*) : right malleus and stapes. Osteol. Series, 433 ; M.C., 433.

E. 931. Persian Lynx (*Felis caracal*): malleus and stapes of the right side, with a left incus. Osteol. Series, 434; M.C., 434.
Doran, *l. c.* p. 391.

E. 932. Persian Lynx (*Felis caracal*) : left malleus and incus. Osteol. Series, 432 ; M.C., 432.
Hunterian.

E. 933. Cat (*Felis domestica*) : ossicula and tympanic bones of both sides, from a new-born kitten. M.C., 419 D.

E. 934. Cat (*Felis domestica*) : bony internal ear and tympanic bulla of the left side. Parts of the outer and of the inner walls of the bulla have been removed to show the ossicles and the separation of the tympanum into inner and outer chambers (*cf.* Physiol. Series, A 200). M.C., 419 A.

E. 935. Cat (*Felis domestica*) : bony labyrinth, ossicula, and tympanic bone of the right side, from a kitten. The tympanic bone shows the separate ossification that forms the wall of the inner chamber of the auditory bulla.

M.C., 419 B.

Max Hübrich Collection.

Doran, *l. c.*, p. 391.

E. 936. Cat (*Felis domestica*) : left bony labyrinth, ossicula, and tympanic bone, from a kitten. The membrana tympani has been preserved, with the malleus in position. The inner wall of the bulla has been mounted separately.

M.C., 419 C.

Max Hübrich Collection.

E. 937. African Golden Cat (*Felis chrysothrix*) : right malleus and incus. Osteol. Series, 393 ; M.C., 393.

Presented by Staff-Surgeon J. R. Thomas.

Doran, *l. c.*, p. 391.

E. 938. Leopard (*Felis pardus*) : the malleus and incus of the left side, from a young specimen (Osteol. Series, 368), with the left stapes of an adult. M.C., 368.

Doran, *l. c.*, p. 391.

E. 939. Leopard (*Felis pardus*) : left malleus and incus.

Osteol. Series, 364 ; M.C., 364.

Presented by Dr. B. C. Henderson.

E. 940. Lion (*Felis leo*) : ossicula of both sides, from an infant lion with a cleft palate. M.C., 312 B.

Doran, *l. c.*, p. 391.

E. 941. Lion (*Felis leo*) : right malleus and left incus.

M.C., 312 A.

INSECTIVORA.

Doran, *l. c.*, p. 443.

INSECTIVORA VERA.

TUPAIIDÆ.

E. 942. Tupaia (*Tupaia tana*) : left malleus and incus, and right stapes. M.C., 3373.

Doran, *l. c.*, p. 441.

MACROSCELIDÆ.

E. 943. Elephant-Shrew (*Macroscelides intufi*): ossicula of the left side. Osteol. Series, 3367; M.C., 3367.
Presented by the Zoological Society.
Doran, *l. c.*, p. 440.

E. 944. *Rhynchocyon cirnei*: ossicula of the left side.
Osteol. Series, 3370; M.C., 3370.
Doran, *l. c.*, p. 441.

ERINACEIDÆ.

E. 945. *Gymnura gymnura*: ossicula of the right side, with the malleus and stapes of the left.
Osteol. Series, 3364; M.C., 3364.
Doran, *l. c.*, p. 439.

E. 946. Hedgehog (*Erinaceus europæus*): the bony labyrinth, ossicula, and tympanic bone of the right side.
M.C., 3359 A.
Max Hübrich Collection.
Doran, *l. c.*, p. 438.

E. 947. Hedgehog (*Erinaceus europæus*, var. *dealbatus*): malleus and stapes of both sides. M.C., A 3359.

SORICIDÆ.

E. 948. Common Shrew (*Sorex araneus*): bony labyrinth, ossicula, and tympanic bone, of both sides. M.C., 3346.
Max Hübrich Collection.
Doran, *l. c.*, p. 434.

E. 949. Common Shrew (*Sorex araneus*): bony labyrinth, ossicula, and tympanic bone of the right side. M.C., 3346 A.
Max Hübrich Collection.

E. 950. *Sorex* sp.: malleus and incus of both sides, from a large American species. The left malleus is attached to the tympanic bone. M.C., 3346 B.
Doran, *l. c.*, p. 433.

TALPIDÆ.

E. 951. Desman (*Myogale moschata*) : ossicula of both sides.
M.C., 3338 A.
Presented by A. H. Garrod, Esq.
Doran, *l. c.*, p. 434.

E. 952. Desman (*Myogale moschata*): ossicula of the left side.
Osteol. Series, 3338 ; M.C., 3338.

E. 953. Star-nosed Mole (*Condylura cristata*) : malleus and tympanic bone of both sides, and the right incus.
M.C., A 3337.
Doran, *l. c.*, p. 437.

E. 954. Mole (*Talpa europæa*) : the bony labyrinth and ossicula of the right side. The stapes is in position. M.C., 3337 B.
Max Hübrich Collection.
Doran, *l. c.*, p. 436.

E. 955. Mole (*Talpa europæa*): malleus and incus of both sides.
M.C., 3337 C.

SOLENODONTIDÆ.

E. 956. Almiqui (*Solenodon cubanus*) : left malleus.
Osteol. Series, 3326 ; M.C., 3326.
Doran, *l. c.*, p. 440.

CENTETIDÆ.

E. 957. Tenrec (*Centetes ecaudatus*): left malleus, with right incus and stapes. M.C., 3320.
Doran, *l. c.*, p. 440.

E. 958. *Ericulus setosus* : ossicula of the right side. M.C., 3324.
Doran, *l. c.*, p. 440.

E. 959. *Ericulus setosus* : malleus, tympanic bone, and stapes of the left side. M.C., 3324 A.

CHRYSOCHLORIDÆ.

E. 960. Cape Golden Mole (*Chrysochloris aurea*) : ossicula of the right side (Osteol. Series, 3318, Hunterian), and right malleus and incus from another specimen (Physiol. Series, 2069). The head of the malleus is of relatively enormous size. M.C., 3318.

Doran, *l. c.*, p. 437.

DERMOPTERA.

GALEOPITHECIDÆ.

E. 961. Colugo (*Galeopithecus volans*): ossicula of both sides.
Osteol. Series, 3378; M.C., 3378.
Presented by the Zoological Society.

Doran, *l. c.*, p. 442.

E. 962. Colugo (*Galeopithecus volans*): ossicula of the left side.
M.C., 3378 A.

CHIROPTERA.

Doran, *l. c.*, p. 449.

MEGACHIROPTERA.

PTEROPIDÆ.

E. 963. Fruit-Bat (*Pteropus medius*): ossicula of both sides. The right malleus is attached to the tympanic bone.
Osteol. Series, 3384; M.C., 3384.

Doran, *l. c.*, p. 445.

E. 964. Javanese Fruit-Bat (*Pteropus hypomelanus*): the ossicula of the left side, with the right malleus and incus. Both mallei are damaged. M.C., A 3382.

MICROCHIROPTERA.

RHINOLOPHIDÆ.

E. 965. *Phyllorhina tridens*: malleus and tympanic bone of the left side. M.C., 3398.

Doran, *l. c.*, p. 446.

E. 966. *Phyllorhina speoris*: ossicula of both sides. The right malleus is attached to the tympanic bone. The right stapes is damaged. M.C., A 3400.
Presented by G. E. Dobson, Esq.

VESPERTILIONIDÆ.

E. 967. Long-eared Bat (*Plecotus auritus*): bony labyrinths, and right tympanic bone with the malleus attached. M.C., 3402.

Doran, *l. c.*, p. 448.

E. 968. *Vesperugo serotinus*: ossicula, bony labyrinth, and tympanic bone of right side. M.C., 3403 A.

Max Hübrich Collection.

Doran, *l. c.*, p. 448.

E. 969. *Vesperugo serotinus*: ossicula, bony labyrinth, and tympanic bone of the left side. The malleus is attached to the tympanic bone. M.C., 3043 B.

Max Hübrich Collection.

E. 970. Natterer's Bat (*Vespertilio nattereri*): left bony labyrinth and incus, and tympanic bone and malleus of both sides. M.C., 3410.

Doran, *l. c.*, p. 448.

EMBALLONURIDÆ.

E. 971. *Rhynchonycteris naso*: bony labyrinth, tympanic bone, malleus, and incus of the right side. M.C., B 3414.

E. 972. *Taphozous melanopogon*: tympanic bone and malleus of both sides. M.C., A 3414.

E. 973. *Molossus rufus*: left malleus and tympanic bone. M.C., 3414.

Doran, *l. c.*, p. 449.

PHYLLOSTOMIDÆ.

E. 974. *Chilonycteris parnellii*: malleus and incus of both sides. Osteol. Series, 3415; M.C., 3415.

Presented by Lucas Barrett, Esq.

Doran, *l. c.*, p. 449.

E. 975. *Mormops blainvillei*: malleus, incus, and tympanic bone of the right side. Osteol. Series, 3416; M.C., 3416.

Presented by Lucas Barrett, Esq.

Doran, *l. c.*, p. 449.

PRIMATES.

Doran, *l. c.*, pp. 379, 382, 389.

LEMUROIDEA.

CHIROMYIDÆ.

E. 976. Aye-Aye (*Daubentonia* [*Chiromys*] *madagascariensis*): ossicula of left side, with another left malleus and right incus and stapes. The upper set are from Osteol. Series, 302; the lower from Osteol. Series, 301. M.C., 302.
Doran, *l. c.*, p. 388.

E. 977. Aye-Aye (*Daubentonia madagascariensis*): ossicula of the left side.

TARSIIDÆ.

E. 978. Tarsier (*Tarsius tarsius*): ossicula and tympanic bones of both sides, from a young specimen. M.C., 300.
Doran, *l. c.*, p. 388.

E. 979. Tarsier (*Tarsius tarsius*): malleus and incus of both sides. M.C., 300 A.

NYCTICEBIDÆ.

E. 980. Bosman's Potto (*Perodicticus potto*): ossicula of the right side, from an adult. M.C., 295.
Doran, *l. c.*, p. 388.

E. 981. Tailless Potto (*Arctocebus calabarensis*): malleus of both sides. Osteol. Series, 297; M.C., 297.
Presented by Andrew Murray, Esq.
Doran, *l. c.*, p. 388.

E. 982. Slender Loris (*Loris gracilis*): ossicula of the left side. Osteol. Series, 290; M.C., 290.
Doran, *l. c.*, p. 388.

E. 983. Slow Loris (*Loris tardigradus*): ossicula of the right side, and another right malleus.
Osteol. Series, 291; M.C., 291.
Presented by Sir Stamford Raffles.
Doran, *l. c.*, p. 387.

E. 984. Javan Loris (*Nycticebus javanicus*): left malleus.
Osteol. Series, 293; M.C., 293.

E. 985. Grand Galago (*Galago crassicaudatus*): ossicula of the right side. M.C., 283.
Doran, *l. c.*, p. 387.

E. 986. Allen's Galago (*Galago alleni*): ossicula of the left side, and malleus and incus of the right. M.C., 287.

LEMURIDÆ.

E. 987. *Chirogaleus pusillus*: malleus and incus of both sides.
Osteol. Series, 281; M.C., 281.
Doran, *l. c.*, p. 387.

E. 988. *Chirogaleus pusillus*: right malleus.
Osteol. Series, 282: M.C., 282.

E. 989. *Lepidolemur mustelinus*: ossicula of the right side.
Osteol. Series, 278; M.C., 277.

E. 990. Ruffed Lemur (*Lemur varius*): tympanic bone and malleus and incus of both sides, with a damaged right stapes. Osteol. Series, 262; M.C., 262.
Doran, *l. c.*, p. 386.

E. 991. White-fronted Lemur (*Lemur mongos*): ossicula of the left side. Osteol. Series, 274; M.C., 274.
Doran, *l. c.*, p. 386.

E. 992. Black-fronted Lemur (*Lemur mongos*): ossicula of the left side. M.C., C 276.
Doran, *l. c.*, p. 386.

E. 993. Ring-tailed Lemur (*Lemur catta*): ossicula of the left side. Osteol. Series, 269; M.C., 269.
Doran, *l. c.*, p. 386.

E. 994. Yellow-whiskered Lemur (*Lemur xanthomystax*): ossicula of the left side. M.C., B 276.
Doran, *l. c.*, p. 386.

E. 995. *Lemur* sp.: the left bulla, prepared to show the tympanic ring. M.C., A 269.

E. 996. Woolly Lemur (*Avahis laniger*): ossicula of the right side. A bony canal was found between the crura of the stapes. M.C., 258.

E. 997. Diadem Lemur (*Propithecus diadema*): ossicula of the right side, and malleus and incus of the left. M.C., A 256.
Doran, *l. c.*, p. 386.

E. 998. Diadem Lemur (*Propithecus diadema*): ossicula of both sides. Osteol. Series, 256; M.C., 256.

ANTHROPOIDEA.

HAPALIDÆ.

E. 999. *Midas geoffroyi*: ossicula of the right side, with the malleus and incus of the left. M.C., B 244.
Doran, *l. c.*, p. 385.

E. 1000. Pinche Monkey (*Midas œdipus*): ossicula of the right side. M.C., 244 A.
Doran, *l. c.*, p. 385.

E. 1001. Pinche Monkey (*Midas œdipus*): malleus and incus of both sides. Osteol. Series, 244; M.C., 244.

E. 1002. Red-handed Tamarin (*Midas midas*): left malleus and incus. M.C., A 244.

E. 1003. Marmoset (*Hapale jacchus*): ossicula of the left side. M.C., 249.
Doran, *l. c.*, p. 385.

E. 1004. Marmoset (*Hapale jacchus*): left malleus and incus. Osteol. Series, 250; M.C., 250.
Presented by the Zoological Society.

E. 1005. *Hapale melanura*: left ossicula. M.C., A 251.
Doran, *l. c.*, p. 385.

CEBIDÆ.

E. 1006. Silky Howler (*Alonata senicula*): ossicula of the left side. Osteol. Series, 239; M.C., 239.
Doran, *l. c.*, p. 384.

E. 1007. *Mycetes ursinus*: ossicula of the right side, with the left malleus and incus. M.C., A 242.
Doran, *l. c.*, p. 384.

E. 1008. Red Howler (*Alonata senicula*): right malleus and incus. M.C., 236.
Doran, *l. c.*, p. 384.

E. 1009. Black Saki (*Pithecia satanas*): left malleus and incus. Osteol. Series, 233; M.C., 233.
Doran, *l. c.*, p. 385.

E. 1010. Feline Douroucouli (*Aotus vociferans*): ossicula of the right side. The malleus and incus from Osteol. Series, 228; the stapes from another individual. M.C., 227.
Doran, *l. c.*, p. 384.

E. 1011. Feline Douroucouli (*Aotus vociferans*): ossicula of the right side. Osteol. Series, 227; M.C., 228.

E. 1012. Feline Douroucouli (*Aotus vociferans*): ossicula of the right side. M.C., 228 A.

E. 1013. Black-handed Spider-Monkey (*Ateles geoffroyi*): ossicula of both sides. M.C., 218.
Doran, *l. c.*, p. 383.

E. 1014. Brown Spider-Monkey (*Ateles hybridus*): incus and stapes of both sides. Osteol. Series, 220; M.C., 220.
Doran, *l. c.*, p. 383.

E. 1015. Black-faced Spider-Monkey (*Ateles ater*): ossicula of both sides. M.C., 219.
Doran, *l. c.*, p. 383.

E. 1016. Capuchin (*Cebus capucinus*): ossicula of the right side.
Osteol. Series, 209; M.C., 209.
Hunterian.
Doran, *l. c.*, p. 384.

E. 1017. White-cheeked Capuchin (*Cebus lunatus*): ossicula of the left side. M.C., A 215.

E. 1018. *Cebus* sp.: ossicula of both sides. M.C., 214.

E. 1019. Squirrel-Monkey (*Chrysothrix sciurea*); ossicula of the right side, and malleus and incus of the left.
Osteol. Series, 204; M.C., 204.
South Collection.
Doran, *l. c.*, p. 385.

CERCOPITHECIDÆ.

E. 1020. Anubis Baboon (*Papio anubis*): ossicula of both sides.
M.C., 188.
Doran, *l. c.*, p. 382.

E. 1021. Chacma Baboon (*Papio porcarius*): ossicula of the right side. M.C., 191.

E. 1022. Black Ape (*Cynopithecus niger*): ossicula of both sides.
M.C., 177.
Doran, *l. c.*, p. 382.

E. 1023. Rhesus Monkey (*Macacus rhesus*): ossicula of both sides. From a new-born male.
Osteol. Series, 159; M.C., 159.
Presented by the Zoological Society.
Doran, *l. c.*, p. 381.

E. 1024. Pig-tailed Monkey (*Macacus nemestrinus*): ossicula of both sides. M.C., 165.

E. 1025. Macaque (*Macacus cynomolgus*): ossicula of both sides.
M.C., 134.

E. 1026. White-collared Mangabey (*Cercocebus collaris*): left malleus and incus. M.C., 129.

E. 1027. Moustache Monkey (*Cercopithecus cephus*): ossicula of both sides. M.C., 123.

E. 1028. Malbrouck Monkey (*Cercopithecus cynosurus*): ossicula of both sides. M.C., A 128.

Doran, *l. c.*, p. 381.

E. 1029. Diana Monkey (*Cercopithecus diana*): ossicula of the right side. M.C., 121.

Doran, *l. c.*, p. 381.

E. 1030. *Cercopithecus* sp.: the ossicula of both sides, lacking the right stapes, and casts of the cavities of the bony labyrinths. M.C., B 128.

Max Hübrich Collection.

E. 1031. Entellus Monkey (*Semnopithecus entellus*): ossicula of both sides. M.C., 91.

Doran, *l. c.*, p. 380.

E. 1032. *Semnopithecus* sp.: the ossicula of both sides, with the left bony labyrinth and a cast of the interior of the right bony labyrinth. M.C., 91 A.

Max Hübrich Collection.

E. 1033. *Semnopithecus* sp.: three left mallei and a right incus and stapes. M.C., 95.

E. 1034. Black Colobus (*Colobus satanas*): ossicula of the right side. M.C., 81.

Doran, *l. c.*, p. 381.

E. 1035. King Colobus (*Colobus polycomus*): left malleus and incus. M.C., A 81.

SIMIIDÆ.

E. 1036. Silvery Gibbon (*Hylobates leuciscus*): ossicula of the right side. Osteol. Series, 65; M.C., 65.

Presented by Dr. B. C. Henderson.

Doran, *l. c.*, p. 379.

E. 1037. Siamang (*Hylobates syndactylus*): ossicula of the left side, and malleus and incus of the right.

Osteol. Series, 61; M.C., 61.

Brookes Collection.

Doran, *l. c.*, p. 379.

E. 1038. *Hylobates* sp.: ossicula of the right side.

Osteol. Series, 70; M.C., 70.

E. 1039. Orang-utan (*Simia satyrus*): ossicula of both sides.

M.C., 38.

Doran, *l. c.*, p. 378.

E. 1040. Gorilla (*Anthropopithecus gorilla*): ossicula and tympanic bone of the right side, from a fœtus of full term.

M.C., 30 A.

Doran, *l. c.*, p. 377.

E. 1041. Gorilla (*Anthropopithecus gorilla*): ossicula and tympanic bone of the left side, from the same individual.

M.C., 30 B.

E. 1042. Gorilla (*Anthropopithecus gorilla*): malleus and incus of both sides, from a young specimen. M.C., 30.

E. 1043. Gorilla (*Anthropopithecus gorilla*): left malleus.

M.C., 30 C.

E. 1044. Chimpanzee (*Anthropopithecus troglodytes*): ossicula of the left side, and the malleus and incus of the right.

M.C., 12 A.

Doran, *l. c.*, p. 378.

HOMINIDÆ.

E. 1045. Bushman: right malleus, and the left incus and stapes. From the female Bushman described in Journ. Anat. and Physiol. 1867. Osteol. Series, 1302; M.C., 1302.

E. 1046. Two right and two left tympanic bones from new-born infants; in one (left) the malleus and membrana tympani are retained in position. *Max Hübrich Collection.*

E. 1047. Right squamosal and tympanic bones from a fœtus of the ninth month, with the ossicles in position, seen from the inner aspect. *Max Hübrich Collection.*

E. 1048. Right bony labyrinth and left ossicula of a new-born child. *Max Hübrich Collection.*

E. 1049. Left bony labyrinth of a new-born child, roughly dissected. *Max Hübrich Collection.*

E. 1050. Right and left malleus and incus of the Irish Giant, O'Brian. Osteol. Series, 223 ; M.C., 223.

E. 1051. A collection of 25 right stapedes.

E. 1052. A collection of 17 left stapedes.

E. 1053. Two sets of ossicula of the right side. *Max Hübrich Collection.*

Doran, *l. c.*, p. 372.

E. 1054. Two sets of ossicula of the left side.

E. 1055. Ossicula of the right side. O. C. (*Physiol.*), 1602 F.

E. 1056. Right bony labyrinth, opened from the tympanic aspect. The left ossicula articulated. *Max Hübrich Collection.*

E. 1057. Left bony labyrinth, with the cochlea laid open. *Max Hübrich Collection.*

E. 1058. Right bony labyrinth, right malleus, and left incus and stapes. *Max Hübrich Collection.*

E. 1059. Left bony labyrinth, with the cochlea laid open to show the lamina spiralis. *Max Hübrich Collection.*

E. 1060. A similar specimen. *Max Hübrich Collection.*

E. 1061. Right bony labyrinth, with fine bristles passed into the aqueducts of the vestibule and cochlea.

Max Hübrich Collection.

E. 1062. Left bony labyrinth. *Max Hübrich Collection.*

E. 1063. Left bony labyrinth, with the cochlea, canals, and vestibule laid open. *Max Hübrich Collection.*

E. 1064. A similar specimen, opened upon the reverse side.

Max Hübrich Collection.

E. 1065. Left bony labyrinth and ossicula. The stapes is attached to the foramen ovale, and the malleus and incus are articulated. *Max Hübrich Collection.*

VISUAL ORGANS.

Carrière, Die Sehorgane der Thiere, 1885 (*anat.*).

Living matter is capable of response to light stimulation without any apparent special modification of structure, such response being manifested by movements to or from the source of light (Heliotropism). But in the majority of animals particular cells of or derived from the epidermis are specially modified, either singly or in groups, to act as light receptive or visual organs. In these organs the sensory cells are, so far as observed, always senso-neural, like those of the olfactory epithelium, *i. e.* sensory cell and nerve-fibre combined, the body of the cell being drawn out proximally to form the nerve-fibre and surmounted distally by a refractive rod-like end organ by which the stimulation is actually received. The simplest forms of light receptive organs are patches of pigmented epithelium, which, owing to their greater absorptive power, are more open to light- and also probably heat-stimulation than the neighbouring integument; but in most cases rod-bearing sensory cells are present, which may be themselves pigmented or may be partly surrounded by pigment, the object of the pigment being apparently to ensure that the light shall strike one special part of the end organ only, and, in the more perfect forms of eye, to absorb diffuse reflected light and thus prevent halation. Very generally between the sensitive membrane (retina) and the source of light some form of lens is interposed, by which the light can be concentrated and brought to a focus upon the end organs of the retina. Around these more essential parts of the visual organ vascular and protective capsules are developed in the case of the larger and more perfect forms of eye.

From a physiological point of view, light receptive organs can, in idea though not so readily in practice, be separated into those without powers of vision in the ordinary sense of the term, but which enable the brain to distinguish light from darkness, and in their more developed forms are sensitive to alterations of light and shade, and thus in a vague way to movement; and into true visual organs, in which by accurate focussing of light reflected from external objects upon the retina, pictures of the outside world are formed and transmitted to the brain. In eyes of this kind the focussing-apparatus is usually not fixed, but is capable of adjustment, so that the focus may be accommodated for light proceeding from objects at different distances from the eye. In the more perfect forms of eye the individual cells of the retina are not only sensitive to variations in the quantity of light which give rise in the brain to the perception of form, but also to differences in the rate of vibration upon which depends the sense of colour.

INVERTEBRATA.

Hesse, Zeitschr. f. wiss. Zool. Bd. lxxii. 1902, p. 589.
Beer, Wiener klin. Wochenschr. 1901, Nos. 11, 12, 13.

The eyes and light perceptive organs of most Invertebrata are too small to be included in this collection, so that very little idea can be given of their variations in structure and extent of occurrence in this Sub-kingdom. As a matter of fact, eyes varying from single cells (Earthworm) and mere pigment spots to highly complex visual organs are found fairly generally distributed in all the main Phyla, the most perfect occurring, as might be supposed, in the more active and predaceous forms (*e.g.*, Errant Annelids, Dibranch Cephalopods, Heteropods, &c.),

sedentary and buried forms being usually eyeless (*e. g.*, Sponges, Internal Parasites, most Pelecypods, Tube Worms).

In Invertebrates the eyes are formed by direct modification of the epidermis and can be grouped into two main divisions :—(1) Simple eyes, including pigment-spots, in which a certain area of the integument is pigmented and otherwise modified to form a continuous retina, upon which light either falls direct or is concentrated by a single dioptric apparatus. Such eyes are generally sunk below the skin in the form of pits or vesicles, the deep wall of which constitutes the retina, the outer wall in the case of the complete vesicular form being transparent, and with the overlying transparent skin and a mass of gelatinous secretion within the cavity of the vesicle forming the dioptric apparatus. (2) Compound eyes (almost entirely confined to Arthropods), in which each eye consists of a large number of simple eyes packed together and isolated from each other optically by pigment.

MOLLUSCA.

Hesse, Zeitschr. f. wiss. Zool. Bd. lxviii. 1900, p. 379.

For the better understanding of the various forms of simple eye that occur among the Mollusca a figure is given of the vesicular eye of a *Helix pomatia* (Pl. II. figs. 1, 2), which in construction occupies a fairly central position among eyes of this kind, and thus makes a good standard of comparison for interpreting the structure of both the simpler and the more complex eyes formed on the same plan.

E. 1066. A Chiton (*Acanthopleura spiniger*). Scattered irregularly over the marginal parts of the lateral areas of the shells are a number of minute black specks. These are the transparent chitinous corneæ of eyes of a simple kind. Each cornea is externally convex and covers over a pear-shaped chamber in the tegmentum, or superficial layer of the shell, in which the soft parts of the eye are lodged. This ocular cavity in the shell is lined by a pigmented capsule, the distal parts of which are slightly inturned to form an iris. Within the capsule are a homogeneous biconvex lens and a cup-shaped retina of simple structure. The retina is innervated by a large nerve which forms part of the system of nerves that enters the shell in the groove

Fig. 47.

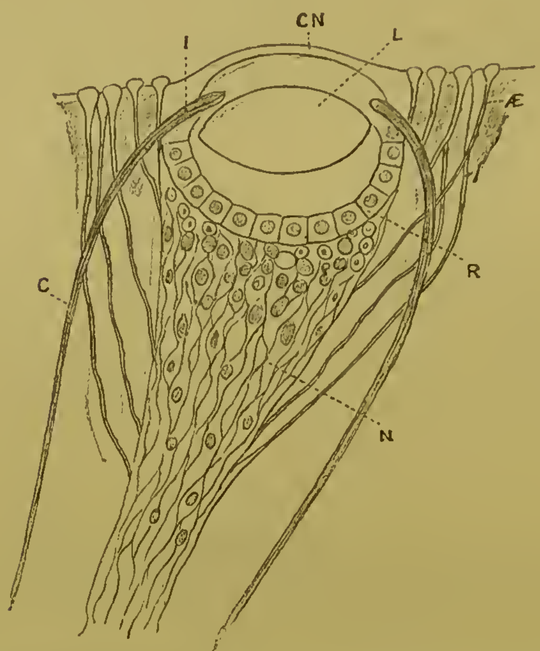


Diagram of eye of *Acanthopleura spiniger*. (After Moseley.)

Æ. Æsthetes. C. Pigmented capsule of the eye. CN. Cornea. I. Iris. L. Lens. N. Optic nerve. R. Retina.

between its superficial and deep layers, and supplies a series of integumentary sense-organs of obscure function, known as æsthetes. There is little doubt that the eyes are æsthetes that have undergone special adaptation. O. C. 1627 A *a*.

Moseley, Quart. Jour. Micr. Sci. vol. xxv. 1885, p. 45.
Plate, Zool. Jahrb. Suppl. Band. v. 1892, p. 502.

E. 1067. An enlarged model of a portion of the lateral area of a shell and neighbouring parts of the mantle of a Chiton (*Acanthopleura spiniger*), showing a cluster of eyes. In the centre of each eye is a black spot representing the pupil seen through the transparent cornea. O. C. 1627 A.


c
ep
ep
p
c.c
rh.(f)
r
5
b m
n
c
6
r
n
1.
c1
c2
c3
l
p
f
r
n
4
g1
g2
r.c
n
rd
l
ep
3
g
rc
rd
t
ch
r
n
f
r
p
2.

PLATE II.

Fig. 1. Longitudinal section through the eye of *Helix aspersa*, × 100.

Fig. 2. Longitudinal section through the retina of *Helix pomatia* (after Bäcker *).

Fig. 3. Longitudinal section through the eye of *Pecten jacobæus* (after Patten).

Fig. 4. Part of the retina of *Pecten jacobæus*, × 300 (after Rawitz).

Fig. 5. Median section through an ommatideum of *Periplaneta orientalis*, × 700 (after Hesse).

Fig. 6. Median section through the central ocellus of *Helophilus* sp., × 315 (after Hesse).

b.m., basement membrane; *c.*, cuticular cornea; c^1, c^2, c^3, the outer epidermal, middle fibrous, and inner epidermal layers of the cornea; *c.c.*, crystal cones; *ch.*, "choroid"; *ep.*, epidermis; *f.*, selvage of terminal receptive fibrils (stiftchensaum); *g.*, ganglion cells; g^1, g^2, outer and inner layers of ganglion cells; *l.*, lens; *n.*, optic nerve; *p.*, pigment cells; *r.*, retinal cells; *r.c.*, rod-cells; *r.d.*, rods; *r.h.*, rhabdome; *t.*, tapetum lucidum; *v.*, cavity of optic vesicle.

* Arbeit. Zool. Inst. Wien, T. xiv., 1903.

E. 1068. A Scallop (*Pecten* sp.) with the left valve and mantle-lobe removed. Along the margin of the mantle amongst the fringe of tentacles are about thirty eyes, which in the specimen appear as minute black rings surrounding a central white area, but in life are brilliantly coloured. These eyes (Pl. II. figs. 3, 4), unlike those of most Molluscs, have a striking similarity to the eyes of Vertebrates in that the rods or terminal receptive organs of the retina face away from the light instead of towards it. The eye is, nevertheless, an integumentary vesicle strictly comparable to that of other Molluscs, but in which the cavity of the vesicle has been lost owing to the invagination of its anterior wall by a lens developed between it and the overlying epithelium. The eye consists of an outer cornea continuous with the epidermis of the ocular tentacle, of a cellular lens attached to the deep surface of the cornea, of a retina formed from the external half of the primary optic vesicle, and in consequence with its rods turned away from the light, and of a brilliantly coloured tapetum lucidum and deeply pigmented "choroid" formed from the posterior wall of the vesicle. O. C. 1628 B.

Hesse, Zeits. f. wiss. Zool. Bd. lxviii. 1900, p. 390.

E. 1069. Anterior part of an Apple Snail (*Ampullaria* sp.), showing the eyes. These are situated, as in most Prosobranchs, on the outer side of the tentacles near the base. Each is lodged in a short rounded process and consists of a spherical vesicle lined by a deeply pigmented retina. The cavity of the vesicle is filled by a firm transparent body—the lens—which is probably secreted by the non-sensory cells of the retina. The distal wall of the vesicle and the skin overlying it are transparent and together form the cornea. On the right, the eye has been longitudinally divided, the lens has been removed and mounted separately at the side, and the optic nerve has been exposed. O. C. 1628 A *a*.

E. 1070. The proboscis, tentacles, and eyes of a Prosobranch Gastropod. The eyes are situated at the free ends of a pair of stout processes that form the lateral and largest branches of the bifurcated extremities of the tentacles. The specimen is much bleached, but the left eye can be recognised by its transparent strongly convex cornea. The right eye has been bisected to show the cavity of the optic vesicle. The brain and proximal parts of the tentacular nerves have been exposed. O. C. 1628 A.

E. 1070 a. The anterior parts of a Heteropod (*Pterotrachea coronata*), with the body-wall removed from the dorsal part of the head to show the eyes and the dorsal ganglia. The eyes are relatively larger than in most Mollusca, particularly in comparison with the size of the cerebral ganglia. In their high organisation as well as in size they form a striking parallel to the eyes of Decapod Cephalopods, which, like the Heteropods, are active free-swimming forms. The detailed structure of the eyes has been described by Grenacher. Each is composed of cornea and sclerotic, choroid, lens, and retina, and is attached to a special optic ganglion whose presence helps to explain the disproportion in size between the eye and the cerebral ganglia. The lens does not occupy the whole of the optic vesicle, but is separated by fluid-filled spaces from the cornea and the retina. Special muscles (one of which can be seen on the left side) give considerable powers of independent movement to the eyes. Upon the right side part of the cornea has been removed to show the anterior chamber of the eye and the lens.

Grenacher, Abhandl. naturf. Ges. Halle, Bd. xvii. 1892, p. 1.

E. 1071. Two specimens showing the eye and other cephalic sense-organs of a Pearly Nautilus (*Nautilus macromphalus*).

The eye is a very simple structure compared with that of the dibranchiate Cephalopods. It consists of a hemispherical chamber of dense connective tissue lined by a retinal membrane, and with its cavity in open communication with the surrounding water through a minute hole in the centre of its flattened external wall. A slight superficial groove leads from the hole to the lower border of the eye. The nerve-supply to the retina is derived from a relatively small optic ganglion attached to the outer end of the cerebral ganglion (*cf.* D. 59).

The auditory organ is represented by a small spherical vesicle lying on either side upon the posterior surface of the pedal ganglion. Within the vesicle is a round otolith.

An olfactory function is supposed to be performed by a deep integumentary pit situated immediately beneath the eye, and also possibly by a pair of supraocular tentacles.

The lower specimen shows the left eye in its natural relations to the other parts of the head. In the upper specimen a dissection has been made of the right side of the head from behind, showing the eye in section, the right half of the brain with the optic lobe, the auditory vesicle (indicated by black paper), the olfactory pit with a red bristle placed behind its nerve, and the posterior of the two supraocular tentacles. O. C. 1646 D.

Merton, Zeits. f. wiss. Zool., Bd. lxxix. 1905, p. 328 (*retina*).

E. 1072. The brain and eyes of an Octopus (*Octopus vulgaris*). On either side of the cerebral ganglion is a large oval optic ganglion, from whose distal surface a brush of nerve-fibres are given off for the innervation of the retina. These nerve-fibres enter the eye through perforations spread over a large area of the deep surface of the cartilaginous capsule in which the greater part of the globe of the eye is enclosed. In front of the lens is an iris of silvery lustre, with a tongue-like process projecting from its upper border. Bateson states (Jour. Mar. Biol. Ass., vol. i. 1889, p. 216) that in Cephalopoda the iris is contractile. O. C. 1696 A.

E. 1073. Anterior portion of the head of a Cuttle-fish (*Sepia fillliouxi*) seen in section from behind. The posterior half of each eye has been removed to show the relations of its several parts to one another, and of the whole organ to the central nervous system.

The eye is protected externally by a lower eyelid. Individuals of the related genus *Sepiola* have been observed to "sit on the ground with their eyes closed by the lower lids throughout the day" (Bateson, Jour. Mar. Biol. Ass., vol. i. 1889, p. 216). Upon the section surface of the lid can be seen the band of muscle by which this closure is effected. The surface of the eye is covered by an extremely delicate cornea, beneath which is a contractile iris. In the specimen both these membranes are closely applied to the surface of the lens. The hinder part of the globe of the eye consists of a cartilaginous sclerotic capsule, lined by a pigmented retina in which the pigment is situated in the actual sensory cells.

The lens is a spherical body composed of transparent concentric lamellæ of homogeneous structure. It is separated into a large inner and small outer portion by a membrane (septum lentis), which passes at its periphery into a thick ring of epithelial cells (corpus epitheliale), which serves for the suspension of the lens to the walls of the globe, and also secretes the laminæ of which the lens is composed. The circum-œsophageal nerve-ring is shown in the centre of the specimen. Between it and the deep surface of either eye are the large optic ganglia. The angles between the upper and lower surfaces of these ganglia and the globe of the eye are filled by a white substance (white bodies), which probably are the degenerate remains of brain-substance.

There is little difficulty in tracing the relationship of this complex organ to the typical Molluscan vesicular eye. The primitive vesicle is represented by the posterior chamber, including the corpus epitheliale and its derivative—the lens. External to this, subsequent insinkings of the integument have produced the iris, cornea, and lid.

The Dibranch Cephalopods are amongst the few Invertebrates, if not the only ones, that have the power of accommodation. In the resting condition the eye is focussed for near vision, but by means of a circular muscle passing forwards from the eye-capsule to the corpus epitheliale the lens can be drawn towards the retina, thus bringing more distant objects into focus. O. C. 1646 B.

Hesse, Arch. f. Physiol., Bd. cix. 1905, p. 393.

Beer, Arch. ges. Physiol., Bd. lxvii. 1897, p. 581 (*accommod.*).

E. 1074. The head of a Cuttle-fish (*Sepia officinalis*) in which the brain, optic ganglia, and eyes have been exposed from in front. The coverings of the right eye have been partly removed to lay bare the sclerotic capsule, the iris, and the front part of the lens. The left eye has been divided to show its internal structure. O. C. 1629.

Hunterian.

E. 1075. The eyes of a Cuttle-fish (*Sepia officinalis*) with the outer integuments and the cornea removed. The lower specimen shows from in front the peculiar shape of the pupil, which is due to a bilobed process of the upper border of the iris that extends downwards in front of the upper half of the lens (*cf.* E. 1093, E. 1104). The upper specimen is in vertical section and shows the relation of the iris to the lens, and the division of the latter into two parts by the corpus epitheliale and the septum lentis. O. C. 1646 C.

E. 1076. The outer half of the eye of a Cuttle-fish (*Sepia officinalis*) seen from within with the lens *in situ.* The lens is attached to the anterior part of the sclerotic capsule by a ring of tissue, radially pleated like the ciliary body of the Vertebrate eye. This is the corpus epitheliale, which, with its secretion (the lens), is the modified anterior wall of the primary optic vesicle. O. C. 1633.

Hunterian.

E. 1077. The lens and corpus epitheliale from the eye of a Cuttle-fish (*Sepia officinalis*). O. C. 1633 A.

Presented by Sir Anthony Carlisle.

E. 1078. The lens of the eye of a Cuttle-fish (*Sepia officinalis*) in section. The concentric structure of the lens is apparent owing to differences in the action of alcohol on its various parts. In the centre is a hard transparent nucleus. This is surrounded by a white opaque zone, and this again by a translucent and an opaque layer. O. C. 1636.

Hunterian.

Home, Phil. Trans., vol. 84, 1794, tab. v. fig. 1.

E. 1079. Two preparations showing the laminated structure of the lens of a Cuttle-fish (*Sepia officinalis*). O. C. 1639.
Hunterian.

E. 1080. A vertical section of the eye and optic ganglion of a Cuttle-fish (*Sepia officinalis*). The separate nerve-bundles given off from the ganglion are well shown passing through the sclerotic to the retina. O. C. 1630.
Hunterian.

ARTHROPODA.

Hesse, Zeitschr. f. wiss. Zool., Bd. lxx. 1901, p. 434.
Viallanes, Ann. Sci. Nat., sér. 7, t. xiii. 1892, p. 369 (*Physiol.*).

In Arthropods there occur compound eyes, in which what superficially appears to be a single eye is in reality an aggregate of many eyes, each with its own retina (retinula) and dioptric apparatus and separated from its neighbours by pigment-cells. Good examples of such eyes are found in Crustacea and in the lateral eyes of Insects. When highly developed (*e. g.*, some Crustacea, Lepidoptera), each single eye or ommatideum consists of the parts shown in Pl. II. fig. 5. The cornea (a specialised part of the general cuticle of the head) and the crystal cones form the dioptric apparatus; the retinula consists of several cells (7 usually) surrounding a central refringent rod (the rhabdom) composed of the rod-like receptive end organs (rhabdomeres) of the retinula-cells, fused together. The entire ommatideum is surrounded by pigment-cells. The whole number of the ommatidea rest with their deep ends upon an outwardly convex basement-membrane and radiate outwards thence to the corneal surface of the eye, the curve of which corresponds to that of the basement-membrane. Between the retinulæ and the brain is a complex optic ganglion. Simpler forms of ommatidea are common in which, although the same plan is kept, the details are less perfect. The crystal cones may be absent (Coleoptera, Heteroptera) (acone eyes) or may be represented by a space filled with a transparent fluid (Diptera) (pseudocone eyes), or the cells of the retinulæ may be more independent, each containing a separate refringent rod (rhabdomere) not united together centrally to form a rhabdom.

The mode of action of such eyes is still a debated point. The most generally accepted hypothesis is that due to Johannes Muller, according to which each retinula is stimulated only by light rays which are parallel to the long axis of the ommatideum. Thus each retinula receives light only from one restricted spot of the general field of vision, but the sum of these impressions gives a complete erect picture formed like a mosaic of as many pieces as there are retinulæ. A critical discussion of this and other hypotheses, including those of Grenacher, Exner, and Lowne, will be found in Lowne's 'Anatomy of the Blowfly,' vol. ii. 1893–95, pp. 554–582, but to those there mentioned should be added that of Viallanes, which, like those of Exner and Lowne, depends on the fact that each united cornea and crystal cone when isolated can be seen to form a minute reversed image of a considerable field. These images on Viallanes's hypothesis are combined by the brain, as in ordinary binocular vision, to form a single picture. If this is so, the vision, although not very acute, would be highly stereoscopic and sensitive to movement. Simple eyes are also found in many Arthropods (Arachnoidea and the ocelli of Insects), which although extremely variable in the details of their structure are characterised, broadly speaking, by a single cuticular lens overlying a cup-shaped continuous retina (Pl. II. fig. 6). Occasionally the sensory cells are grouped to form retinulæ, although still covered by a single lens, giving a condition somewhat transitional between a simple and a compound eye.

CRUSTACEA.

E. 1081. A Crab (*Podophthalmus vigil*). The compound eyes are borne upon the ends of remarkably long pedicels. The elongation is due to the length of their basal segments. Between these segments and the small terminal ones that carry the eyes are movable articulations, and as the whole pedicel is also movably jointed to the carapace, the eyes have a very extensive range of movement. When not in use the eyes and pedicels can be placed for protection in a deep groove situated along the anterior border of the carapace. O. C. 1626 B.

Presented by the late F. C. Pascoe, Esq.

ARACHNOIDEA.

E. 1082. Part of the carapace of a Scorpion (*Scorpio africanus*) showing the position of the eyes. These are eight in number, two of large size situated near the mid-line one on either side of a central prominence, and six smaller ones lying at either anterior and lower angle of the carapace. In the specimen both of the larger eyes are preserved (that of the left side being in section), but of the smaller ones only the three on the right side.

The central eyes of Scorpions differ in structure from the lateral, and are intermediate between the simple and the compound type. The retina is covered by a single lens, but is divided into retinulæ—the sensory cells being grouped into separate bundles surrounded by a sheath of pigment-cells. The lateral eyes are simple.

O. C. 1625. *Hunterian.*

Lankester & Bourne, Quart. Jour. Micr. Sci., vol. xxiii. 1883, p. 177.

INSECTA.

E. 1083. The head of a Cicada (*Tacua speciosa*) showing upon its dorsal surface between the large compound eyes three simple eyes or ocelli arranged in a triangle with the apex directed forwards.

E. 1084. Head of a Longicorn Beetle (*Cerambyx heros*) showing the large compound eyes. Their numerous corneal facets are of sufficient size to give the organs a punctate appearance to the naked eye. The facets, as shown in the drawing below the specimen, are hexagonal.

E. 1085. A Water-Beetle (*Dineutes mellyi*). Each compound eye is divided by a horizontal band of plain chitin into two parts, one of which faces directly upwards, the other downwards. The insect, which swims on the surface, is thus enabled to see at the same time in both air and water. This adaptation finds a parallel in the small Teleostean fish (*Anableps*), Nos. E. 1111 and E. 1112.

E. 1086. A male Dipterous Fly (*Achias longividens*). The compound eyes are borne upon stiff and immoveable pedicels, produced by the lateral elongation of the sides of the head. The antennæ are situated on the front of the head below the bases of the eye-stalks.

E. 1087. A Dipterous Fly (*Diopsis tenuipes*) from South Africa. A slender process of the head on either side bears at its extremity the antenna and the compound eye.

O. C. 1626 A.

VERTEBRATA.

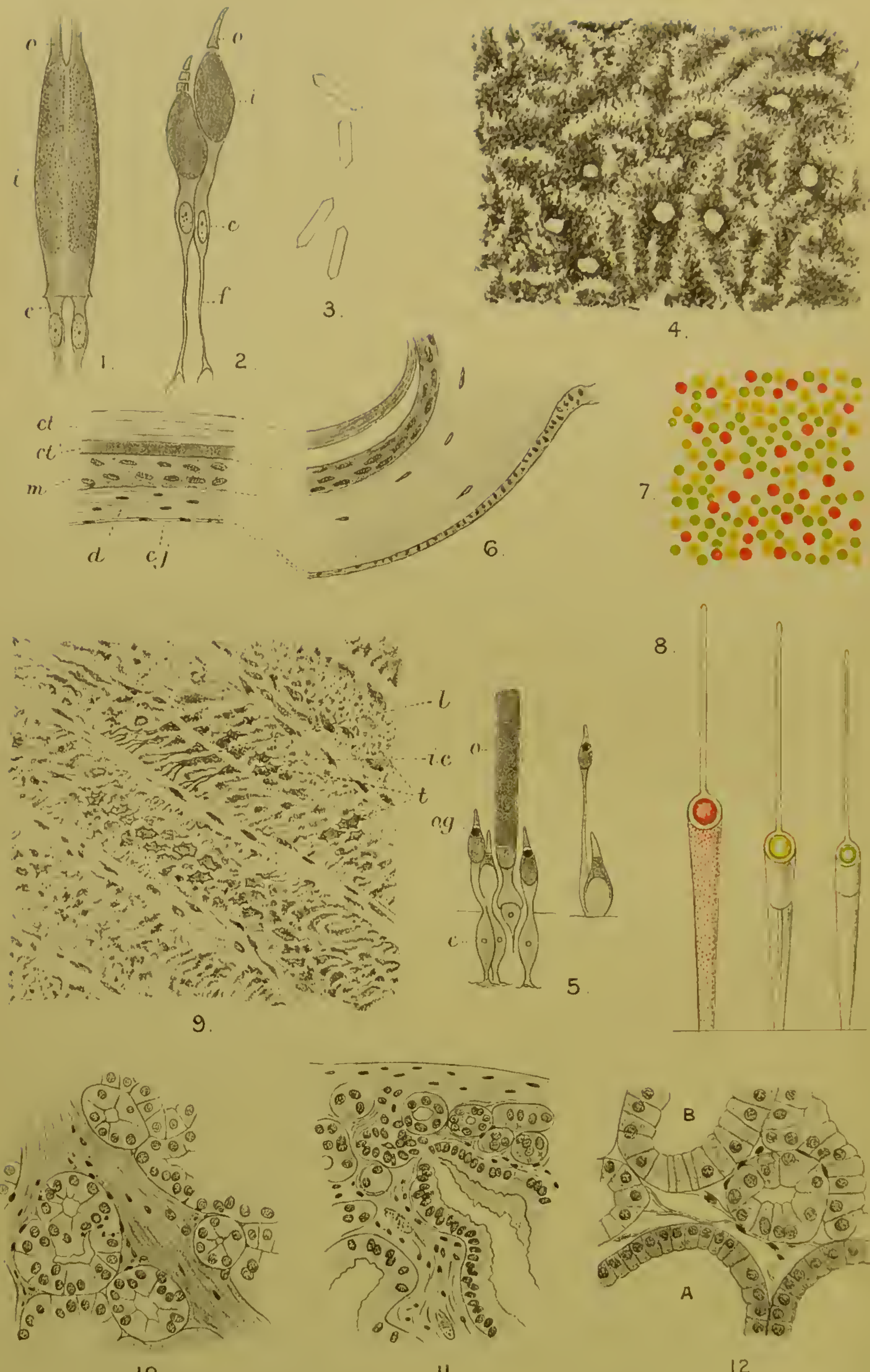
The Eyeball.

John Hunter, Essays and Observations, edit. R. Owen, vol. i. p. 166 ; and this Catalogue, 1st ed. vol. iii. pt. 1, p. 129.
On the Colour of the Pigmentum of the Eye in different Animals, Animal Economy, Works of Hunter, Palmer, vol. iv. p. 277.
Letter to Sir Joseph Banks on the Structure of the Crystalline, Phil. Trans. vol. lxxxiv. 1794, p. 91 ; also Works of Hunter, Palmer, vol. iv. p. 287.
Beer, Wiener Klin. Wochenschr., Bd. xi. 1898, no. 42, p. 942 (*accom.*).
Slonaker, Jour. Morph., vol. xiii. 1897, p. 445 (*acute vision*).
Leuckart, Graefe u. Saemisch Handb. Augenheilkunde, Bd. ii. Th. 2, 1876, p. 145 (*anat.*).
Greef, Graefe u. Saemisch Handb. Augenheilk., Zweite Auflage, Bd. i. 1900, p. 74 (*retina and bibliog.*).

In Vertebrates the actual sensitive membrane or retina is not a single layer of senso-neural cells, as it is in most Invertebrates, but is built up of many layers. One of these consists of senso-neural and pigment cells and is analogous to the typical Invertebrate retina ; the rest form part of the central nervous system and are in fact an optic ganglion comparable to that found beneath the compound eyes of Arthropods.

Owing to the development of the retina from an outpushing of the brain and not by direct invagination of the epidermis, the receptive end organs face away from the light and not towards it, as in most Invertebrates. In every retina the retinal end organs have the form of refringent rods or cones, but the relative numbers of these in different retinæ and in different parts of the same retina varies greatly. Thus it is stated (Slonaker) that in Mammals and Amphibians the rods far outnumber the cones, but in Birds the cones are more numerous than the rods, while in Reptiles the rods are scarce or even absent and cones may alone be present ; in Fishes the rods and cones are about equal in number, or the cones may outnumber the rods. In many animals cones only are present over one or two (Birds) areas of the retinal surface situated usually in the direct line of vision. In Man, this area (macula lutea) and particularly a depression in its centre (fovea centralis) is the point of acutest vision and of the most delicate colour discrimination. Towards the margins of the retina, where the proportion of cones is diminished, there is a notable loss of sharpness of vision and of sensitiveness to colour, but the sensitiveness to weak stimulation is much increased. These facts in Man suggest that the cones differ in function from the rods, being the agents in acute vision and chiefly concerned in the discrimination of colours, while the rods are more sensitive to subdued stimulation. This idea is to some extent borne out by comparative anatomy. In the eyes of many nocturnal animals cones are scarce or possibly quite absent, whereas the fovea centralis, which in Man is the area of acutest vision, is present chiefly in those animals whose vision is undoubtedly acute—*e. g.*, Primates, Birds, and, to a less extent, in Lizards.

Although the rods and cones in all cases have a fundamental similarity of structure, they differ considerably in form and other details not only from each other but amongst themselves. Thus rods of very different sizes and proportions occur in the several Vertebrate classes or even in the same retina (e. g., *Rana*) ; and there is still greater variation among the cones. The cones, for instance, in the fovea centralis of the Human retina are more than three times as long and as narrow as those at the periphery, and in the different groups of Vertebrates the variations in size and proportions are equally striking. The largest cones are found in Fishes, the longest and narrowest in Birds, and the smallest in Amphibia. In all classes, except Mammals, the cones often are united by their inner segments in



J. Green lith.

PLATE III.

Fig. 1. Large twin cone from a Perch, × 330 (from Graefe-Saemisch).

Fig. 2. Double cone from a Roach, × 500 (from Graefe-Saemisch).

Fig. 3. Crystals from the tapetum lucidum of *Scyllium catulus*, × 300.

Fig. 4. Surface view of a portion of the tapetum lucidum of *Carcharias glaucus*, × 75.

Fig. 5. A. Double and single cone and a rod from the retina of a Frog exposed to light (from Græfe-Sæmisch); the cones are retracted. B. Double cone from a Frog kept in the dark—the chief cone is extended (from Graefe-Saemisch). × 500.

Fig. 6. Section through the eyelids of a Snake (*Tropidonotus natrix*), × 280.

Fig. 7. Distribution of coloured oil-globules in the macula of a Fowl, × 500 (from Graefe-Saemisch).

Fig. 8. Cones from the retina of a Pigeon, showing coloured oil-globules, × 870 (from Graefe-Saemisch).

Fig. 9. Section of the lachrymal gland of *Chelone mydas* (after Stewart).

Fig. 10. Section of the nictitating gland of a Pig, × 150.

Fig. 11. Section of the Harderian gland of a Pig, × 150.

Fig. 12. Section of the Harderian gland of a Rabbit, × 150 A. White part; B. Pink part.

c., cone-cells; *cj.*, conjunctiva; *ct.*, *ct'.*, old and new cuticle; *d*, dermis; *f.*, filamentous root of cone-cell; *i.*, inner segment of cone; *i.c.*, intercellular substance; *l.*, lumen; *m.*, Malpighian layer of epidermis; *o.*, outer segment of cone or rod; *o.g.*, oil-globule; *t.*, cells in transverse section.

pairs, forming, when they are of unequal size, "double cones," or if they are similar in every way, "twin cones (Pl. III. figs. 1, 2)." In the cones of Birds, and of some Reptiles and Amphibia, brilliantly coloured or colourless oil-globules occur in the outer end of the inner segment (Pl. III. figs. 7, 8). The physiological meaning of these variations in structure is unknown.

Little is known of the actual mode of stimulation of the visual end organs. In the rods of many Vertebrates it is apparently due to the decomposition of a peculiar pigment (visual purple) located in their outer segments, which is gradually deposited there when the eye is kept in the dark, but is bleached and decomposed on exposure to light. In the cones there is no such pigment, but they have been observed (in the Frog) to extend or retract according to their degree of illumination (Pl. III. fig. 5).

The whole external surface of the retina is covered by a vascular and deeply pigmented tunic (choroid); this is in part nutritive owing to its great vascularity, but also serves to absorb surplus light that has passed through the retina and which unless absorbed would tend to blurr the retinal image. In some few groups (Elasmobranchs, Ungulata, Cetacea, Carnivora) the retinal surface of the choroid has a silvery or iridescent lustre, due either to the presence of a layer of cells packed with crystals of guanin (?) or (Cetacea, Ungulata) to a special arrangement of fibrous tissue. This reflector (the tapetum lucidum) is at present of unknown function, though its occurrence most frequently in nocturnal or aquatic animals suggests that it may be of some service in assisting vision in weak light. Among several suggestions as to its action the most plausible seems to be that put forward by Pütter (Zool. Jahrb., Bd. xvii. 1903, p. 324), in which he supposes that the diffuse or decomposed light reflected from the tapetum serves as a subminimal stimulus by which the retina is sensitised and rendered more capable of response to feeble direct stimulation. This hypothesis would also explain the otherwise inexplicable fact of the illumination of the posterior chamber of the eye of certain Deep-sea Fishes by special luminous organs.

The contents of the globe and the cornea constitute a compound lens, which by means of accommodating mechanisms of different kinds can accurately focus upon the retina light proceeding from different objects at different distances. The refractive indices of some of the components of this lens (the cornea, aqueous humour, and vitreous) are all practically the same as water and higher than that of air, while that of the crystalline lens is again somewhat higher. Thus, in air, light is refracted at the surface of the cornea and upon entering and leaving the lens; but in water, the cornea is optically obliterated, its refractive index being the same as that of water, and its place is then taken by a sharper curvature of the lens. The dioptric apparatus is completed by a diaphragm, the iris, interposed between the lens and the cornea. This is chiefly composed of the inturned anterior border of the choroid, and, except in most Teleostea, is contractile to regulate the amount of light admitted to the retina.

The outermost tunic of the globe (sclerotic) is protective, and although mainly fibrous may be strengthened by cartilage or plates of bone. Posteriorly it is continuous with the sheath of the optic nerve and so with the dura mater. In front it passes into the cornea.

PISCES.

Berger, Morph. Jahrb., Bd. viii. 1882, p. 97 (*anat.*).

Beer, Arch. ges. Physiol., Bd. lviii. 1894, p. 523 (*accommod.*).

Hirschberg, Arch. f. Anat. u. Physiol. (Physiol.), 1883, p. 493 (*diopt.*).

Rabl, Zeits. wiss. Zool., Bd. lxiii. 1898, p. 502 (*lens*).

In Fishes the globe of the eye is generally large and more or less hemispherical with a flat cornea. The curvature of the cornea is optically of little importance, as it has roughly the refractive index of water, so that its flatness is probably part of the general adaptation of the body-contours to the needs of aquatic locomotion by the avoidance of unnecessary prominences. The sclerotic is usually strengthened by cartilage or thin plates of bone. The lens, to compensate for the want of a refractive corneal surface, has a far sharper curvature than in most Land animals, and is normally in focus for near objects. Accommodation for distant vision is effected by the retraction of the lens towards the retina, and not by an alteration in its curvature. The mechanism for this purpose is best developed in Teleostea, and consists of a muscle (campanula Halleri) attached to the lower part of the lens and retracting it in opposition to a suspensory ligament (lig. quadratum).

An iris is always present, but, except in Elasmobranchs and a few Teleosts, is not appreciably contractile. The choroid has the usual Vertebrate characters, including in some cases a zone of feeble ciliary pleats for the efficient anchorage of the suspensorium of the lens, converging from the ora serrata towards the iris. Between the capillary and vascular layers there is in Elasmobranchs a silvery tapetum lucidum (Pl. III. figs. 3, 4), which consists of cells filled with crystals of different form, but probably composed of guanin. Crystals of guanin also occur in some few Teleosts in the pigment-cells of the retina, forming a retinal tapetum lucidum, and in very many Fishes of this group there is a strong layer of argentea between the choroid and sclerotic—a position in which it can have little or nothing to do with vision. Most probably the guanin in this case is merely a waste product, like similar layers of argentea that frequently occur in skeletogenous tissue in other parts of the body, *e. g.* beneath the scales and in the muscle septa.

In Bony Fishes also, but apparently only in those possessed of a pseudobranch, there is a large rete of blood-vessels (choroid gland) situated around the optic nerve between the vascular layer of the choroid and the sclerotic. In structure it closely resembles the pseudobranch, but its function is unknown. The retina in Teleostea is interrupted ventrally along a diagonal line from the optic disc to the base of the campanula, by the intrusion of a narrow fold of the vascular layer of the choroid (falciform process) into the cavity of the globe for the conveyance of nerves and blood-vessels to the campanula.

Although many Fishes, especially Teleosts, hunt their prey by sight, their power of vision is probably not very acute, except in the case of some few which, like the Wrasses and Pipe-fishes, minutely examine seaweed for any creatures suitable for food (Bateson, Jour. Mar. Biol. Ass., vol. i. 1889, p. 215). A fovea centralis is rarely present.

ELASMOBRANCHII.

Franz, Jena. Zeitschr., Bd. xxxiii. 1905, p. 697.

E. 1088. Parts of the two eyes of a "Grey Shark" (*Galeus* sp.) showing a silvery layer of argentea (tapetum lucidum) that lies between the retina and the vascular layer of the choroid. In the lower specimen the argentea has been scraped off to show the underlying pigmented choroid. O. C. 1669.
Hunterian.

E. 1089. A similar specimen of the posterior half of the eye of a Dog-fish (*Scyllium catulus*), showing the tapetum lucidum, which in this species covers only the upper half of the globe. The tapetum consists of a layer of flattened cells, which contain elongated plate-like hexagonal crystals, probably consisting of guanin.

E. 1090. A longitudinal section of the eye of a Basking Shark (*Selache maxima*). The sclerotic cartilage is of great thickness as far forward as the line of insertion of the ocular muscles. Here it turns inwards and becomes for a short space relatively quite thin, thickening again at its corneal border. The outer surface of the globe is flattened. The cornea has apparently been dried and so is probably thinner than it should be; it is perfectly flat and passes peripherally into the thick conjunctiva external to the sclerotic cartilage. The cartilaginous eye-stalk is attached to the sclerotic by a thick fibrous pad about 2 to 3 cm. in length. The spherical lens is also shown separately.
O. C. 1670 C.

Franz, *l. c.*, p. 730.

E. 1091. The inner and outer portions of the eye of a Basking Shark (*Selache maxima*), showing in the outer half the weakly developed ciliary plicæ and the elongated form of the pupil, and in the inner half the choroid membrane with some of the ciliary nerves. O. C. 1670 A & B.

E. 1092. A piece of skin from the right side of the head of a Monk-fish (*Rhina squatina*) including the eye. The cornea has been removed to show the shape of the contracted pupil. It forms a narrow slit directed diagonally from behind downwards and forwards. The expanded pupil is circular.

A slit-like contracted pupil is common to nocturnal Sharks. The iris is speckled like the surface of the body, forming part of the general protective scheme of coloration.

Preserved in 50 per cent. glycerine.

Bateson, *l. c.*, p. 215.

E. 1092 a. The posterior half of the eye of a Monk-fish (*Rhina squatina*) showing the tapetum lucidum.

E. 1093. Two preparations of the eye of a Skate (*Raja batis*). The cornea has been removed from the lower specimen to show a fringed process of the upper border of the iris that projects downwards across the pupil. This process shields the retina from the direct action of light coming from above, and in the daytime covers the whole pupil. During twilight it is gradually drawn up and at night is entirely so, leaving the pupil clear (Bateson). In the upper specimen the iris with the fringed process expanded, has been isolated by the removal of the anterior and posterior parts of the eyeball. O. C. 1658 B.

Bateson, *l. c.*, p. 215.

E. 1094. Eye of a Thornback (*Raja clavata*) with the outer parts and the retina removed. Upon the surface of the choroid, above the optic nerve, is a horizontal glistening band of argentea (tapetum lucidum) about 4 mm. broad. Bateson (*l. c.*, p. 216) states that "the eyes of the Elasmobranchs glow in the light of the lantern like a Cat's eye, but the eyes of the other fishes in the tanks do not."

E. 1095. A longitudinal section of the eye of a Devil-fish (*Cephaloptera giornæ*), including the eye-stalk. The cartilaginous layer of the sclerotic is of great thickness proximally, and is in places further thickened for the attachment of the ocular muscles and for the articulation of the expanded end of the eye-stalk. The joint between the eye-stalk and the globe is truly diarthrodial ; its cavity has been opened by the removal of part of the capsule. The vitreous humour has been removed, but the small spherical lens is preserved *in situ*, as are also the retina and the choroid. The termination of the retina at the margin of the ciliary zone is clearly marked. O. C. 1673. *Hunterian.*

GANOIDEI.

E. 1096. Vertical section through the right eye of a Sturgeon (*Acipenser sturio*). The globe of the eye is protected externally by an immoveable fold of skin, which is separated from it by a remarkably deep conjunctival space. The eye has thus, for a Fish, great freedom of movement. The sclerotic consists of two layers—cartilage within and a fibrous layer without. The latter is extremely thick, and is without a definite boundary towards the orbit. It is continuous with the sheath of the optic nerve. The posterior chamber of the eye is relatively small, and somewhat longer than broad. The lens is spherical, and the cornea very nearly flat.

Mounted in 50 per cent. glycerine.

E. 1097. A similar specimen in which the cartilaginous layer of the sclerotic is relatively very much thicker. The lens and optic nerve have been removed. The continuation of the sheath of the optic nerve into the fibrous layer of the sclerotic is clearly shown. O. C. 1666. *Hunterian.*

TELEOSTEA.

E. 1098. The right eye of a Sea-Bream (*Pagellus centrodontus*) with the posterior half of the sclerotic removed to show upon the deep surface of the choroid a band of yellow tissue arching over the optic nerve like a horse-shoe. This tissue (the choroid "gland") is composed of blood-vessels and capillaries and is of unknown function. It is said to occur only in those fishes in which there is a pseudo-branch.

In this specimen also the optic nerve has been divested of its sheath to show its flattened ribbon-like form and deep longitudinal pleating. O. C. 1661 A.

E. a 1098. Two specimens of the eye of a Pike (*Esox lucius*). The upper specimen, which is one-half of a vertical section, shows the general form and structure of the eye. The cornea is slightly convex and is thinner in the centre than at the circumference, a form similar to that found also in aquatic Mammals. The lens is globular and projects some way through the large circular pupil into the anterior chamber. The sclerotic, which is easily separable from the choroid owing to the presence of loose areolar tissue between the two, is hemispherical, but the posterior chamber of the eye is considerably shortened antero-posteriorly by the presence of a thick choroid gland in the outer parts of the choroid. This can be seen in section above the optic nerve. Along the lower border of the posterior chamber lies the falciform process, projecting as a thin pigmented lamina through the retina. At its anterior end it is confluent with the campanula Halleri, a rounded mass of pigmented tissue attached by its free end to the lower surface of the lens capsule. In the lower specimen, which is the ventral half of an eye with the lens removed, the falciform ligament and campanula are shown from above. Preserved in 5 per cent. formol.

E. 1099. A longitudinal section through the eye of a Bonito (*Thynnus pelamys*). The falciform ligament is remarkably prominent and projects as a thin pigmented lamina into the posterior chamber of the eye. In this preparation are also shown the cornea and iris, the coagulated vitreous, the retina, which has partly separated into layers at its edges, the choroid, and the sclerotic. Between the two latter tunics at the posterior end of the globe the dense tissue of the choroid gland is visible upon the section surface.
O. C. 1651. *Hunterian.*

E. 1100. The sclerotic of a Bonito (*Thynnus pelamys*). The periphery of the sclerotic is stiffened by a pair of thin bony plates that meet in a straight line above and below, and bound the corneal aperture by their inturned and slightly thickened anterior edges. Posteriorly they are separated by a large diamond-shaped membranous area, perforated in the centre for the passage of the optic nerve.
O. C. 1663. *Hunterian.*

E. 1101. A similar specimen of the sclerotic, together with the flattened cornea of Short-finned Tunny (*Thunnus thynnus*).
O. C. 1664. *Hunterian.*

E. 1102. Two specimens of the right eye of a Cod (*Gadus morrhua*), in which the blood-vessels of the choroid "gland" have been injected. The arteries are shown in the upper specimen, the veins in the lower. Arterial blood is brought to the "gland" by the arteria ophthalmica after having in the first place passed through the pseudo-branch. In the "gland" the artery divides, and finally breaks up into a mass of radially-arranged capillaries, which reunite to form vessels spread over the deep surface of the choroid. The venous blood is returned from the gland by a large vein situated upon the postero-dorsal surface of the optic nerve. O. C. 1661 B.

Berger, Morph. Jahrb., Bd. viii. 1882, p. 142.

E. 1103. The posterior half of the globe of the eye of a Haddock (*Gadus æglefinus*), with the retina and most of the choroid removed to show a glistening silvery membrane that coats the inner surface of the sclerotic. This membrane (Membrana argentea) consists of elongated irregular cells packed with needle-like crystals of guanin. Similar tissue occurs beneath the scales and sometimes upon the swim-bladder and between the muscles of Teleost Fishes. The choroid gland has been left around the point of entry of the optic nerve. O. C. 1652 B.

Mus. Sir Astley Cooper.

E. 1104. The eye of a Turbot (*Rhombus maximus*), with the cornea removed to show the iris. The pupil, unlike that of most Bony Fishes, is contractile. The movement is confined to a part of the upper border of the iris. When the pupil is contracted, as in daylight, this part extends downwards in the form of a rounded curtain, shutting off, very much as in the Skate, light coming from above. When dilated during the night the curtain shrinks to an insignificant knob. In the specimen the pupil is contracted, as usually is the case in death. A similar curtain is said to be present in the Brill (*Rhombus lævis*).

Preserved in 50 per cent. glycerine.

Bateson, Jour. Mar. Biol. Ass., vol. i. 1889, p. 228.

E. 1105. The greater part of the cartilaginous sclerotic of a Sun-fish (*Orthagoriscus* sp.), with the cornea and conjunctiva. O. C. 1665 A.

E. 1106. An antero-posterior section of the distal parts of the eyeball of a Sun-fish (*Orthagoriscus* sp.). The cornea is separable into two layers, a superficial conjunctival layer of considerable thickness continuous with the skin, and a deeper true corneal layer attached to the edge of the sclerotic. In the specimen these layers have been artificially separated; in life they are more or less firmly united by fibrous tissue. O. C. 1665. *Hunterian.*

E. 1107. A segment of the eye of a Sun-fish (*Orthagoriscus mola*), including parts of the cornea, iris, and ventral wall of the globe. The retina terminates anteriorly at the distance of nearly an inch from the margin of the pupil. Part of the coagulated vitreous is shown attached to the wall of the globe by the falciform process.
O. C. 1649. *Hunterian.*

E. 1108. The posterior part of the eye of a Sun-fish (*Orthagoriscus mola*), showing the small size of the optic disc and the fine radiation of the retina around it. From the lower border of the disc (left in the specimen) the deep end of the falciform process can be seen passing to the cut edge of the specimen. From it a part of the coagulated vitreous is suspended by the hyaline membrane. Between the retina and sclerotic is a thick layer of cellular tissue which is composed of the vascular layer of the chŏroid and also, in its outer parts, of the lymph-containing supra-choroidal tissue. O. C. 1648. *Hunterian.*

E. 1109. Eyeball of a Light-horseman Fish (*Ephippus gigas*), dried. *Hunterian.*
(In rail-case, Room V.)

E. 1110. Bony sclerotic of the eyes of a Light-horseman Fish (*Ephippus gigas*), dried. *Hunterian.*
(In rail-case, Room V.)

E. 1111. A male "Four Eyes" (*Anableps tetrophthalmus*). The cornea is divided into an upper and a lower portion by a narrow transverse band of pigment situated in its deeper layers. Besides this, the pupil is divided into an upper and a lower division by a pair of lobes which project from the sides of the iris, and overlap without fusion. The cornea has been removed from the left eye to show the iris and double pupil.

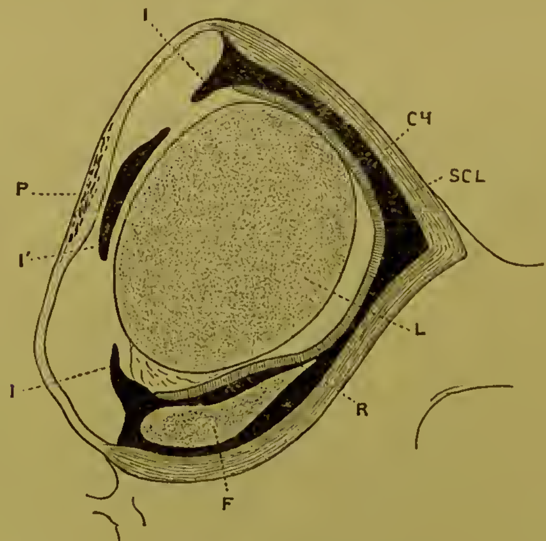
The following is a brief account of the habits of the fish as observed by Klinckowström. The fish inhabit estuaries and delta channels, and usually lie partly above water in small shoals near the bank waiting for flies and similar prey. When lying thus, the water-line coincides with the pigmented band across the cornea. Occasionally the whole shoal darts forward for a few hundred paces, but the fish always swims half out of the water and has never been seen to dive beneath the surface. O. C. 1658 A.

Presented by Walter Watkins, Esq.

Klinckowström, Skandinavisches Arch. f. Physiol., Bd. v, 1895, p. 67.

E. 1112. Posterior view of a transverse section through the cranium of *Anableps dovii*, including the eyes. In addition

Fig. 48.



Transverse section of the left eye of *Anableps dovii*, enlarged.

Ch. Choroid. F. Fat. I. Iris. I'. Lobe of iris separating the two pupils. L. Lens. P. Band of pigment in the cornea. R. Retina. Scl. Sclerotic.

to the features described in the previous specimen, it can be seen that the curvature of the lower cornea is much sharper than that of the upper, and also that the lens is oval, its two axes being to one another in the ratio of 4 : 5 and so placed that the light passing through the lower pupil traverses the long axis, that through the upper pupil the shorter axis. The retina is bent (not enough in fig. 48) opposite the pigmented band of the cornea in such a way that its upper half is at right angles to the long axis of the lens, its lower half at right angles to the short axis. Each eye is thus physiologically divided into two eyes, one directed downwards with a lens of sharp curvature for vision in water (the curvature of the cornea being in this case ineffective), and one directed upwards with slightly convex cornea and lens of relatively low curvature for vision in air. O. C. 1658 A *a*.

AMPHIBIA.

Hirschberg, Arch. f. Anat. 1882 (Suppl.), Physiol. Abt., p. 509 (*diopt.*).

Rabl, Zeits. wiss. Zool., Bd. lxiii. 1898, p. 527 (*lens*).

Beer, Arch. ges. Physiol., Bd. lxxiii. 1898, p. 501 (*accommod.*).

Amphibia in general are probably short-sighted, as may be inferred from the convex cornea and almost spherical lens usually found in members of this group. In water, however, they are apparently in many cases hypermetropic owing to the optical loss of the corneal refractive surface. At rest the eye is in focus for the distant limit of clear vision, and frequently has no power of accommodation, especially in nocturnal forms, in which the iris is strongly contractile ; but in some cases slight accommodation for nearer sight can be effected by the bodily shifting of the lens away from the retina. This movement is brought about by the contraction of a ciliary muscle which compresses the vitreous and causes it to push forward the lens, which is the least fixed part of the wall of the posterior chamber of the eye.

E. 1113. A vertical longitudinal section of the eye and eyelids of a female Guppy's Frog (*Rana guppyi*). The cornea, which is very thin, is too much deformed to show its true curvature. The lens is almost spherical, and is remarkable for its great size. The inner parts of the sclerotic are composed of hyaline cartilage as far forward as the meridian of the posterior chamber. O. C. 1694 A.

Ecker's Anat. des Frosches, 2te Aufl. Gaupp, Abt. 3, 1904, p. 762.

REPTILIA.

Beer, Arch. ges. Physiol., Bd. lxix. 1898, p. 507 (*accom.*)

Studnička, Lehrb. vergl. mikr. Anat., Oppel, Th. v. 1905, p. 124 (*pariet. eye*).

Rabl, Zeits. f. wiss. Zool., Bd. lxv. 1899, p. 257 (*lens*).

In Reptiles (with the exception of the Ophidia) accommodation for near distance is effected, as in the higher Vertebrates, by alteration of the curvature of the lens, particularly of its anterior surface. This is due to the action of the ciliary muscle, which by dragging forward the choroid slackens the suspensory ligament and allows the lens to assume by its natural elasticity a more rounded form. In most Snakes the mechanism is in principle the same as in Amphibians. The lens undergoes no alteration in curvature (except in special cases), but is pushed bodily forward owing to the compression of the vitreous by a circular muscle-band situated at the base of the iris. In many Lizards the contents of the globe receive their nourishment from a process of the vascular layer of the choroid comparable to the pecten of Birds, that projects into the vitreous from beside the optic disc. The sclerotic, as in almost all Vertebrates other than Mammals, is partly cartilaginous and in Lizards and Chelonians is stiffened in its anterior parts by a ring of bony plates radiating in a circlet round the cornea.

In many Lizards besides the two lateral eyes of the normal Vertebrate type there are vestiges of what seems to be a median unpaired eye lodged in a foramen in the roof of the skull and connected by nerve-tissue with the brain in front of the pineal body. This "parietal" eye varies much in its degree of degeneracy in different species, and shows a type of structure comparable to the simple vesicular eye of an Invertebrate, consisting when least degraded (e. g., *Sphenodon*) of a vesicle whose proximal wall has some resemblance to a retina with the sensory elements facing the light, and whose distal wall forms a cellular lens.

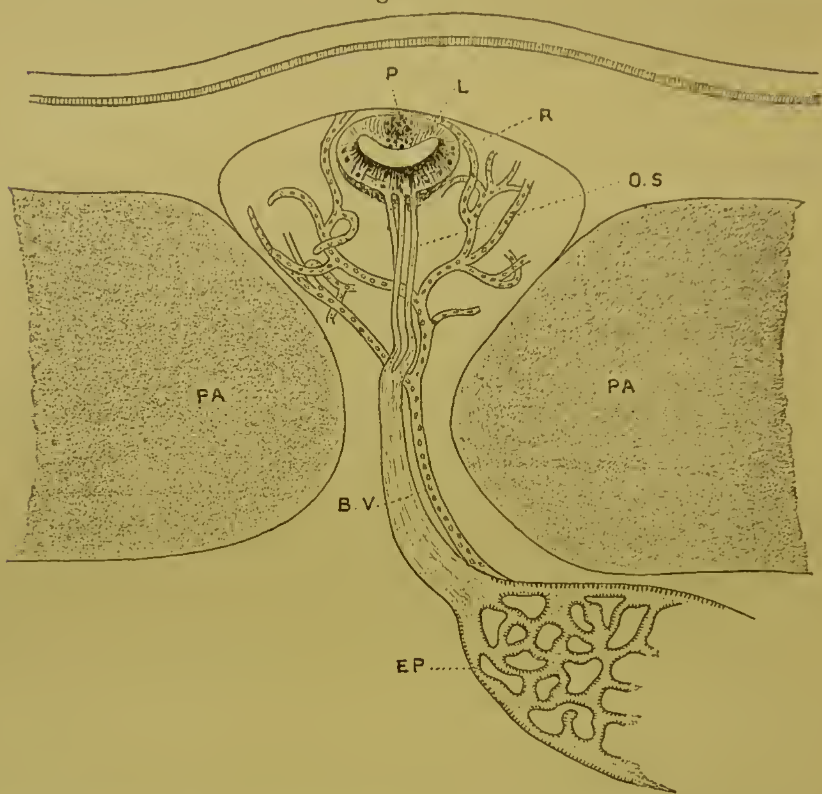
LACERTILIA.

E. 1114. The sclerotic and cornea of a Monitor Lizard (*Varanus salvator*), dried. The anterior, inturned, border of the sclerotic is strengthened by a ring of 15 overlapping bony plates. O. C. 1754 E.

E. 1115. The right eye of a Monitor Lizard (*Varanus salvator*) in vertical longitudinal section. The lens and vitreous have been removed, leaving the lens-capsule and parts of the hyaloid membrane visible. The hinder part of the globe has kept its natural hemispherical form owing to the stiffness of the cartilaginous layer of the sclerotic, but the softer cornea has collapsed. The greater part of the optic disc is included in the lower specimen and from it a long pointed process of vascular and pigmented tissue projects forward across the posterior chamber to the hinder surface of the lens-capsule, to which it is attached by a fold of the hyaloid membrane. This process is similar to the pecten in the eye of Birds and carries nutriment from the choroid to the contents of the globe. In these specimens the conjunctival sac and the eyelids are also shown, and in particular the position and thickness of the tarsal cartilage in the lower lid. O. C. 1765 B.

E. 1116. Longitudinal vertical section of the head of a Monitor Lizard (*Varanus salvator*). A hollow process of the brain (pineal body) extends upwards from the roof of the third ventricle just anterior to the optic lobes towards a foramen (parietal foramen) in the mid-line of the roof of the skull. Before reaching the foramen it narrows to form a nerve that terminates in a small eye-like structure (visible as a black speck in the specimen) embedded in the outer parts of a plug of connective tissue by which the foramen is filled. Above this "parietal" eye the integument is transparent and forms a cornea-like area known as the brow-spot. The microscopic structure of this vestigeal eye has been recorded for *Varanus* by Spencer (Quart. Jour. Micr. Soc., vol. xxvii. p. 165). The nerve of the parietal eye is probably not continuous with the pineal body, but passes along its anterior surface independently to the roof of the brain in the region of the corpora habenulæ. O. C. 1699 D.

Fig. 49.



Diagrammatic longitudinal vertical section through the parietal foramen of *Varanus giganteus*, showing the eye within the parietal foramen and the pineal stalk. (After Spenser.)

B.V. Blood-vessels. EP. Epiphysis (Pineal body). L. Lens. O.S. Pineal stalk. P. Pigment. PA. Parietal bone. R. Retina.

E. 1117. Part of the skin from the top of the head of a Monitor Lizard (*Varanus salvator*), showing the large white scale (brow-spot) resembling a cornea beneath which lies the parietal eye. O. C. 1699 c.

E. 1118. Head of a Monitor Lizard (*Varanus* sp.), showing the brow-spot. In this specimen it is peculiarly well marked. The centre is transparent and shows the dark pigment of the eye beneath. O. C. 1699 A.

E. 1119. Head of an Iguana (*Lophura amboinensis*). The brow-spot forms a rounded eminence. O. C. 1699 B.

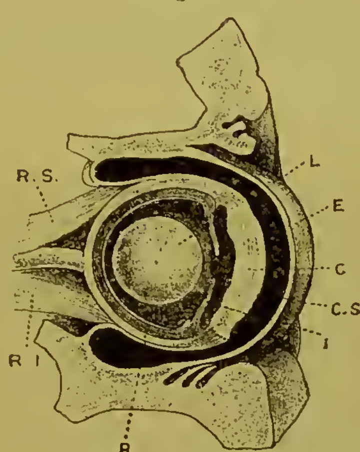
E. 1120. The anterior parts of the eye of a Chameleon (*Chamæleon* sp.), showing from within the ciliary region of the choroid, upon which the pleats are very inconspicuous, the glistening inner surface of the iris, and the circular form of the pupil. At the side of the specimen parts of the lids have been removed to show the extent of the conjunctival sac. O. C. 1699. *Hunterian.*

John Hunter, 'Essays and Observations,' edit. R. Owen, vol. ii. 1861, p. 373.

OPHIDIA.

E. 1121. The right eye of a Python (*Python reticulatus*), in longitudinal vertical section, with the surrounding parts.

Fig. 50.



Eye of *Python reticulatus*, in vertical longitudinal section. (From E. 1121, slightly modified.)

C. Cornea. C.S. Conjunctival sac. E. Cut edge of the eyelids. I. Iris. L. Lens. R. Retina. R.I., R.S. Inferior and superior recti.

The conjunctival sac, which is closed in front by the permanently united eyelids, extends back three parts of the way to the optic nerve. The transparent lids (Pl. III. fig. 6), which form the first refracting surface, are strongly convex; the cornea is flatter, but is of great thickness, and the lens, which is remarkably large and nearly fills the whole posterior chamber of the eye, is approximately spherical. Strong curvature of the refracting surfaces would be expected from the observed shortsightedness of Snakes. The sclerotic has no ring of bony plates around the margin of the cornea. The Harderian gland, which is of very great size and pours its secretion directly into the mouth (*cf.* E. 1232), has been left in its natural position enveloping the optic nerve and recti muscles. O. C. 1699 E.

E. 1122. A similar section through the eye of a Sea-Snake (*Distira ornata*). The eye shows characters resembling those seen in the previous specimen, but the lens is relatively much smaller and the cornea thinner. In this specimen it has collapsed. O. C. 1699 F.

CHELONIA.

E. 1123. The sclerotic of a Turtle (*Chelone mydas*) dried to show the ring of bony sclerotic plates that surrounds the cornea. The plates are ten in number, of irregular form, and overlap one another by their edges. O. C. 1754 D.

E. 1124. The eye of a Turtle (*Chelone mydas*), transversely divided. The ciliary arteries are injected and form a fine plexus around the optic nerve. The nerve forms a blunt conical projection at its entry into the cavity of the eye. The choroid is thick and of a brown colour ; it has no fold projecting through the retina comparable to the processus falciformis of Fishes or the pecten of Birds. The ciliary plicæ are sharply defined though small, and, as in Fishes, do not project forward as distinct "processes." The pupil is circular. The sclerotic consists of two layers—a thin outer one of fibrous tissue and an inner layer of hyaline cartilage. The latter is thicker over the posterior part of the globe than in front and on the temporal surface than on the nasal. The cornea is circular and flat.

O. C. 1674. *Hunterian.*

John Hunter, 'Essays and Observations,' edit. R. Owen, vol. ii. 1861, p. 354.

E. 1125. The sclerotic and cornea of a Leathery Turtle (*Dermochelys coriacea*). The plates, as in *Chelone mydas*, are ten in number and overlap by their edges, but they are somewhat more regular in shape and stouter in build.

E. 1126. The globe of the left eye of a Leathery Turtle (*Dermochelys coriacea*) in longitudinal vertical section. From the one half (upper specimen) the contents of the globe have been removed, leaving only the cornea and sclerotic. The cornea is surrounded, as in *Chelone*, by a ring of bony plates which slightly overlap the anterior edge of the cartilaginous part of the sclerotic. The sclerotic is thin from the edge of the bony plates to slightly in front of the meridian, but then suddenly increases in thickness, its whole posterior part being about 6 mm. thick. The cartilage is soft and towards its inner surface contains an increasing quantity of fibrous tissue. It is perforated by numerous pigmented blood-vessels, and upon its inner surface is deeply pitted and scored where the vessels emerge. In the lower specimen the contents of the globe are retained. The lens is nearly circular and, as in *Chelone*, of peculiarly small size, measuring 7 mm. × 7·5 mm.

AVES.

Beer, Arch. ges. Physiol., Bd. liii. 1893, p. 175 (*accommod.*).

Rabl, Zeits. f. wiss. Zool., Bd. lxv. 1899, p. 304 (*lens*).

Direct observation shows that in Birds the visual apparatus reaches a very high degree of efficiency, and this conclusion is fully borne out by its structure. The eye, relative to the size of the Bird, is peculiarly large ; the retinal area directly exposed to stimulation is generally very extensive, owing to the wide curve of the posterior wall of the globe, and there are frequently two areas of acute vision in each retina. There is also provision for great range of accommodation. The globe of the eye, especially in Nocturnal and Raptorial Birds, has a somewhat tubular shape, due to the horizontal lengthening of the ciliary area to form a more or less cylindrical segment between the broadly curved fundus of the globe and the much more sharply convex cornea. This region is strengthened, as in many Reptiles, by a ring of scleral plates, which serve as a basis of attachment for the powerful ciliary muscles by which accommodation is effected.

Active accommodation is for near vision as in Mammals, and is directly due to the relaxation of the capsule and suspensorium of the lens and its consequent resumption of its natural and more rounded form. The relaxation is brought about partly by the backward dragging of the margin of the cornea by the action of Crampton's muscle and partly as in Mammals by the forward dragging of the choroid.

In all Birds, except *Apteryx*, the contents of the globe are nourished by means of a pleated process of the vascular layer of the choroid that projects through the retina into the vitreous. This, which is known as the pecten, extends for a variable distance from the optic disc along the wall of the posterior chamber. Nutriment is also probably furnished by the ciliary processes, which in Birds are peculiarly large; their chief function, however, seems to be to afford an efficient anchorage for the suspensorium of the lens.

E. 1127. The cornea and sclerotic of an Ostrich (*Struthio camelus*), dried. The form of the globe is characteristically Avian. The posterior wall is extensive and of shallow convexity, and is separated from the much more sharply convex cornea by a short tubular segment stiffened by a ring of sixteen bony sclerotic plates. O. C. 1754 C.

E. 1128. A transverse section of the cornea, sclerotic bony plates, and a small part of the sclerotic of an Ostrich (*Struthio camelus*). The internal lamina of the cornea has been reflected, and the fibrous tissue which is continued from it to the bony plates is left attached to its outer margin. O. C. 1755 A.

E. 1129. The eye of an Ostrich (*Struthio camelus*) transversely divided, showing (in the posterior segment) the pecten, surrounded by the remains of the retina and attached by a portion of the hyaloid membrane to one side of the posterior part of the capsule of the lens. On the anterior segment may be observed the broad ciliary zone, with its deep sharply defined ciliary folds, which terminate abruptly towards the iris to form "ciliary processes." The pupil is circular. O. C. 1744. *Hunterian.*

E. 1130. A segment of the posterior part of the eye of an Emeu (*Dromæus novæ-hollandiæ*), showing the pecten. This consists of a vascular pigmented membrane (an extension of the vascular layer of the choroid) that projects freely into the posterior chamber of the eye from a line extending downwards from the optic disc and is folded fan-wise upon itself five times. The folds converge towards its free end, so that it terminates in a bluntly pointed extremity.

O. C. 1744 A.

E. 1131. A similar preparation from the opposite eye of the same Emeu. Two folds of the pecten have been cut off near their bases, showing their breadth and mode of plication. A part of the hyaloid membrane and the capsule of the lens remains attached to the apex of the pecten in this and the preceding preparation.

O. C. 1744 B.

E. 1132. Cornea and ring of sclerotic bones of a Goose (*Anser ferus*), dried. In this condition the cornea is practically flat. The intermediate area of the globe, which is protected by the sclerotic bony ring in this specimen, is not tubular as in most Birds. O. C. 1755 D.

Mus. Sir Astley Cooper.

E. 1132 a. The eye of a Goose (*Anser ferus*) in vertical longitudinal section. Although the cornea has a far sharper curvature than the posterior part of the sclerotic and is separated from it by a ciliary zone concave externally and slightly prolonged forward in a tubular form, the general shape of the globe is not so markedly avian as in many Birds. The lens is relatively small and strongly curved, especially upon its posterior face. Its antero-posterior and transverse diameters are equal. The position of the pecten, passing diagonally forward and outwards upon the floor of the globe from the optic disc is clearly shown. The pecten consists of ten folds that slightly converge towards their apices.

Preserved in 5 per cent. formol.

E. 1133. Eye of a Crane (*Grus cinerea*), with part of the wall removed to show the pecten. This is relatively shorter and wider than in *Struthio* or *Dromæus* and consists of many more pleats. Part of the hyaloid membrane remains attached to its apex. The ring of sclerotic bones lies more nearly in the vertical plane than in *Struthio*, but less so than in the Goose. O. C. 1748 A.

E. 1134. The head of an Eagle (*Aquila* sp.). The anterior parts of the left eye, including the lens and the vitreous humour, have been removed to show the origin of the pecten from a line that extends obliquely downwards and forwards from the optic disc. The pecten is of an unequal quadrilateral form, broadest at its base and projecting upwards and inclined a little backwards with a slight convexity towards the nasal side of the eyeball. The right eye has been divided horizontally, and the lens, vitreous, and the greater part of the retina removed to show in the lower half the pigmented choroid and the pecten. In this section the form of the eyeball is well shown—the hinder part of the globe flattish and encased in the thin but very dense sclerotic; the sudden transition to a cylindrical tubular form in the region of the sclerotic bony ring; and the sharply convex cornea. The relatively large size of the eyes is worthy of notice. The eyes of an Erne (*Haliaëtus albicilla*) are shown in No. E. 120. O. C. 1741. *Hunterian.*

John Hunter, Essays and Observations, edit. R. Owen, vol. ii. 1861, p. 270.

E. 1135. The eye of an Eagle (*Aquila* sp.) with a portion of the coats removed from one side, showing the pleated pecten, from which the colouring-matter has been removed.
O. C. 1743. *Hunterian.*

E. 1136. The cornea and sclerotic of a Virginian Hooded Owl (*Bubo virginianus*), showing the shape of the eyeball, which is flattened posteriorly, greatly extended in the form of a tube in the region of the sclerotic bony ring, and with a strongly convex cornea. O. C. 1754 B.

Mus. Sir Astley Cooper.

E. 1137. The sclerotic bony ring of a Virginian Horned Owl (*Bubo virginianus*), consisting of fourteen narrow quadrilateral plates. O. C. 1754 A.

E. 1138. The crystalline lens and vitreous humour of a Great Horned Owl (*Bubo bubo*), prepared to show that the vitreous humour has a distinct capsule (hyaloid membrane), part of which is in the specimen reflected from its outer surface. O. C. 1749. *Hunterian.*

John Hunter, Essays and Observations, ed. R. Owen, vol. ii. 1861, p. 279.

E. 1139. The eye of a Great Horned Owl (*Bubo bubo*), from which the cornea, the walls of one side, and the lens and vitreous have been removed, showing the remarkable elongation of the intermediate segment of the eye, which assumes in consequence a tubular form. The posterior part of the sclerotic is very thin. The pecten is relatively small, consisting of seven slightly converging plicæ. O. C. 1755. *Hunterian.*

E. 1140. A longitudinal section of the tunics of the eye of a White or Albino Thrush (*Turdus* sp.), showing the absence of pigment. O. C. 1753. *Hunterian.*

E. 1141. The anterior part of the other eye of the same Bird, showing the absence of the colouring-matter of the iris. O. C. 1754. *Hunterian.*

E. 1142. The eyes of a Crow (*Corvus* sp.). In the upper specimen (reverse side) the cornea has been cut away to show the dark-coloured iris; parts of the sclerotic, choroid, and retina have also been removed from the posterior surface of the globe to show the apex of the pecten sunk in the vitreous humour. In the lower specimen the eye is laid open from above. O. C. 1746. *Hunterian.*

E. 1142 a. The eye of a Raven (*Corvus corax*). A bony sclerotic plate surrounds the entry of the optic nerve.

MAMMALIA.

Lindsay Johnson, Phil. Trans., vol. cxciv. 1901, p. 1.
Virchow, Morph. Jahrb., Bd. xi. 1886, p. 437 (*cil. proc.*).
Rabl, Zeits. f. wiss. Zool., Bd. lxvii. 1900, p. 1 (*lens*).
Lang & Barrett, Ophth. Hosp. Rep., vol. xi. 1886, p. 103 (*refrac.*).

In Mammals the eyeball varies very considerably in size, and in some species of underground habits is quite vestigeal. It is generally more or less globular, with the cornea of somewhat sharper curvature than the sclerotic. The sclerotic is thin, except in aquatic and some few other species, and is not strengthened by cartilage (except in Monotremes) or by plates of bone. There is great variation in the curvature of the cornea and lens; usually the lens has the anterior surface flatter than the posterior, but in aquatic and nocturnal animals it is almost spherical. This is also the case where the axes of the eyes are very divergent, and then also the cornea is peculiarly extensive, giving a wide field of vision. The majority of wild Mammals are long-sighted. With the possible exception of some aquatic forms, near objects are brought into focus by alteration in the shape of the lens, as in Birds. This is due to the contraction of the ciliary muscle, by which the choroid is dragged forward and the suspensorium and capsule of the lens are relaxed, allowing the lens to assume its natural and more rounded form. The iris is always contractile, but the form of the contracted pupil varies greatly. In many Ungulates special processes of the uvea (corpora nigra) project from the upper and lower margins of the iris. These, although similar in many ways to the umbracula of Rays and Flat-fishes, are not contractile except in *Hyrax*, but from their position may perhaps to some extent act as a shield from light coming from above. Similar uveal prominences occur in Man as congenital malformations (Stephenson, Med. Press, 1893, p. 419).

A fovea centralis is confined to Man and the Apes, but in most Mammals there is an area comparable to the macula lutea, though it is often very indefinite. Probably vision is not acute in most members of the class and is not used for the close examination of near objects.

In most Mammals and some few Snakes the retina is nourished in part by a special system of vessels that enter the globe in the centre of the optic disc. This special blood-supply is correlated with the absence of a pecten or superficial and deep hyaloid vessels, through which the retina indirectly gets part of its nourishment in lower Vertebrates. Remains of the hyaline vessels occur, however, in fœtal life, and may persist in some cases in the adult.

MARSUPIALIA.

E. a 1143. The eye of a Kangaroo (*Macropus melanops*) in vertical longitudinal section. The globe, except for the slightly sharper curve of the cornea, would be spherical. The cornea is very extensive, reaching to within a few mm. of the limits of the conjunctival sac. It passes abruptly into the sclerotic at the base of the iris, the line of junction being marked externally by a pigmented band upon the conjunctiva. The sclerotic is of nearly equal thickness throughout, but shows an appreciable thinning in the equatorial region. The lens is biconvex, with its antero-posterior diameter to its transverse as 11–15. The posterior surface is more sharply curved than the anterior. The relation of the ciliary processes to the iris and lens can be well seen on the section surface; they are very strongly developed.

Preserved in 5 per cent. formol.

CETACEA.

John Hunter, Phil. Trans., vol. lxxvii. 1787, p. 437.

ODONTOCETI.

E. 1143. The sclerotic and cornea in longitudinal section and the optic nerve of a Bottle-nose Whale (*Hyperoodon* sp.). The globe of the eye is much flattened antero-posteriorly. The sclerotic is enormously thick over the hinder part of the globe, but thins out, as in the Pinnipedia, in the equatorial region, and is again thicker where it joins the cornea. The optic nerve, owing to the great width of the head in comparison with that of the brain, is remarkably long. It passes through the sclerotic in a funnel-shaped passage.

O. C. 1692. *Hunterian.*

Pütter, Zool. Jahrb., Bd. xvii. 1903, p. 272.

E. 1144. A portion of the eye of a Bottle-nose Whale (*Hyperoodon dalei*), in which the canal in the sclerotic that lodges one of the long ciliary arteries is laid open. A canal occupied by a vein that receives blood at the circumference of the iris is also opened, and a bristle is inserted into the trunk of another similar vein upon the section surface. The dense fibrous structure of the sclerotic and the spongy appearance of the vascular layer of the choroid are well shown in this specimen. The tapetum lucidum covers the whole of the fundus of the globe, and has the appearance of a dense white layer internal to the lamina vasculosa of the choroid. In the Cetacea the tapetum is fibrous, as in Ungulates. The ciliary processes are small, pointed, and crinkled. In this specimen the colour of the choroid and tapetum is lost. O. C. 1690. *Hunterian.*

E. 1145. Eye of a Bottle-nose Whale (*Hyperoodon dalei*) with the cornea and a segment of the anterior part of the sclerotic removed. The long ciliary arteries can be clearly seen passing on either side on to the iris, and branching to form the circulus major, from which numerous serpentine folds (doubtless enclosing arteries) radiate to the periphery of the iris. The pupil, as in other Cetacea, is bean-shaped, convex below and concave above. The concavity is due to a downward process of the upper border of the iris, said to be almost entirely composed of muscle.

O. C. 1689. *Hunterian.*

E. 1146. The eye of a Porpoise (*Phocæna phocæna*) injected and with the cornea removed to show the iris and the form of the pupil. The anterior surface of the iris is characterised by wavy vessels that radiate outwards, as in *Hyperoodon*, from the circulus major. The circulus itself is very indistinct in the specimen.

The pupil is bean-shaped, encroached upon from above by a process of the superior margin of the iris. Compare with the Skate E. 1093, Turbot E. 1104, and Hyrax E. 1158. O. C. 1688. *Hunterian.*

Pütter, *l. c.*, p. 239.

E. 1147. A longitudinal section through the right eye of a Porpoise (*Phocæna phocæna*). The globe is much flattened antero-posteriorly. The cornea is flat and is much thinner in the centre than at the periphery. The sclerotic is very thick posteriorly, though not so much so as in other Whales. It thins considerably where it turns in to form the anterior face of the globe, and thickens again at its margin. The marginal thickening of the cornea and sclerotic results in a structural form well calculated to withstand pressure on the surface of the cornea. The lens is spherical. Between the sclerotic and the outer edge of the ciliary zone a coagulum can be seen in the strongly developed peri-choroidal lymph space. The optic nerve, which has been mesially divided, is surrounded by a thick sheath of fibrous tissue different in texture from the sclerotic.

O. C. 1677 A.

E. 1148. Skin from the right side of the head of a young Gangetic Dolphin (*Platanista gangetica*), showing the exceedingly small size of the degenerate eye. In this specimen the small auditory aperture is also shown; it lies at a considerable distance behind the eye, and is not provided with a pinna of any kind. O. C. 1776 A.

Presented by Sir Joseph Fayrer, Bt.

E. 1149. A longitudinal section of the sclerotic and choroid of a Grampus (*Orca orca*), showing the great thickness of the posterior parts of the sclerotic and their penetration by the conical anterior termination of the sheath of the optic nerve. The nerve itself narrows very much in its passage through the sclerotic. O. C. 1693. *Hunterian.*

E. 1150. The eye of an adult Sperm-Whale (*Physeter macrocephalus*) longitudinally bisected, showing the enormous thickness of the hinder parts of the sclerotic, the small spherical lens, and the relatively small size of the cavity of the eye. This specimen was taken from the animal whose skeleton (2846, Osteol. Ser.) is suspended in the centre of Room V. The whole eye is minute compared to the size of the animal. O. C. 1692 A.

Presented by W. L. Crowther, Esq.

MYSTACOCETI.

E. 1151. Part of the cornea of a Piked Whale (*Balænoptera acuto-rostrata*). It is much thinner in the centre than at the margin. This feature is common to the cornea of most aquatic Mammals. Hunter (Œcon. of Whales, p. 733) states that it is soft and very flaccid.

O. C. 1681. *Hunterian.*

John Hunter, Essays and Observations, edit. R. Owen, vol. ii. 1861, p. 117.
Pütter, *l. c.*, p. 188.

E. 1152. The other half of the cornea of the same Whale, in which its laminated structure is shown.

O. C. 1682. *Hunterian.*

E. 1153. The anterior part of the choroid with the iris and ciliary processes of a Piked Whale (*Balænoptera acuto-rostrata*). Bristles are placed in the long ciliary arteries, which, advancing on either side in the direction of the long axis of the pupil, may be seen to terminate in a canal (circulus major) surrounding at a little distance the pupillary margin. Wavy branches radiate from this canal to the circumference of the iris. The pupil is slightly bean-shaped, owing to a feeble downgrowth of the superior margin of the iris. The veins of the choroid surrounding the iris have been injected. O. C. 1683. *Hunterian.*

E. 1154. The anterior part of the eye of a Piked Whale (*Balænoptera acuto-rostrata*), from which the cornea and lens have been removed to show the iris and ciliary processes. The form of the ciliary processes is very clearly shown; of the numerous minute folds which constitute the ciliary zone every third, fourth, or fifth is enlarged to form an inwardly directed wrinkled process about 5 mm. in length, said to be composed almost entirely of blood-vessels; the intermediate processes are shorter, but vary in length: the larger processes are about seventy in number.

O. C. 1680. *Hunterian.*

E. 1155. The hinder part of the same eye, showing externally the cut ends of the vessels that form a close plexus around the optic nerve, and internally the collapsed retina with part of the coagulated vitreous suspended from the optic disc; the choroid divisible into an inner white layer (tapetum lucidum) and an outer spongy vascular layer; and the cut surface of the thick fibrous sclerotic, in the outer parts of which can be seen the four canals that lodge the long ciliary arteries and the vorticose veins.

O. C. 1679. *Hunterian.*

Beauregard et Boulart, C. R. Soc. Biol. Paris, (10) vol. i. pp. 775–776 (*plexus*).

E. 1156. The eye of a Whalebone Whale (*Balæna mysticetus ?*) divided transversely into two equal hemispheres. By this section, in consequence of the great thickness of the posterior parts of the sclerotic, the cavity of the globe is left almost entirely within the anterior hemisphere, being laid open just beyond the entrance of the optic nerve. On the outside of the posterior hemisphere can be seen the elastic vascular mass of tissue that surrounds the optic nerve in its passage through the sclerotic. Upon the section surface is the small optic disc with part of the retina plicated in a radiated manner adhering to it. The tapetum lucidum and vascular layer of the choroid are clearly distinguished by their colour and texture.

In the sclerotic, at a little distance from the choroid, are several orifices for the short ciliary vessels, and near its outer margin are four nearly equidistant apertures, which are the canals for the passage of the long ciliary arteries and vorticose veins in section. O. C. 1678 A.

Pütter, *l. c.*, p. 221.

UNGULATA.

HYRACOIDEA.

E. 1157. Two specimens of the eye of a Cape Hyrax (*Procavia capensis*) with the cornea removed in each case to show a lobe of the upper border of the iris depending in front of the pupil. In the upper specimen this "umbraculum" almost reaches to the lower border of the iris, constricting the pupil to an hour-glass shape. In the lower specimen it extends still further downwards, forming a curtain over the whole pupil. A thread has been stretched across the pupil beneath the umbraculum to distinguish it from the rest of the iris.

The umbraculum is analogous to the contractile lobe of the iris seen in the Turbot, and no doubt shades the retina from a strong top light. It differs from the corpora nigra of other Ungulates in being composed of all layers of the iris, and not only of the uvea, and in being thus capable of movement.

Preserved in 50 per cent. glycerine.

Johnson, *l. c.*, p. 27.

PROBOSCIDEA.

E. 1158. The tunics of the eye of an Elephant (*Elephas indicus*) longitudinally bisected. The sclerotic is thick, especially towards its hinder part. The retina has been removed to show the tapetum lucidum, which covers a large part of the fundus of the globe. The cornea is thick and strongly convex, and the optic nerve of great length.

O. C. 1739. *Hunterian.*

John Hunter, Essays and Observations, edit. R. Owen, vol. ii. 1861, p. 173.

E. 1159. The eye of an Indian Elephant (*Elephas indicus*) transversely bisected. In the anterior half (upper specimen) the lens and ciliary processes are shown. In the posterior segment one half of the retina has been removed to show the position and extent of the tapetum lucidum, which covers the upper part of the fundus, extending also for several mm. below the optic disc.

Presented by the London County Council (Horniman Museum).

PERISSODACTYLA.

E. 1160. The tunics of the eye of a Horse (*Equus caballus*) minutely injected, cut open transversely and everted to show the central artery of the retina and the vascularity of the choroid and the ciliary processes. The form and arrangement of the latter are particularly well displayed. Upon the nasal side the ciliary zone is narrower than elsewhere, owing to the relative shortness of the outer parts of the ciliary plicæ in this region. O. C. 1711 B.

Museum Heaviside.

E. 1161. The eye of a "Horse, foaled of a white cream colour," bisected transversely to show that pigment is absent except upon the ciliary bodies and upon the corpora nigra. The latter show in strong relief against the white iris; they form a fringe of nodular masses of uvea along the inner surface of the upper edge of the iris. Their function is not clear. Upon the reverse of the upper specimen the white iris is exposed by removal of the cornea. The pupil is transversely oval. O. C. 1726. *Hunterian.*

ARTIODACTYLA.

E. 1162. The two eyes of a Boar (*Sus scrofa*), minutely injected by the ciliary arteries and the vorticose veins. In the upper specimen the eyeball is transversely bisected and the humours with part of the retina removed to show the vascularity of the choroid. In the lower specimen the sclerotic has been transversely divided and reflected to display the peculiar convergent course of the vorticose veins. O. C. 1711. *Hunterian.*

E. 1163. The posterior half of the eye of a Hog (*Sus scrofa*), showing the cup-like form of the optic disc and the radiate character of the surrounding retinal surface. One half of the retina has been removed to expose the choroid.

O. C. 1703. *Hunterian.*

E. 1164. Two specimens of the anterior segment of the eye of a Camel (*Camelus dromedarius*), showing the iris and pupil from the inner and outer aspect. Corpora nigra very similar to those of the Sheep occur upon both the upper and lower margins of the iris, but those upon the latter are very minute. The pupil is transversely oval.

Preserved in 50 per cent. glycerine.

Presented by Prof. G. Elliot Smith.

E. 1165. The posterior half of the eye of an Antelope (*Antilope* sp.) in which the retina has been removed to show a broad band-like tapetum lucidum lying transversely above the optic nerve. Its lower border is clearly defined, but it gradually fades away above. O. C. 1729. *Hunterian.*

E. 1166. Part of the globe of the eye of a fœtal Calf (*Bos taurus*) injected, to show the central artery of the vitreous and lens. O. C. 1705 A.
Mus. Sir Astley Cooper.

E. 1167. The eye of an Ox (*Bos taurus*) transversely divided. The retina has collapsed, thus uncovering the choroid and a large band-like tapetum lucidum of the normal Ungulate type that occupies the whole upper half of the globe. In the anterior segment of the eye the ciliary processes, iris, corpora nigra, and pupil are well shown. The corpora nigra are not nodulated, but form a pair of smooth folds of the uvea, of which that on the upper part of the iris is the larger. O. C. 1728. *Hunterian.*

E. 1168. The crystalline lens and parts of the lens-capsule of an Ox (*Bos taurus*). The anterior face of the lens, as in most other Mammals, is less sharply convex than the posterior.
O. C. 1705. *Hunterian.*

E. 1169. The choroid tunic of the eye of a Sheep (*Ovis aries*) with the short ciliary arteries injected with mercury.
O. C. 1711 A.
Presented by William Lawrence, Esq.

E. 1170. The eye of a Sheep (*Ovis aries*) transversely bisected. showing, in the upper specimen, the iris, corpora nigra, and pupil. The corpora nigra form an irregular deeply pigmented fringe upon both the upper and lower margins of the iris. In the lower specimen the retina has been removed to show the tapetum lucidum, which has the normal Ungulate position and form.

Preserved in 50 per cent. glycerine.

E. 1171. The anterior segment of the eyes of a Sheep (*Ovis aries*) showing the ciliary zone. This pleated area of the choroid is narrower upon the nasal side than elsewhere, measuring (in the upper specimen) 4 mm. upon this side, as compared with 5 mm. above and below, and 5·5 mm. upon the temporal side. In the upper specimen the lens and retina have been removed, but have been retained in the lower to show the position of the ora serrata. A similar disproportion in the breadth of the ciliary zone occurs in the Horse.

Preserved in 50 per cent. glycerine.

E. 1172. The eye of a large Quadruped, with the cornea removed and the long ciliary arteries injected with mercury. The trunk of each artery divides at the ciliary margin of the iris into two branches, that diverge and run parallel to the border of the pupil until they meet the corresponding branches of the other long ciliary artery, forming thus a vascular ring (circulus major). So far as can be seen, the circle is not completed by anastomosis of the finer branches of each ciliary artery. Numerous vessels are given off from the ciliary side of the circle, but none can be seen upon its pupillary side. The pupil is small and oval, but it is doubtful whether it should be vertical or horizontal. Judging by analogy with the Human subject, the long ciliary arteries should lie in the horizontal plane, in which case the long axis of the pupil should be vertical.

O. C. 1737 B.

E. 1173. A transverse section of the tunics of the eye of a large Quadruped with the capillary layer of the choroid minutely injected. The ciliary zone and processes are very clear. The latter are much nodulated. O. C. 1738. *Hunterian.*

RODENTIA.

E. 1174. The globe of the eye of a Flying Squirrel (*Pteromys petaurista*) showing the large size and pronounced convexity of the cornea in this nocturnal species.

O. C. 1708. *Hunterian.*

E. 1175. The eye of the same animal, transversely divided, showing the large almost spherical lens, the ciliary processes, iris, and cornea. O. C. 1707. *Hunterian.*

E. 1176. Skin from the left side of the head of a Strand Mole-Rat (*Spalax typhlus*) seen from the deep aspect. The eyeball is reduced to a minute pigmented speck buried beneath the skin in connective tissue. This is the most extreme example of reduction of the eye among Rodents. The animal lives in its winding underground galleries and practically never comes to the surface. O. C. 1787 E *a*.

Presented by Dr. J. Anderson.

Hanke, Arch. f. Ophth., Bd. li. 1900, p. 321.

E. 1177. The skin of the right side of the head of a Coast Rat (*Bathyergus maritimus*), with the eyeball exposed upon its inner surface. Although the eye is of very small size, it is apparently complete, with an optic nerve and with well-developed lacrymal glands. The palpebral orifice is also of considerable size.

E. 1178. The eyes of a Black and a White Rabbit (*Lepus cuniculus*), showing the strongly pigmented choroid and iris in the former, in contrast to the entire absence of pigment in the latter.

Preserved in 50 per cent. glycerine.

PINNIPEDIA.

E. 1179. A longitudinal section of the eye of a Seal (*Phoca vitulina*). The cornea is flattened (in this specimen) and is considerably thinner in the centre than at the periphery, as in Fishes and Cetaceans. The sclerotic is thick posteriorly and along its corneal margin, but is extremely thin in its middle third. The marginal thickening of the sclerotic and cornea are fitted to withstand pressure on the surface of the cornea, but the physiological meaning of the meridional thinning of the sclerotic is not clear. It has been suggested by Blumenbach (Manual Comp. Anat., Engl. trans. 2nd ed. p. 289) that it may adapt the eye for vision in air by allowing the posterior chamber to be shortened by the contraction of the muscles around the globe. The choroid is peculiarly thick and is covered internally by a tapetum lucidum, which is said to resemble that of the Cat and other Carnivora in its minute structure. Interposed between the base of the ciliary zone and the sclerotic is a highly vascular ligamentum pectinatum. This structure and the longitudinal part of the ciliary muscle (tensor chorioidæ) are remarkably developed in Pinnipedia, and it has been suggested (Pütter, p. 334) that in these animals accommodation takes place, as in Amphibians, by the forward movement of the lens as a whole and not by alteration of its shape, which in the resting condition is nearly spherical. In this action the tensor chorioidæ is supposed to compress the vitreous and drive forward the lens, the extra pressure in the anterior chamber being relieved by the expansion of the ligamentum pectinatum. The retina has shrunk away from the choroid, keeping its attachment only at the ora serrata and around the optic disc. The optic nerve is accurately bisected. It is surrounded by a thick sheath of connective tissue, which is, however, relatively soft and, as in the Cetacea, forms a conical plug let into the thickened hinder part of the denser sclerotic. O. C. A 1694.

Pütter, Zool. Jahrb., Bd. xvii. 1903, pp. 130, 308.

E. 1180. Anterior part of the eye of a Bladder-nosed Seal (*Cystophora cristata*), showing the ciliary zone, iris, and pupil. The ciliary processes are long and show a sharply indented line of division about halfway between their free extremities and the ora serrata. The pupil is oval, but in the condition of the specimen it is impossible to say whether its long axis should be horizontal or vertical. In *Phoca* it is vertical. O. C. 1738 A.

E. 1181. The eye of a Sea-Lion (*Otaria* sp.). The cornea and half the sclerotic have been removed with the lens, humours, and retina. The whole inner surface of the choroid is exposed, showing that it is covered to the margin of the ciliary zone by a tapetum lucidum. The ciliary processes are well developed but thin. The ligamentum pectinatum is very large, as in *Phoca*, and is bounded on both sides by a dense membrane. The sclerotic is greatly thickened in its anterior and posterior parts, but very thin upon a level with the base of the ciliary zone, as in *Phoca*. The sheath has been removed from the optic nerve to show its diminution in size as it nears the optic disc.

O. C. 1694. *Hunterian.*

CARNIVORA.

AILUROIDEA.

E. 1182. Three preparations of the eye of a Cat (*Felis domestica*). The upper specimen is the hinder part of the globe with the vitreous and retina removed to show the glistening metallic-coloured tapetum lucidum which occupies a considerable area of the fundus above and just including the optic disc. The tapetum consists of a layer of cells filled with crystals of guanin and lying external to the capillary layer of the choroid. The light that falls upon it is decomposed and reflected by the crystals and possibly, acting as a sub-minimal stimulus, increases the sensitiveness of the retina to direct stimulation and thus assists vision in the dark. In the middle and lower specimens the iris and pupil are shown in a state of slight contraction and complete expansion. When fully contracted the pupil forms a vertical slit, in the dark it expands to a circular form. The slit-like form of the contracted pupil apparently acts as a corrective to the astigmatism of the cornea, which has been shown to be very marked in the Cat (Wolfskehl). In the lower specimen the lens has been retained and shows upon its anterior and posterior faces a faint Y-shaped mark, which is upright upon the anterior face, reversed upon the posterior. These lines indicate the point of end-to-end junction of the fibres of which the lens is composed.

O. C. 1733 A.

Preserved in 50 per cent. glycerine.

Wolfskehl, Zeits. f. vergl. Augenheilkunde, Bd. i. 1882, p. 7 (*pupil*).

Schultze, Centrbl. med. Wiss., Bd. x. 1872, p. 582 (*tapetum*).

E. 1182 a. The eye of a Cat (*Felis domestica*) in vertical longitudinal section. The cornea is strongly convex and very extensive, forming almost the whole of the conjunctival area of the globe. The sclerotic is peculiarly thin, in contrast to the decidedly thick cornea. The lens is situated almost midway between the cornea and fundus, dividing the eye into anterior and posterior chambers of nearly equal size, of which the posterior is slightly the larger. The ciliary zone is of great breadth, the ora serrata reaching very slightly in front of the middle of the posterior chamber. The lens is more strongly curved upon its anterior than its posterior surfaces. The antero-posterior and transverse diameters are to each other as 2–3. Upon the section surface above the optic nerve part of the tapetum lucidum is visible beneath the retina.

Preserved in 5 per cent. formol.

E. 1183. The hinder part of the eyeball of a Lion (*Felis leo*) with the vitreous and retina removed to show the tapetum lucidum. This has the same form and position as in the Cat. O. C. 1730. *Hunterian.*

John Hunter, Essays and Observations, edit. R. Owen, vol. ii. 1861, p. 43.

E. 1184. The eye of a Lion (*Felis leo*) divided horizontally, showing that almost the whole of the tapetum lucidum is confined to the upper half as in the Cat. The humours, lens, and retina have been removed, and the long pointed ciliary processes are well displayed.

O. C. 1731. *Hunterian.*

E. 1185. The eye of a Leopard (*Felis pardalis*) transversely bisected and with the lens, vitreous, and most of the retina removed to show the tapetum lucidum, which exactly resembles that of the Cat. O. C. 1733. *Hunterian.*

John Hunter, Essays and Observations, edit. R. Owen, vol. ii. 1861, p. 46.

INSECTIVORA.

E. 1186. The skin of the head of a Golden Mole (*Chrysochloris trevelyani*), bisected to show upon the inner side of the right half the minute vestigeal eyeball (surrounded by black paper), and upon the outer surface of the left half the small hairless patch of skin that overlies the eyeball, and may be regarded as a cornea that has resumed the characters of ordinary integument. To show this patch it was necessary to cut off some of the surrounding hair.

O. C. 1787 E *b*.

E. 1187. The anterior part of a young Mole (*Talpa europæa*), showing the minute circular palpebral orifices, through which can be seen the pigment of the vestigeal eyes. The colour has been much lost through age.

O. C. 1772. *Hunterian*.

Kohl, Bibliotheca Zoolog., Bd. v. 1892–95, p. 1.

PRIMATES.

LEMUROIDEA.

E. 1188. Portions of the two eyes of a Slender Loris (*Loris gracilis*). The upper specimen shows the large and prominent cornea,—large to allow of the admission of as much light as possible, and convex to adapt the vision of this nocturnal species to the small distances at which the gloom of night renders its prey visible to it. A portion of the sclerotic has been removed to show its thinness and the uniform dark brown colour of the choroid. (The Loris are stated to show with the ophthalmoscope indications of a tapetum lucidum. Johnson, *l. c.*, p. 13.)

The middle specimen shows the iris. The lens, which is very convex, as in other nocturnal animals, is mounted separately below.

O. C. 1706. *Hunterian*.

ANTHROPOIDEA.

E. 1189. The anterior parts of the eye of a Monkey, with the lens removed to show the circular form of the pupil. The characteristic difference between this and the Human eye is the dark colour of the conjunctiva that surrounds the cornea. The colour has completely faded.

O. C. 1736. *Hunterian.*

E. 1190. The iris and membrana pupillaris, injected, of a fœtus. The membrana pupillaris is the anterior part of a vascular membrane (tunica vasculosa lentis) that surrounds and nourishes the lens during its development. It is a mesenchymal structure supplied by the central artery and from the circulus iridis. The membrana pupillaris lies beneath the iris and is later absorbed. When occasionally it persists the condition known as atresia pupillæ congenita results. O. C. 1735 F.

Mus. Sir Astley Cooper.

Schultze, Festschr. A. von Kölliker, 1892, p. 4.

E. 1191. A similar specimen of the iris and membrana pupillaris of a fœtus. The membrana is partially absorbed.

O. C. 1735 G.

Mus. Sir Astley Cooper.

E. 1192. The eye of a fœtus injected and with one half removed to show an extremely delicate central vitreous artery. A piece of black paper has been placed behind it. This vessel is present only in the fœtus, although in some of the lower Vertebrates it persists throughout life. O. C. 1709 A.

Mus. Sir Astley Cooper.

Schultze, Festschrift A. von Kölliker, 1892, p. 8.

E. 1193. The eye of a "fair Person," from which a lateral segment of the tunics and the whole of the humours have been removed to show the light-coloured choroid. The specimen is much faded. O. C. 1721. *Hunterian.*

E. 1194. A longitudinal section of the sclerotic of a Human eye, with the optic nerve attached. This layer is slightly thicker in its posterior region than elsewhere.

O. C. 1740. *Hunterian.*

E. 1195. Preparations of the two eyes of a "dark Person." From the upper specimen one half has been removed longitudinally, showing the collapsed retina in relief against the dark colour of the choroid. The ciliary processes and iris can also be seen. In the lower specimen the cornea and anterior part of the sclerotic have been removed and the posterior part of the sclerotic reflected to expose the iris and choroid, which are both pigmented, but are separated by a paler ciliary zone, upon the surface of which fibres of the ciliary muscle can be seen. The ciliary nerves are well defined, running forward over the dark-coloured choroid. O. C. 1714. *Hunterian.*

E 1195 a. The anterior segment of the coats of the eye of a "Fair Person," with the cornea cut away to show the iris and pupil. The uvea has been removed from the posterior surface of the iris. O. C. 1722. *Hunterian.*

E. 1196. The anterior segment of a Human eye, with the lens removed, showing the ciliary body with its processes and the iris. This is divisible into two separate regions—a smooth area around the pupil and an outer zone radially marked by pleats that form inward prolongations of the ciliary processes. The pupil is circular. Upon the reverse of the specimen the small convex cornea is shown. O. C. 1735. *Hunterian.*

E. 1197. The sclerotic and choroid tunics of a Human eye transversely divided to show the ciliary body, ciliary processes, and iris. O. C. 1713. *Hunterian.*

E. 1198. The tunics of the eye of a Negro, transversely bisected. The dark colour of the uvea is especially remarkable, although the pigment of the choroid is much faded. O. C. 1716. *Hunterian.*

E. 1199. A segment of the hinder part of a Human eye, including half the optic nerve. The latter is encased in a thick fibrous sheath continuous with the sclerotic and becomes much contracted as it enters the globe. O. C. 1702. *Hunterian.*

E. 1200. The choroid, iris, and ciliary ligament, injected and exposed from without. O. C. 1713 c.

Mus. Sir Astley Cooper.

E. 1201. The eye of a Human Albino, from which a portion of the sclerotic has been reflected to show the thin colourless and almost transparent choroid ; the vascularity of which being unobscured by the usual pigment occasions the pink colour observable in the eye of these persons during life. O. C. 1724 A.

Presented by Jos. Henry Green, Esq.

Parts accessory to the Organ of Vision.

John Hunter, Use of the Oblique Muscles, Animal Œconomy, Works, Palmer, vol. iv. p. 274.

*Power, Med. Times and Gazette, 1883, vol. ii. pp. 335, 363, 419, 508, 540.

Corning, Morph. Jahrb., Bd. xxix. 1902, p. 94 (*muscles*).

Peters, Arch. f. mikr. Anat., Bd. xxxvi. 1890, p. 192 (*Hard. gl.*).

Sardemann, Berichte naturf. Gesell. Freiburg, Bd. i. 1886, p. 95 (*lac. gl.*).

The eyes of Vertebrates, except sometimes when vestigeal, are lodged in cavities in the skull-wall (orbits) and are usually so placed that their optic axes have, broadly speaking, a lateral and horizontal direction. The position of the axes varies, however, considerably in the horizontal plane, examples being easy to find (especially among Mammals) of almost any direction between the purely frontal and the transverse. Deviation from the horizontal plane is less frequent, but in many bottom Fishes the eyes are turned more or less directly upwards. The orbit is not entirely filled by the eyeball and its appendages, the rest of the space, which is often (Fishes) very great, being occupied partly by a lymphatic or venous

* Many of the following preparations were made to illustrate Mr. Power's lectures on the Protective and Lachrymal Apparatus of the Eye.

cavity (Tenon's capsule, orbital sac), which envelops the hinder part of the globe and the ocular muscles and nerves, and partly by fat, which, when present in any quantity, forms a supporting cushion or pivot, upon which the eye can rotate when acted upon by the individual ocular muscles. In the Elasmobranchs this support is usually given by a rod of cartilage that stretches across the orbital sac from the skull-wall to the sclerotic.

The eyeball is moved within the orbit by a series of ocular muscles. In all cases (except where the eye is degenerate) there are at least six of these—four recti, which, with few exceptions (*Chimæra,* some Teleosts), arise close together in the depth of the orbit behind or around the optic nerve and are respectively inserted upon the upper, lower, anterior, and posterior surfaces of the sclerotic; and two obliqui which normally arise from the anterior walls of the orbit and are inserted upon the upper and lower surfaces of the sclerotic near the insertions of the superior and inferior recti. In Mammals the superior oblique gains an increased length of pull by the transference of its origin to the fundus of the orbit near to that of the recti, the direction of the pull being preserved by its passage at the anterior and upper part of the orbit through a ligamentous ring (trochlea). The ocular muscles are always innervated by the IIIrd, IVth, and VIth cranial nerves: the superior oblique by the IVth, the posterior rectus (and in *Petromyzon* the inferior rectus) by the VIth, and the rest by the IIIrd. Among the Amphibia, Reptiles, and Birds, and in many Mammals a sheath of muscle, often of great size, surrounds the optic nerve within the recti and acts as a retractor of the eyeball. It is probably derived from the posterior rectus.

The orbit is closed in externally by the skin. This may pass smoothly from its edge to the surface of the eyeball (some Fishes), but is usually loose in this part to allow the movement of the eye within the orbit, and in most cases the area of loose skin is tucked in between the orbit and the globe to form a conjunctival space the orbital margin of which projects more or less as a palpebral fold around the eye. A circular and immoveable fold of this kind is commonly found in Fishes and has been secondarily acquired in the case of many aquatic Mammals, but in most Land Vertebrates the upper and lower borders of the fold are enlarged to form horizontal eyelids, one or both of which can generally be moved by special muscles. These lids are most perfect in Mammals and take an important share in cleaning the surface of the eye by sweeping the lachrymal secretion across it. In lower Land Vertebrates, where they frequently have no power of independent movement, their place as regards this function is taken by a fold of the conjunctiva (nictitating membrane) situated either under cover of the lower lid (some Amphibia) or at the anterior corner of the eye, and capable of being rapidly drawn in front of the eye by means of ligamentous connections with the muscles of the globe or by muscles specially developed from the retractor bulbi for the purpose. In Mammals, although this membrane is present, it is usually in a degenerate condition and is incapable of independent movement. In Fishes a similar third lid occurs only in some few Sharks.

Except in Fishes, where the exposed surface of the eye is washed and moistened by contact with the surrounding water, a special fluid is secreted for this purpose by glands developed at the reflection of the conjunctiva. These usually lie at the anterior and posterior corners of the eye and are known respectively as the Harderian and lachrymal glands. The first is best developed in those Animals in which the nictitating membrane is highly functional and may be completely absent when the membrane is very degenerate (Man). In some Mammals it is separable by a difference of structure into two parts known as the nictitating and true Harderian glands (Pl. III. figs. 10, 11).

The lachrymal gland, on the other hand, is absent (Anurous Amphibia, Ophidia) or of small proportions in lower Vertebrates, and increases in importance with the functional activity of the horizontal lids. The mechanism for cleansing the eye is completed by a duct (lachrymal duct) through which the lachrymal fluid and dirt swept from the surface of the eye by the nictitating membrane or eyelids are discharged into the nose-cavity, or in rare cases (Snakes, Geckos) into the mouth. The entry to this duct lies at the anterior corner of the eye and consists of from one to about eight minute pores upon or near the margins of the lids.

PISCES.

Bishop Harman, Jour. Anat. & Physiol., vol. xxxiv. 1900, p. 1.

ELASMOBRANCHII.

Tiesing, Jena Zeits., Bd. xxx. 1896, p. 76 (*muscles*).

E. 1202. Two dissections of the eyelid-muscles of a Dog-fish (*Scyllium catulus*). The muscles of the right eye are shown in the upper specimen from within, those of the left eye in the lower specimen from without. As in the Carchariidæ (see Nos. E. 1205, E. 1207), levator palpebræ nictitantis and depressor palpebræ superioris (marked A and B) are present, but in this case both muscles, and not only the levator of the third eyelid, are apparently derived from the superficial constrictor group of muscles (*cf.* No. E. 1212). They arise together from the skull between the levator maxillæ superioris and the constrictor superficialis dorsalis II., the levator nictitantis above and to the median side of the depressor palpebræ superioris. Both muscles run forward and cross each other to reach their respective insertions upon the posterior corners of the upper lid and of the fold of skin in the lower lid that represents a nictitating membrane.

Ridewood, Jour. Anat. & Physiol., vol. xxxiii. 1899, p. 238.

E. 1203. The left eye of a Spotted Dog-fish (*Scyllium catulus*) dissected to show the contents of the orbit. The orbital sac is a spacious cavity, enveloping the hinder part of the globe and traversed by the ocular muscles and nerves and by branches of the trigeminus and facial. Its outer limit is shown by the cut edge of its enclosing membrane. The globe of the eye is not supported by a cartilaginous rod. The eye-muscles have the number and arrangement usual among Fishes—four recti arising from the hinder wall of the orbit and passing respectively to the anterior, posterior, dorsal, and ventral surfaces of the globe, and two obliqui that arise close together from the anterior wall of the orbit and are inserted into the dorsal and ventral parts of the anterior surface of the globe. The superior oblique is innervated by the IVth cranial nerve, the posterior

Fig. 51.

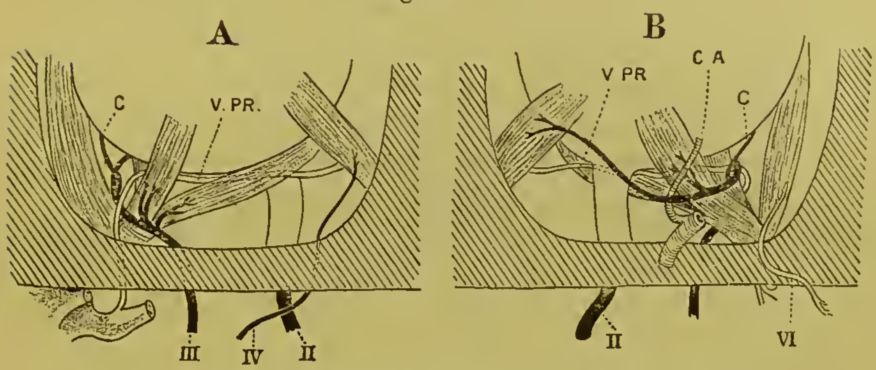


Diagram of the contents of the orbit of *Scyllium catulus*.

A. Dorsal aspect. B. Ventral aspect.
C. Ciliary nerve. C.A. Ciliary artery. V.PR. Ophthalmicus profundus V. II., III., IV., VI. Cranial nerves. The branches of the third and fourth nerves are black.

(external) rectus by the VIth, and the rest by branches of the IIIrd. The chief trunk of the IIIrd nerve, as it passes between the superior and posterior recti, gives off a small ciliary branch for the supply of the eyeball. A branch of the trigeminus (ophthalmicus profundus) which arises from the root of the superficial ophthalmic traverses the orbit longitudinally, passing round the posterior margin of the superior rectus across the main trunk of III, and continuing above the optic nerve to a foramen in the anterior wall of the orbit between the obliqui. The optic nerve enters the orbit almost as far forward as the anterior margin of the globe, not, as in higher Vertebrates, far back amongst the recti. Branches of the IIIrd and VIth nerves and the ophthalmicus profundus have been marked by black paper, and a red rod has been inserted into the ophthalmic artery where it gives origin to the ciliary artery.

E. 1204. The right eye of a Tope (*Galeus communis*), showing the circular palpebral fold and the nictitating membrane.

A secreting conjunctiva is deeply reflected between the eyelids and the globe of the eye and also forms a smooth lubricated covering to both sides of the third eyelid. The third eyelid lies at the anterior and ventral margin of the orbit and is moved over the eye in a postero-dorsal direction by a special muscle, the cut end of which can be seen at the posterior edge of the specimen (see also following specimen). The upper part of the circular eyelid is also capable of feeble movements, the range of which is indicated by a slight fold in the skin just above the lid.

O. C. 1763. *Hunterian.*

John Hunter, Essays and Observations, edit. R. Owen, vol. ii. 1861, p. 400.

E. 1205. The left eyelids and neighbouring parts of the skin of a Tope (*Galeus communis*), showing the muscles of the lids from the inner side. These are two in number—a large levator palpebræ nictitantis and a levator palpebræ superioris. The origin of the first is not shown. It in fact arises from the skull in conjunction with the dilator spiraculi, of which it is probably a part, between the levator maxillæ superioris and the superficial constrictor of the hyoid arch (*cf.* E. 1207). Thence it passes downwards and forwards external to the muscle of the upper lid to its insertion into the posterior corner of the nictitating membrane. The depressor palpebræ superioris arises from the skin above the spiracle in close connection with the sphinctor spiraculi, and passes forwards between the levator palpebræ nictitantis and the descending portion of the infraorbital lateral-line canal to be inserted into the posterior corner of the upper lid. A blue rod has been placed in the spiracle. O. C. 1763 B.

Ridewood, Jour. Anat. & Physiol., vol. xxx. 1899, p. 233.

E. 1206. The left eye of a Tope (*Galeus communis*) isolated, to show the optic nerve, the cartilaginous eye-stalk, and the mode of insertion of the ocular muscles. The obliqui are attached to the same protuberances of the sclerotica as the superior and inferior recti, which is the position most favourable for effecting the rotatory movements of the eye upon its axis due to the action of these muscles.

O. C. 1761. *Hunterian.*

E. 1207. Right eye of a Tope (*Galeus communis*) dissected *in situ* from below to show the muscles of the eyelids and of the globus oculi. Green and red rods have been placed respectively beneath the levator palpebræ nictitantis and the depressor palpebræ superioris. The muscles of the globe are well developed and quite normal in their disposition. The delicate rod of cartilage by which the globe is connected with the skull and supported is attached to the wall of the orbit close in front of the origin of the recti muscles. The optic nerve leaves the skull more than 1 cm. in front of this eye-stalk.

O. C. 1763 A.

E. 1208. The head of a small Hammer-headed Shark (*Zygæna* sp.) sagittally bisected and with the two halves mounted to show the ocular muscles in dorsal and ventral view. The recti muscles are remarkably long in consequence of the position of the eyes at the ends of lateral expansions of the head. The muscular tissue, however, extends from the insertion of the muscles little beyond the limits of the globe, the whole of the proximal part of the muscles between this point and the skull being degenerate and represented by tendinous strands that ensheath the cartilaginous eye-stalk, and are only with difficulty to be separated from one another. The obliqui are normal in form and position. O. C. 1760. *Hunterian.*

Bishop Harman, *l. c.*, p. 29.

E. 1209. Right eye and surrounding parts of a Porbeagle (*Lamna cornubica*), showing the ocular muscles, the eyelids, and the conjunctival sac. The depth of the latter, which is sufficient to allow of very considerable movement of the eyeball, has been displayed by the removal of the ventral parts of the circular immoveable eyelid. The muscles of the globe are six in number—four recti arising

from the skull posterior to the optic nerve, and two obliques rising respectively from the roof and floor of the orbit at its anterior end. They are all strongly developed.
O. C. 1667 A.

E. 1210. The eyeball, part of the optic nerve, and the cartilaginous eye-stalk of a Basking Shark (*Selache maxima*), showing the relatively enormous development of the ocular muscles. The eye-stalk is united to the cartilaginous sclerotic by a ligamentous substance and not by a diarthrodial joint as in many Elasmobranchs. O. C. 1761 A.

E. 1211. Eyelids and part of the right side of the head of a Spiny Dog-fish (*Acanthias vulgaris*) dissected from within to show the muscles from which in other species the palpebral muscles are probably derived. The eyelids are immoveable and have no musculature. The spiracle is large and capable of considerable dilatation by the action of a muscle (dilator spiraculi) (derived probably from the levator maxillæ superioris) that arises from the skull between the latter muscle and the second part of the constrictor dorsalis superficialis, and is inserted partly into the upper jaw, but mainly into the spiracular cartilage.

E. 1212. Specimens of the eye and neighbouring parts of the head of a Spiny Dog-fish (*Acanthias vulgaris*) showing the relation of the globe of the eye to the orbit. In the lowest specimen the left orbit has been dissected from above to show the extent of the orbital sac. This is a cavity lined by a smooth membrane very similar to Tenon's capsule and filled by lymph or in some cases by blood (Parker, Phil. Trans. vol. 177, 1886, p. 711). The sac occupies a large part of the ocular cavity and is traversed freely by the ocular muscles and nerves. The capsule of the sac has been opened and part of the superior rectus removed to show by means of black paper the reflected (visceral) layer of the capsule upon the stump of the muscle. The orbital cavity in the parts not occupied by the orbital sac or the eyeball is filled with gelatinous connective tissue, two especially large masses of which occur anteriorly and posteriorly at the point of reflection of the capsule. Black paper has been inserted beneath the upper eyelid to mark the depth of the conjunctival sac.

In the middle specimen are shown the position and form of the cartilaginous rod by means of which the globe of the eye is held away from the mesial wall of the orbit, and (in the upper specimen) the diarthrodial mode of articulation that occurs between the expanded plate-like head of this rod and the sclerotic. The capsule of the joint is furnished by the "visceral" layer of the orbital sac, which is closely adherent to the head of the rod, but is free from the sclerotic for some distance around it. This specimen also shows the line of reflection of the capsule.

Bishop Harman, *l. c.*, p. 23.

E. 1213. The eyes of a Ray (*Raja clavata*) dissected to show the cartilaginous process of the skull that extends from a point on the median wall of the orbit posterior to the exit of the optic nerve to the deep surface of the eyeball. The eyeball is pivoted upon this "eye-stalk," being jointed to its end by a diarthrodial joint. The joint has, however, no definite capsule, but the connective tissue that envelops the globe passes direct from the sclerotic cartilage to the outer surface of the eye-stalk, leaving the actual surfaces of contact bare. The rod is steadied in its position by a ligament that runs from its distal end to the anterior wall of the orbit. Below the chief specimen, in which the general relations of the globe to the eye-stalk are shown, separate pieces of the mechanism are mounted, showing the flattened almost ribbon-like form of the stalk and the presence of a prominent articular boss on the sclerotic cartilage.

GANOIDEI.

E. 1214. The left eye of a Sturgeon (*Acipenser sturio*) in its natural position, showing the circular immoveable eyelid, the great extent of the conjunctival space, and the muscles of the globe. The optic nerve leaves the skull at least 1 cm. in front of the origin of the recti muscles.

TELEOSTEA.

E. 1215. The head of a Shad (*Clupea alosa*), showing the eyelids of transparent muco-areolar tissue that extend partly over the eyes from their anterior and posterior borders. The posterior fold is a simple enlargement of the posterior border of the circular palpebral fold, but the anterior has more the characters of an immoveable third eyelid, being a process extending backwards from beneath the anterior part of the true palpebral fold. These lids are more pronounced during the breeding-season. Black paper has been placed between the eyeball and the eyelids. 1759 A.

Bishop Harman, *l. c.*, p. 7.

E. 1216. Two specimens showing the arrangement of the eye-muscles of a Shad (*Clupea alosa*). In the lower specimen the head and shoulders are seen in median sagittal section from the left, with the inner wall of the right orbit removed. The oblique and inferior rectus muscles are of normal length and disposition, but the other recti extend to different degrees backwards beyond the orbital cavity. The superior rectus is the shortest and arises mainly from the back of the orbit, but its lower fibres are prolonged for about 1 cm. beyond this point. The internal and external recti pass backwards below the floor of the skull and anterior part of the vertebral column, and take their origin from the vertebral column and aorta as far back as the third vertebra. The extra-orbital part of these muscles is enclosed in a canal formed by two delicate wings that project backwards from the lower surface of the sphenoid. This canal and its connections with the orbit are shown in the sagittal section of a skull mounted above. Below is a diagram.

E. 1217. Head of a Herring (*Clupea harengus*), showing the anterior and posterior protective palpebral folds. A black bristle is placed beneath them. O. C. 1759. *Hunterian.*

E. 1218. The head of a Conger (*Conger vulgaris*). In this fish there are no definite eyelids. The skin of the head passes directly over the cornea, without forming a conjunctival recess. The cornea is slightly convex and of very great extent, covering the whole outer surface of the globe. Its conjunctival layer is thick, and is separated by loose connective tissue from the deeper true corneal layer. The loose intervening tissue allows of a limited amount of movement to the eyeball, notwithstanding the want of a conjunctival reflection. The ocular muscles are, however, very feeble. Upon the right side, the skin, conjunctiva, and cornea are shown in section, and the orbital sac has been opened, exposing two of the ocular muscles. The capsule of the orbital sac is peculiarly thick.

Bishop Harman, *l. c.*, pp. 5, 21.

E. 1219. The head of a Mackerel (*Scomber scombrus*), showing a development of the eyelids similar to that described in the Shad and Herring (Nos. E. 1215, E. 1217). The special adipose lids are slightly raised by a black bristle.

O. C. 1758. *Hunterian.*

E. 1220. Part of the head of a John Dory (*Zeus faber*), with the right eye dissected from the median aspect. In fishes with the head much laterally compressed, the position of the eye and the relative length of the internal and external recti are such that the contraction of the internal rectus causes an outward projection of the posterior part of the globe, thus allowing an increased frontal range of vision. The insertions of the obliqui overlap those of the superior and inferior recti.

Bishop Harman, *l. c.*, p. 31.

E. 1221. Left eye of a Halibut (*Hippoglossus vulgaris*), with the muscles of the globe displayed. The superior oblique is double. One part of the muscle has the usual insertion upon the centre of the dorsal margin of the sclerotic in apposition to that of the superior rectus. The other part arises close beneath the first, then runs backwards around the posterior surface of the eyeball, crosses superficial to the superior rectus 1 cm. from its insertion, and is finally attached to the margin of the sclerotic at the postero-dorsal part of the globe. This extra oblique muscle is peculiar to the flat fishes, either as a separate muscle or as an offshoot of the superior oblique, and materially assists in the strong rotation of the eye about its axis that has been observed in fishes of this family. All the eye-muscles except the external rectus are remarkably large, and by reason of the great length of their muscular portion are capable of producing extensive movements of the eyeballs, especially those of convergence. Great freedom of movement is allowed to the eyes of these fishes by the area of loose skin between the conjunctiva and the margin of the orbit.

Bishop Harman, *l. c.*, p. 33.

E. 1222. Head of a Halibut (*Hippoglossus vulgaris*), showing the mechanism for the protrusion of the eyes. The left eye has been removed and a blue rod inserted into a passage that leads from the outer part of the floor of the orbit into a large muscular outpushing of the orbital wall (recessus orbitalis) situated upon the blind side of the head. This sac can be seen upon the reverse of the specimen. A similar though less marked recessus is present upon the outer and posterior wall of the right orbit. In the specimen this part of the orbital wall has been exposed and in part removed to show the connections of this rudimentary sac with the orbital cavity. The recessus orbitalis serves as a reservoir into which a great part of the orbital fluid passes when the eye is retracted. Upon relaxation of the muscles of the globe, the fluid is again driven into the orbit by the contraction of the walls of the recessus, and in consequence the eye is protruded.

Holt, Proc. Zool. Soc., 1894, p. 422.

E. 1223. Specimens of the recessus orbitalis in the Plaice (*Pleuronectes platessa*). The recessus orbitalis of the left eye has similar relations to the orbit as that of the Halibut, but is of rounder form and is not embedded in fat. The recessus of the right eye is quite as large as the left; it opens into the posterior part of the orbital cavity. Both recessus have thin walls strengthened on the inner side by numerous delicate muscular trabeculæ. The general form and position of the recessus are shown in the two lower specimens. Above are isolated specimens of the recessus opened to show the internal structure. A blue rod has been inserted into the passage from the recessus of the blind side into the left orbit.

Holt, Proc. Zool. Soc., 1894, p. 422.

AMPHIBIA.

E. 1224. The eyes of a female Guppy's Frog (*Rana guppyi*), showing the palpebral and muscular apparatus. In the upper specimen (left eye) the lower part of the conjunctival reflection has been cut through and the bulb turned upwards. The muscles of the globe are left in their normal position, and the tendon of the lower eyelid is shown passing round the ventral surface of the globe between the recti and the retractor bulbi muscles from one corner of the lid to the other. Black paper is placed beneath the tendon. In the lower specimen (right eye) the oblique and recti muscles have been separated to show their small size in comparison with the enormous retractor bulbi that surrounds the optic nerve. The course of the tendon of the lower lid is also shown, with its fibrous attachment to the inferior rectus and retractor bulbi. The small Harderian gland can be seen at the inner corner of the eye between the obliqui. The lower eyelid is far larger than the upper ; it is transparent towards its margin, and although it has no muscles of its own, is capable of movement by the traction of the retractor bulbi on its tendon. The upper lid has no intrinsic muscles, but only moves slightly through its attachment to the eyeball.

Ecker's Anat. des Frosches, 2nd Aufl., Gaupp, Abt. 3, 1904, p. 872. O. C. 1763 D.

E. 1225. A male *Megalophrys nasuta*, showing a prominent integumentary fold above each eye. This is a triangular expansion of the external surface of the eyelid. It is said to be lowered at will. O. C. 1763 E.

REPTILIA.

LACERTILIA.

Weber, Arch. f. Naturges., Bd. xliii. 1877, p. 261.

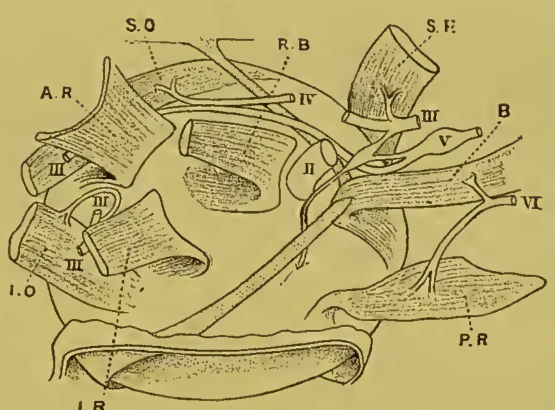
E. 1226. The left eyeball and eyelids with their muscles of a Chameleon. The conjunctival reflection has been cut except along its dorsal part and the eyelids turned upward to show the extent of the conjunctival sac and the small size of the palpebral opening. The recti and obliqui muscles are also shown. O. C. 1764. *Hunterian.*

E. 1227. Left half of the head of a Chameleon, showing the circular and prominent eyelids, the loose flexible character of the skin where they join the border of the orbit, and the small fusiform palpebral orifice. The eyelids in the Chameleon move chiefly with the eyeball.
O. C. 1765. *Hunterian.*

E. 1228. The right eye and eyelids of a Chameleon (*Chamæleon vulgaris*). The globe of the eye has been removed by cutting the conjunctiva along its line of reflection. The skin of the head is mounted below to show the extent of the conjunctival space, the small palpebral orifice, and the circular tarsal cartilage in the lower lid into which is inserted a well-developed depressor palpebræ inferioris. Above is shown the eyeball from its ventro-median aspect. It is moved by the usual recti and obliqui muscles, and in addition by a retractor bulbi formed of three indistinctly separate bundles. The superior rectus is particularly strong. A rudimentary nictitating membrane can be seen at the inner corner of the eye, extending some little way across its surface. In connection with it is a well-marked Harderian gland, partially concealed in the specimen by the inferior oblique.

E. 1229. The head and an isolated specimen of the eye of a Monitor Lizard (*Varanus griseus*), dissected to show the muscles of the eye and eyelids and the Harderian gland. In the lower specimen the left eye has been removed from its socket to expose the nictitating membrane and its tendon and the Harderian gland. The tendon arises from about the middle of the median border of the roof of the orbit and passes thence behind the optic nerve around the posterior and ventral parts of the globe to be inserted into the lower corner of

Fig. 52.



Right eye of *Varanus griseus.*

A.R. Anterior rectus. B. Bursalis. I.O. Inferior oblique. I.R. Inferior rectus. P.R. Posterior rectus. R.B. Retractor bulbi. S.O. Superior oblique. S.R. Superior rectus. The tendon of the nictitating membrane dotted. II., III., IV., V., VI. The cranial nerves.

the third eyelid. At the back of the orbit, immediately behind the optic nerve, the tendon passes through a sling formed by the bursalis muscle, which by means of this connection is enabled to draw the nictitating membrane over the surface of the eye. The bursalis muscle is innervated by the sixth nerve and belongs to the same group as the retractor bulbi. The chief part of it is inserted upon the globe of the eye.

In the upper specimen the innervation of the muscles of the globe and nictitating membrane and their insertions are shown. The depressor palpebræ inferioris has been cut short and the chief part of the Harderian gland removed.

E. 1230. The lids and glands of the left eye of a Monitor Lizard (*Varanus salvator*), seen from within. The lower lid is larger and capable of more movement than the upper. It can be opened by a sheet-like depressor muscle (not shown in this specimen) inserted mainly into a large round tarsal cartilage embedded in the substance of the lid. The nictitating membrane is well developed ; it has a vertical position at the anterior corner of the eye, and can be drawn across the surface of the eyeball by a special muscle and tendon : in the specimen part of this tendon, from its insertion in the lower corner of the nictitating membrane to its passage through the bursalis muscle, is retained. The nictitating membrane is lubricated by the secretion of a large compact Harderian gland situated at the anterior part of the orbit. The lachrymal gland is attached to the outer surface of the reflection of the conjunctiva at the posterior corner of the lower eyelid. O. C. 1765 A.

OPHIDIA.

E. 1231. The left eye of a Python (*Python reticulatus*) showing, from the inner aspect, the muscles and glands of the eyeball. The muscles (four recti and two obliqui) are feebly developed, but normal in their arrangement. There is no retractor bulbi. In the specimen the muscles have been spread out ; their insertions upon the eyeball are obscured by the reflected edge of the peculiarly deep conjunctival sac. The lachrymal gland is represented by a slight glandular thickening upon the postero-dorsal part of the conjunctival reflection, just behind the external rectus. The Harderian gland, on the contrary, is an enormous structure, that in its natural position wraps around the mass formed by the globe, the optic nerve, and eye-muscles. In the specimen it has been turned forwards (the hollow in which lay the eye-complex being occupied by a pink rod). The gland communicates with the lachrymal sac by a wide duct (green rod), and is said by Cloquet (Mém. du Museum, t. vii. 1821) to assist deglutition by pouring its secretion through the lacrymal duct, direct to the mouth. The opening of the passage from the palpebral cavity into the lachrymal sac (purple rod) is so valved that the secretion of the Harderian gland cannot pass into the palpebral cavity. O. C. 1770 C.

E. 1232. Left half of the fore part of the head of an Anaconda (*Eunectes murinus*), in which the lachrymal duct has been exposed throughout its course from the conjunctival sac to the mouth. An explanatory diagram has been mounted below the specimen. The lachrymal duct leaves the conjunctival sac at its anterior and ventral reflection. Very soon it receives the duct of the Harderian gland, and then runs forward within the outer wall and floor of the nasal cavity and opens together with the organ of Jacobson into the mouth-cavity. In this specimen the strongly convex outer covering of the eye is also clearly shown. This at first sight appears to be the cornea, but is in reality the eyelids fused together and transparent. Around them the integument is again invaginated, giving rise to a false conjunctival space and circular lid.

EMYDOSAURIA.

E. 1233. Right half of the head of a young Crocodile, showing the three eyelids. The horizontal ones have each been divided and reflected from the front of the eyeball : the vertical or nictitating eyelid is drawn over the cornea and a bristle placed under it, showing its extent and semi-transparency. O. C. 1769. *Hunterian.*

E. 1234. The left eyelids of a Crocodile. The upper and under lids have been separated at their posterior union and spread apart to show the nictitating membrane and, at its base, at the point of reflection of the conjunctiva, the wide open mouth of the duct of the Harderian gland, into which a black bristle has been inserted.

O. C. 1771. *Hunterian.*

E. 1235. The right eye of the same Crocodile, with the eyelids and the muscles of the globe prepared, particularly to show the mechanism for the movement of the nictitating membrane.

The muscle by which this membrane is drawn upwards and backwards across the surface of the eye arises from an area of the sclerotic just below the insertion of the internal rectus. From this origin it passes round the globe above the optic nerve and retractor bulbi and below the insertion of the external rectus to be inserted to the lower angle of the nictitating membrane. O. C. 1770. *Hunterian.*

John Hunter, Essays and Observations, edit. R. Owen, 1861, vol. ii. p. 342.

E. 1236. The right eye of a Crocodile (*Crocodilus americanus*) in position, showing the muscles of the globe and eyelids, and the Harderian gland. The upper and under lids have been divided at their posterior end to show the nictitating membrane more clearly. Black bristles have been inserted into the puncta lachrymalia. In addition to the normal recti and obliqui there is a well-marked retractor bulbi surrounding the optic nerve. A description of the nictitator muscle is given for the previous specimen. The upper lid is raised by a strong levator muscle inserted into its outer corner. The depressor of the lower lid forms a muscular floor to the orbit; in action it probably not only lowers the eyelid but also slightly protrudes the eyeball. O. C. 1770 B.

E. 1237. The left eye and part of the snout of a Crocodile (*Crocodilus americanus*), showing the origin and course of the lachrymal duct. The eyelids have been separated from the eyeball and reflected outwards, and black bristles have been inserted into the puncta lachrymalia—three small orifices situated in a row just within the margin of the lower lid near its anterior limit—and passed thence along the lachrymal duct into the nose. The single duct formed by the union of the three passages from the puncta lachrymalia is broad and much flattened dorso-ventrally; it opens into the nose under cover of the turbinal by a wide mouth. At its ocular and nasal ends it is dilated, forming respectively a saccus lachrymalis, which receives the three ducts from the puncta lachrymalia, and a saccus naso-lachrymalis, remarkable for its thick glandular walls. The lachrymal sac, the flattened portion of the duct, and the saccus naso-lachrymalis have been opened. O. C. 1770 A.

CHELONIA.

E. 1238. The eyeball, eyelids, and lachrymal glands of a Turtle (*Chelone mydas*). The upper and under lids are well developed and are both capable of movement. The third lid is situated vertically at the anterior canthus of the eye and has a horizontal motion over the cornea : it is here slit across to show the orifice of the duct (indicated by a black bristle) of the Harderian gland, of which the secretion is expressly destined to facilitate its movements. This gland, however, is of small size compared with the true lachrymal gland, which consists of the thick and broad conglomerate mass surrounding the outer and upper parts of the eyeball : its duct (into which a quill has been inserted) is short and wide, and terminates just below the outer canthus of the eye. The gland is made up of a number of sharply defined conical lobules that converge towards a central duct. The secreting epithelium (Pl. III. fig. 9) of the tubular acini of the gland is composed towards the centre of the lobules of slender cells, which are fluted longitudinally and separated from one another by spaces filled with an intercellular substance. The basal part of each cell breaks up into a number of delicate root-like processes. Towards the periphery of the lobule the cells of the secreting epithelium are nearly cubical in form.

O. C. 1766. *Hunterian.*

Stewart, Monthly Microsc. Jour., vol. xviii. 1877, p. 241.

John Hunter, Essays and Observations, edit. R. Owen, vol. ii. 1861, p. 353.

E. 1239. The right eye of a female Turtle (*Chelone mydas*), with the eyelids, glands, and muscles shown. The Harderian gland can be seen more clearly than in the previous specimen. Its opening into the conjunctival sac beneath the nictitating membrane is indicated by a pale blue rod. A dark blue rod has been passed into the duct of the true lachrymal gland. The several lobes of the latter have been slightly separated. The muscles of the globe can be better seen in the following specimen.

O. C. 1767 A.

Presented by the Manager of the Westminster Aquarium.

E. 1240. Left eye of a Turtle (*Chelone mydas*) with the eyelids and the muscles of the globe. In addition to the six usual muscles of the globe, which have the normal positions, there is a strong retractor bulbi surrounding the optic nerve. The superior oblique divides just before its insertion into two well-defined slips—one passes beneath the superior rectus to be inserted towards the hinder part of the globe about its meridian ; the other is inserted in common with the superior rectus. The external rectus is partly double and sends slips of insertion to the conjunctival sac. The muscle of the third lid is very similar in form and position to that of the Crocodile, but at the point where it passes above the optic nerve it is crossed by and forms a connection with a depressor of the upper lid. This latter muscle arises from the surface of the globe just below the nictitator, crosses superficial to it, passes upwards to the posterior canthus of the eye, and is inserted by tendon into the corner of the upper lid. In consequence of the connection between these two muscles, the nictitating membrane and upper lid move together. In the specimen part of the conjunctival sac has been removed at the anterior canthus to show the insertion of the nictitator muscle to the third lid. A black bristle has been placed beneath the point of union of the nictitator and depressor palpebræ superioris muscles and a blue rod into the duct of the lachrymal gland. A small part of the orbital wall has been retained to preserve intact the origins and mutual relations of the external, superior, and internal recti and of the two obliqui.

O. C. 1767 B.

Presented by H. Power, Esq.

Power, *l. c.*, p. 338.

E. 1241. Lids from the left eye of a Leathery Turtle (*Dermochelys coriacea*), seen from the inner aspect. In general form the lids closely resemble those of *Chelone*. But the mucous membrane upon the deep surface of the upper lid and of the nictitating membrane, and to a less degree that upon the lower lid, is thrown into numerous deep plications, giving to these areas a strongly laminate appearance. A similar though very much less marked plication is present in *Chelone*. The nictitator muscle is labelled B, the depressor of the outer corner of the upper lid A, and a black bristle has been passed through one of the ducts of the Harderian gland.

AVES.

E. 1242. The right eye and eyelids of an Ostrich (*Struthio camelus*). The horizontal lids are well defined, the lower being the larger and capable of most movement. They are beset along their margins by a fringe of irregularly placed bristle-like feathers resembling the eyelashes of Mammals.

O. C. 1794. *Hunterian.*

John Hunter, Essays & Observations, edit. R. Owen, 1861, p. 297.

E. 1243. The right eye of an Emeu (*Dromæus novæ-hollandiæ*), dissected to show the muscles of the globe and third eyelid, and the Harderian gland. The normal six muscles of the globe are present, their insertions only being retained. The muscles of the nictitating membrane are two in number—the quadratus and the pyramidalis. The former arises from an extensive area of the dorsal surface of the globe beneath the insertions of the superior rectus and superior oblique. Its fibres converge towards the optic nerve, just short of which the muscle terminates in a tendinous border channelled to lodge the tendon of the pyramidalis muscle. The pyramidalis arises from the lower surface of the eyeball, just in front of the insertion of the inferior rectus. From its origin, where it is some 10 mm. in breadth, its fibres converge to form a round tendon that plays within the fibrous selvage of the quadratus. It then winds over the optic nerve and is inserted into the lower angle of the free margin of the third lid, along which it is continued for some distance and is gradually lost. By the simultaneous contraction of these two muscles, the third lid is drawn forcibly and rapidly outwards and with an oblique inclination downwards over the fore part of the eye. The tendon of the pyramidalis gains a suitable direction by winding round the optic nerve, and is restrained from pressing upon the nerve by the counteracting force of the quadratus, which thus increases the pull of the pyramidalis upon the lid, whilst at the same time obviating any injurious pressure on the optic nerve. The nictitating membrane returns, on the relaxation of its muscles, by virtue of its own elasticity to the inner corner of the orbit, where it lies folded up when not in use. The Harderian gland, the secretion of which lubricates the third lid, lies upon the anterior surface of the globe. It is pear-shaped and compared with that of some Birds of quite small size. It communicates with the conjunctival sac by a long and wide duct, into which a black bristle has been placed. O. C. 1797 B.

E. 1244. Right half of the head of a Goose (*Anser ferus*). The median and upper walls of the orbit have been removed to show the glands and muscles of the globe. The lachrymal gland is small and lies at the outer and upper border of the eye, connected with the conjunctival sac just above the insertion of the external rectus. The superior oblique has been cut short; beneath its cut end can be seen the quadratus muscle. The Harderian gland forms a conspicuous rounded mass at the inner and lower angle of the eye. O. C. 1795 A.

E. 1245. The opposite eye of the same Goose, removed from the orbit to show the insertions of the muscles of the globe and the mechanism of the third lid. Black bristles have been placed beneath the pyramidalis muscle and its tendon. The quadratus is relatively about twice as large as in *Dromæus* (No. E. 1243). O. C. 1795 B.

E. 1246. Left half of the head of a Black Swan (*Chenopis atrata*) showing the lachrymal duct. The eyelids have been reflected forwards and black bristles have been inserted into the two large puncta lachrymalia, which are situated upon the inner surface of the lids just in front of their anterior point of union. The lachrymal duct is a broad membranous tube that runs forward over the outer surface of the lachrymal bone to the hinder edge of the nasal. At this point it dips towards the nose-cavity, into which it opens beneath the maxillo-turbinal by a vertical slit-like aperture.

Presented by W. B. Tegetmeier, Esq.

E. 1247. Right eye of a Stork (*Ciconia ciconia*) removed from the orbit and dissected to show the insertions of the muscles of the globe, the mechanism of the third lid, and the Harderian gland. The superior oblique, although thin, is at least twice the breadth of any other muscle of the globe. The muscles of the third eyelid, except for the greater development of the quadratus, resemble those of the Emeu (No. E. 1243). The Harderian gland is relatively small; it is connected by a long duct with the conjunctival space beneath the nictitating membrane. O. C. 1796 A.

Presented by the Zoological Society of London.

E. 1247 a. Left eye of a Rough-billed Pelican (*Pelecanus erythrorhynchus*) showing the muscles and glands of the eyeball. The muscles have the disposition and general characters normal for Birds, but the Harderian gland is unusually large, being almost equal in size to the globe of the eye (measuring 27 × 23 × 10 mm.). The lachrymal gland is relatively quite small. Upon the sclerotic, in the angles between the pyramidalis muscle and the optic nerve and quadratus muscle, are two small masses of congested blood-vessels. These are retia mirabilia, into which the ciliary arteries divide before traversing the sclerotic. The mass of gland tissue beneath the Harderian is part of the nasal gland.

E. 1248. Left side of the head of a Spanish Imperial Eagle (*Aquila adalberti*) dissected to show the eyelids with their muscles, the Harderian gland in its natural relations to the globe, and the insertions of the ocular muscles. Black bristles have been inserted beneath the tendon of the pyramidalis. The tarsal cartilage in the lower lid is exposed from the outside, as also is a similar though more elongated plate of cartilage that lies in the substance of the upper lid. O. C. 1797 A.

E. 1249. The eyeball of an Eagle, with the nictitating membrane and anterior parts of the horizontal lids. The latter are fringed by stout bristle-like feathers. Bristles have been inserted into the puncta lachrymalia and beneath the third eyelid into the duct of the Harderian gland.
O. C. 1796. *Hunterian.*
John Hunter, Essays & Observations, edit. R. Owen, 1861, vol. ii. p. 271.

E 1250. Lids of the right eye of an Eagle (*Aquila* sp.) seen from within, to show the position of the nictitating membrane and the large round tarsal cartilage in the lower lid.
O. C. 1797. *Hunterian.*

E. 1251. Left half of the head of a Horned Owl (*Asio otus*), showing the lids. The margins of the horizontal lids are beset by plumose feathers, analogous to the eyelashes of Mammals. The third lid is very large, and is situated mainly under cover of the upper lid : its lower angle lying slightly below the inner corner of the eye, and its outer angle reaching nearly to the outer canthus. It sweeps over the eye downwards as well as outwards and is usually accompanied in its movements by the upper lid. A black bristle has been inserted into one of the puncta lachrymalia and thence to the nose ; and a white bristle (seen on the reverse of the specimen) into the duct of the Harderian gland. O. C. 1799. *Hunterian.*
John Hunter, Essays & Observations, edit. R. Owen, 1861, vol. ii. p. 278.

E. 1252. The left eye of a Great Horned Owl (*Bubo bubo*), with the lower lid, parts of the nictitating membrane, and the Harderian gland. The round tarsal cartilage can be clearly seen on the inner surface of the lower lid (cf. *Varanus*, No. E. 1230). Bristles have been placed in the puncta lachrymalia and into the duct of the small Harderian gland. O. C. 1798. *Hunterian.*
John Hunter, Essays & Observations, edit. R. Owen, 1861, vol. ii. p. 279.

E. 1252 a. The cranium and right eye of a Raven (*Corvus corax*) dissected from the ventral aspect to show the depressor of the lower eyelid. This is a flat fan-shaped muscle, that arises from the skull in the fundus of the orbit close in front of the optic foramen, and passes outside the lining membrane of the orbit to the lower lid. The levator of the upper lid, though present, is relatively very feeble.

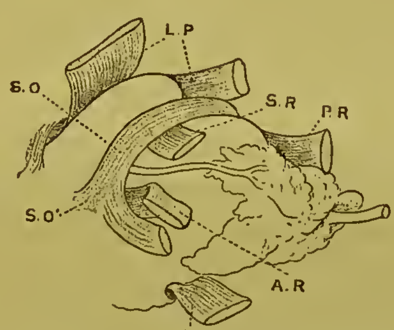
MAMMALIA.

Eggeling, Jena. Zeits., Bd. xxxix. 1905, p. 1 (*lids*).

MONOTREMATA.

E. 1253. The right eye and surrounding integument of a Spiny Anteater (*Tachyglossus* [*Echidna*] *aculeatus*), showing the muscles of the globe and eyelids and the Harderian gland from the inner aspect. The superior oblique is in a condition transitional between that of other Mammals and

Fig. 53.



The right eye of *Tachyglossus aculeatus.*

A.R., I.R. Anterior and inferior recti. L.P. Levator palpebræ. P. Its slip to lower lid. P.R. Posterior rectus. S.O. Superior oblique. S.O.' Its attachment to the connective tissue of the orbit. S.R. Superior rectus.

that of lower Vertebrates. The greater part takes origin at the anterior part of the orbit from a mass of fibrous tissue, but its deeper fibres pass on and at the same time turn towards the fundus of the orbit lying external to the anterior rectus. Their actual point of origin is not shown, but Göppert states that this part of the muscle arises from the orbital wall in front of the origin of the recti. Both obliques are inserted far round the eyeball, one above and one below the insertion of the posterior rectus. The Harderian gland is large and loose in texture and, like that of Snakes, envelops the hinder part of the globe and the optic nerve. There is a strong levator of the upper lid, and a peculiar palpebral muscle that runs from the depth of the orbit to the posterior angle of the lids, where it is inserted into the lower lid. Its contraction closes the lids. O. C. 1771 A.

Göppert, Morph. Jahrb., Bd. xxi. 1894, p. 278.

MARSUPIALIA.

E. 1254. The left eye of a Black Wallaby (*Halmaturus ualabatus*) showing the lachrymal and Harderian glands and the presence of a small retractor bulbi around the optic nerve. O. C. 1772 A.

EDENTATA.

E. 1255. The left eye of a Hairy Armadillo (*Dasypus villosus*) with its associated glands. The globe of the eye, which is peculiarly small for the size of the animal, is mounted separately above the lids. The latter are seen from the inner side. The lachrymal and more especially the Harderian glands are of great size, and the latter, as in *Bradypus*, has a looser texture than in most Mammals.

E. 1256. The left eye of a Three-toed Sloth (*Bradypus tridactylus*), with the muscles and glands displayed. The line of insertion of the retractor bulbi can be seen between the optic nerve and the insertions of the recti and obliqui. The Harderian gland is large and much lobulated, semi-isolated lobules extending along the conjunctival reflection as far as the levator palpebræ superioris. The true lachrymal gland is small and occupies the usual position at the posterior corner of the eye.

E. 1257. The eyes of an Anteater (*Myrmecophaga jubata*), showing the muscles and glands of the eyeball. The Harderian gland is remarkable for its enormous size. It consists of two definite lobes—one above the eyeball and one encircling its posterior, ventral, and anterior parts. Ducts from these two lobes enter the conjunctival space by a single orifice at the base of the third eyelid. (The opening is not shown.) In addition to this, which may be called the true Harderian gland, the outer surface of the third eyelid is covered by a glandular mass similar in position to the nictitating gland upon the third eyelid of the Pig and some other Mammals. The lachrymal gland lies above the postero-dorsal parts of the eyeball, between the two lobes of the Harderian gland. The usual ocular muscles are present (lower specimen). The superior, inferior, and anterior recti, in addition to their usual insertions upon the sclerotic, give off slips to the upper, lower, and third eyelids, the first two of which are indicated by blue rods in the upper specimen. There is also a well-developed levator palpebræ superioris. A retractor bulbi of moderate size surrounds the optic nerve.

Pouchet, Mémoire sur le Grand Fourmilier, 1874, pp. 55, 60.

CETACEA.

John Hunter, Phil. Trans., vol. lxxvii. 1787, p. 438.

E. 1258. The eyeball and surrounding muscles, with the eyelids, of a Porpoise (*Phocæna phocæna*). The eyelids consist of a continuous fold of the skin, leaving a circular opening in front of the eye with a narrow margin unprovided with cilia. The palpebral opening is closed by an orbicular sphincter, and expanded by four broad and almost confluent muscles. In the specimen their cut ends can be seen close below the section surface of the skin. The eyelid has been cut at its inner side, showing the depth of the conjunctival sac. Black bristles have been inserted into two of the ducts of the glands that cover the reflection of the conjunctiva. O. C. 1774. *Hunterian.*

E. 1259. The eyeball of a Porpoise (*Phocæna phocæna*), isolated to show the muscles of the globe. The obliqui are ill-developed in comparison with the recti. The superior oblique becomes slightly tendinous in its passage through the trochlea ; the retractor bulbi is well marked.
O. C. 1773. *Hunterian.*

E. 1260. The eye of a Dolphin (*Delphinus tursio*), showing a zone of glandular tissue situated upon the reflection of the conjunctiva. Bristles have been inserted into the ducts of these glands. A larger and more definite mass of this tissue lies at the inner side of the eyeball ; its ducts are distinguished by thicker bristles. O. C. 1776. *Hunterian.*

John Hunter, Essays & Observations, edit. R. Owen, 1861, vol. ii. p. 108.

E. 1261. The left eye and eyelids of an adult male Dolphin (*Delphinus tursio*). The muscles have been cut short. The recti and obliqui are poorly developed in comparison with the retractor bulbi. The eyeball has been artificially retracted, to show clearly the circle of glands attached to the conjunctiva along its line of reflection. At the inner and lower angle of the eye the amount of glandular tissue is much increased and forms a very definite lobe. The muscle by which the lids are opened forms a continuous sheet inserted into the entire circumference of the lids ; it has here been cut short, its cut edge standing up like a frill outside the circle of glands. The sheath of the optic nerve is extremely thick. O. C. 1775 B.

Presented by the Manager of the Westminster Aquarium.

E. 1262. The eye and skin of the right side of the head of the same Dolphin. The muscles of the eyelids and globe of the eye and the conjunctival glands are shown, the several parts being less displaced than in the previous specimen. Posterior to the eye lies the long and narrow external auditory meatus, traversed by a black bristle.

O. C. 1775 A.

Presented by the Manager of the Westminster Aquarium.

E. 1263. A portion of the circular eyelid, with the conjunctival glands, of a Piked Whale (*Balænoptera acuto-rostrata*) Bristles have been inserted into the ducts of the conjunctival glands. O. C. 1777. *Hunterian.*

Carte & MacAlister, Phil. Trans., vol. clviii. 1868, p. 255.

SIRENIA.

E. 1264. The eyeball of a young Dugong (*Halicore dugong*), showing the presence of a nictitating membrane, and the small size of the cornea. O. C. 1777 A.

Presented by Sir Everard Home, Bart.

UNGULATA.

HYRACOIDEA.

E. 1265. Right eye of a Hyrax (*Procavia capensis*). The large nictitating membrane is supported by a **T**-shaped cartilage whose shaft runs inwards parallel to the anterior surface of the globe. This process of the nictitating cartilage is covered at its free end by a dense mass of gland-tissue corresponding in position and appearance to the nictitating gland of other Ungulates. It serves also as a point of attachment for two strands of muscle-fibres that branch respectively from the upper and lower parts of the orbicularis palpebrarum and in action tend to thrust the nictitating membrane backwards across the surface of the eye. Between these muscle-strands lies another small mass of gland-tissue. The lachrymal gland is flat and lies at the lower outer angle of the eye. The muscles attached to the anterior and upper surfaces of the globe and the levator palpebræ superioris are peculiarly weak. The eye, as a whole, is small compared with that usually found in animals of about the same size.

PROBOSCIDEA.

E. 1266. The nictitating membrane, with its muscles and glands, of an Elephant (*Elephas indicus*). The fibres of the nictitator muscle pass at first in a regular curve (seen on the reverse of the specimen) over the base of the membrane, but afterwards deviate from the curve and form an angle to include the extremity of the cartilage of the nictitating membrane. This is in consequence moved in the direction of the resultant of the contracting forces and drags the membrane backwards and outwards over the front of the eyeball. A bristle has been inserted into the duct of the gland of the third eyelid. This gland

closely resembles that just described in a similar position in *Procavia* and is most probably a combination of nictitating and true Harderian glands. O. C. 1780. *Hunterian.*
John Hunter, Essays and Observations, edit. R. Owen, 1861, vol. ii. p. 173.

E. 1267. The nictitating membrane with its associated gland from the opposite eye of the same Elephant, isolated. The membrane is supported by a thin, flattened, and slightly curved cartilage, that broadens and thins out towards the free edge of the membrane. Its distal end is narrower and is partially embedded in the surface of the gland of the third eyelid. The duct of the latter opens beneath the nictitating membrane; it is indicated by a black bristle. O. C. 1779. *Hunterian.*

PERISSODACTYLA.

E. 1268. The right eye of a Horse (*Equus caballus*), showing the eyelids and the accessory organs of the globe. Eyelashes are fully developed only on the upper lid, those on the edge of the lower lid being quite insignificant, although upon its outer surface are several irregularly scattered tactile vibrissæ. Blue rods have been placed in the puncta lachrymalia in either lid and can be seen at the cut edge of the specimen in the lachrymal canal. A green rod is inserted into one of the ducts of the nictitating gland which open under cover of the third eyelid, and black bristles are passed into the openings of the lachrymal gland. The lachrymal gland occupies the normal position upon the upper and outer surface of the eyeball, but is of exceptionally large size. The nictitating gland on the other hand is relatively small and of more compact texture. The direct and oblique muscles of the globe have been cut short to expose the strong retractor bulbi, indistinctly separable into four bundles. O. C. 1780 B.
Presented by Henry Power, Esq.
Ellenberger & Baum, Handbuch der vergleichenden Anat. der Hausthiere, 1903, p. 857.

E. 1269. The eyelids of a Horse (*Equus caballus*) removed by dividing the conjunctiva along its reflection and seen from within. The lachrymal and nictitating glands are shown, and green rods and black bristles have been inserted into their ducts as in the previous specimen. O. C. 1780 c.

Presented by Henry Power, Esq.

E. 1270. Left nictitating membrane of a Horse (*Equus caballus*), isolated, to show its supporting cartilage and the nictitating gland. The cartilage is roughly triangular in form, with its base lodged within and supporting the membrane and its elongated apex buried in the tissue of the nictitating gland. O. C. 1780 D.

Presented by Henry Power, Esq.

E. 1271. Right half of the face of an Ass (*Equus asinus*), showing the contents of the orbit from the median aspect and the entire course of the lachrymal duct. The duct, which is filled with a blue injection, passes along the roof of the antrum to the base of the maxillo-turbinal. It follows the line of attachment of this turbinal to the boundary between the nostril and false nostril, and at this point bends sharply outwards to open finally just within the outer lip of the false nostril, the opening being indicated in the specimen by a white rod. The muscles of the globe, including the strong retractor bulbi, are clearly displayed. The superior oblique is fleshy throughout, with no intermediate tendon where it passes through the trochlea. O. C. 1780 F.

Presented by Henry Power, Esq.

ARTIODACTYLA.

E. 1272. The left eyelids and nictitating membrane with the Harderian and nictitating glands of a Boar (*Sus scrofa*). The Harderian gland is of large size; the opening of its single large duct upon the lower part of the inner surface of the nictitating membrane is marked by a bristle. The nictitating gland is only partly exposed ; it appears as a rounded mass protruding from the cut edge of the conjunctiva close to the duct of the Harderian gland. A black bristle is passed through the single punctum lachrymale in the upper lid (vestiges of the lower canali-

culus and occasionally the lower punctum are said also to be present: Ellenberger & Baum. Anat. der Hausthiere, 1903, p. 885). The same lid is provided with a fringe of stiff long cilia, beneath which may be observed the orifices of the Meibomian glands. The lower lid has no eyelashes.
O. C. 1781. *Hunterian.*

E. 1273. Dissection of the right orbit of a Pig (*Sus scrofa*), showing the ocular glands and muscles and the course of the lachrymal duct. The lachrymal gland is well developed, and in general form and position resembles that of the Horse. The relative positions of the Harderian and nictitating glands in the floor of the orbit are clearly shown. The superior oblique does not become tendinous till after it has passed through the trochlea. There is a strong retractor bulbi. A bristle has been passed through the punctum lachrymale in the upper lid and along the lachrymal duct. Its extremity can be seen emerging into the nose below the line of attachment of the maxillo-turbinal.
O. C. 1781 A.

E. 1274. The right eye of a Pig (*Sus scrofa*), showing the nictitating membrane with its glands, the lachrymal gland, and the muscles of the eyeball: below is mounted an isolated specimen of the glands and supporting cartilage of the nictitating membrane. In the Pig the separation of the gland of the third eyelid into two parts—the true Harderian and the nictitating glands—is more clearly marked than in other species in which this separation occurs. The Harderian gland is an oval compact body lying upon the floor of the orbit; a large duct arises from its ocular surface and opens into the conjunctival sac between the third eyelid and the globe. The nictitating gland is closely applied to the outer (convex) surface of the nictitating cartilage and opens by four main ducts (Löwenthal) upon the inner surface of the third lid. The histological structure of these two glands of the third eyelid is shown in Pl. III. figs. 10, 11. The supporting cartilage of the nictitating membrane is T-shaped as in other Ungulates, with the cross of the T in the free border of the membrane and the shaft embedded in the nictitating gland.

Miesner, Arch. f. Thierheilk., Bd. xxvi. 1900, p. 135.

E. 1275. Right eye of an old female Hippopotamus (*Hippopotamus amphibius*), showing the muscles of the globe, cut short, and the nictitating membrane with its glands. The retractor bulbi is strongly developed. As in the Pig, there are two glands in connection with the nictitating membrane—the Harderian and nictitating glands. In their relative positions they resemble those of the Pig, but the Harderian gland is more broken up into lobules. The sheath of the optic nerve is peculiarly thick.

O. C. 1781 B.

E. 1276. The eyeball of a Dromedary (*Camelus dromedarius*), with the horizontal lids removed to show the small nictitating membrane. O. C. 1782. *Hunterian.*

E. 1277. The nictitating membrane and glandula nictitantis of a Dromedary (*Camelus dromedarius*). The latter opens into the conjunctival sac beneath the nictitating membrane by four ducts, into which bristles have been introduced. O. C. 1784. *Hunterian.*

John Hunter, Essays & Observations, edit. R. Owen, 1861, vol. ii. p. 133.

E. 1278. The right eye of a Javanese Chevrotain (*Tragulus javanicus*). The accessory structures of this eye show a marked degree of degeneracy compared with those of Ungulates previously described. The muscles are throughout peculiarly slight and feeble, the lachrymal and nictitating glands fairly developed, and the Harderian very small. The latter is apparently represented by a mass of glandular tissue attached by a pedicle (its duct?) to the upper border of the nictitating gland. O. C. 1786 A.

Presented by J. Abrahams, Esq.

E. 1279. Part of the right side of the face of a Sambur Deer (*Cervus aristotelis*) showing the contents of the orbit, the eyelids with the puncta lachrymalia, and the nasal extremity of the lachrymal duct. The muscles of the globe are very clearly shown and conform to the normal type. The superior oblique narrows slightly and becomes partly tendinous where it passes through the trochlea. Both Harderian and nictitating glands are strongly developed. The eyelashes are most marked on the upper lid. As in the Horse, the outer surface of the lower lid is beset by a number of long tactile vibrissæ. There is a punctum lachrymale in each lid. O. C. 1785 E.

E. 1279 a. The right eyelids of an Axis Deer (*Cervus axis*) seen from within and prepared to show the follicles of a number of tactile vibrissæ upon both lids. O. C. 1965 C.

E. 1280. Right eye of *Cervulus reevesii*, showing the eyelids with their glands, and the muscles of the globe. The Harderian and nictitating glands are clearly separable; the lachrymal gland is large; the muscles of the globe are normal in arrangement and moderately developed.

O. C. 1786 A *a*.

Presented by Sir E. G. Loder, Bart.

E. 1281. The nictitating membrane and anterior part of the left eyelids of a Cow (*Bos taurus*). Bristles have been placed in the puncta lachrymalia and into five of the openings of the ducts of the lachrymal gland. The lachrymal caruncle—an elevation at the inner canthus of the eye composed mainly of sebaceous glands—is well seen in this specimen. The eyelashes although stronger on the upper than on the lower lid are present on both. There are no tactile vibrissæ on the surface of the lower lid, as in the Horse and Deer.

O. C. 1785. *Hunterian.*

E. 1282. The eyelids and nictitating membrane of the left eye of an Ox (*Bos taurus*) with the Harderian and nictitating glands seen from within. The free margin of the nictitating membrane is stiffened by the cross-piece of a T-shaped supporting cartilage. The shaft is flattened and expanded, and lies imbedded in the nictitating gland. The latter communicates by three ducts, into which black bristles have been inserted, with the conjunctival sac beneath the nictitating membrane. The Harderian gland is a compact rounded body partly enveloped by the aboral end of the nictitating gland. An isolated specimen of the nictitating cartilage is shown below. Blue rods are inserted into the puncta lachrymalia. O. C. 1785 B *a*.

Peters, Arch. f. mikr. Anat., Bd. xxxvi. 1890, p. 198.

E. 1283. The contents of the left orbit of a Calf (*Bos taurus*). Blue rods have been inserted into the puncta lachrymalia, a green rod into the duct of the nictitating gland, and black bristles into the ducts of the lachrymal gland. The passage of the superior oblique through the trochlea is particularly well shown in this specimen. O. C. 1785 B.

E. 1284. Right side of the face of a Calf (*Bos taurus*), dissected to show the contents of the orbit, the eyelids, and the course of the lachrymal duct. The lachrymal duct has much the same course and general relations as in the Sheep (E. 1286). As in that specimen, it is filled with blue injection and its openings are marked by blue rods. It runs almost directly forwards from the anterior margin of the orbit, passing through the lachrymal bone and close beneath the maxilla and præmaxilla to its nasal opening close within the nostril. O. C. 1785 A.

E. 1285. The left eye of a Sheep (*Ovis aries*), showing the lids and other accessory organs of the eye. The anterior and superior recti, the superior oblique, and the levator palpebræ superioris have been cut short to expose the powerful retractor bulbi. The lachrymal gland is large. The nictitating gland is finger-shaped and compact, but with its surface broken up by minor lobulations. There is no true Harderian gland. Blue rods have been inserted into the puncta lachrymalia and along the first part of the lachrymal duct. O. C. 1785 D.

Löwenthal, Internat. Jour. Anat., 1896, p. 42.

E. 1286. Right side of the head of a Sheep (*Ovis aries*), dissected to show the contents of the orbit and the course of the lachrymal duct. From the two puncta lachrymalia (indicated by blue rods) the canaliculi run inwards to the orbital margin of the lachrymal bone. Here they unite to form a small sacculus, from which the lachrymal duct is continued forwards through the lachrymal bone to the deep surface of the maxilla and finally opens into the nose close within the nostril at the anterior end of the maxillo-turbinal. The opening is marked by a blue rod. The lachrymal duct has been filled with blue injection. The position of the duct in different parts of its course can be seen in the series of transverse sections of the nose, No. E. 140, it is there marked by green rods.

O. C. 1785 c.

E. 1287. The eyelids of a Sheep (*Ovis aries*), dissected to show the follicles of a series of vibrissæ arranged in two rows along the lower lid below its margin. These help in the protection of the eye by giving warning of approaching danger. O. C. 1965 B.

RODENTIA.

E. 1288. Head of a Rat (*Mus decumanus*). There are two glands in connection with the conjunctival sac, in addition to the lachrymal and Harderian. They lie behind the orbit close under the skin—one (the extraorbital) in front of the ear close above the parotid and communicating with the conjunctival sac by a long duct that accompanies the temporal artery; the other (infraorbital) below the ocular end of the duct of the first close outside the conjunctival sac. The ducts of the two glands unite before entering the conjunctival sac.

Löwenthal, Arch. f. mikr. Anat., Bd. lvi. 1900, p. 538.

E. 1289. The eyelids of a Rabbit (*Lepus cuniculus*). The horizontal lids have been propped open to show the well-developed nictitating membrane in the inner angle of the eye. O. C. 1787. *Hunterian.*

Krause, Anatomie des Kaninchens, 1868, pp. 126–132.

E. 1290. Part of the right side of the head of a Rabbit (*Lepus cuniculus*). The lower eyelid has been turned outwards to show the punctum lachrymale on its inner surface (there is no punctum in the upper lid). A bristle has been passed through it along the lachrymal duct. The termination in the nasal cavity can be seen on the reverse of the specimen below the attachment of the maxillo-turbinal.

O. C. 1787 C.

E. 1291. The left side of the head of a Rabbit (*Lepus cuniculus*) with the lachrymal, Harderian, and orbital glands exposed. The lachrymal gland lies at the upper and outer part of the orbit, extending backwards some little way outside the orbital cavity. The Harderian gland forms a solid whitish mass (divisible into two parts by a difference in colour and structure [Pl. III. fig. 12]) situated at the anterior and lower part of the orbit closely applied to the muscles and globe of the eye. The lower and posterior part of the orbital floor is occupied by a large glandular mass (orbital gland) apparently continuous with the lachrymal. In reality it belongs to the salivary series, and is separated by membrane from the orbital cavity. O. C. 1787 A.

E. 1292. Left eye of a Hare (*Lepus europæus*) showing, from the deep aspect, the retractor bulbi surrounding the optic nerve, and the ocular and orbital glands. The lobules of the several glands have been separated, showing very plainly the pink and white portions of the Harderian gland and the arrangement of their main collector ducts, and the loose texture of the lachrymal and orbital glands.

O. C. 1787 C *a*.

E. 1293. The right eyelids and part of the nasal wall of a Hare (*Lepus europæus*) with the lachrymal duct exposed. There is only one punctum lachrymale, which is very large (1 mm. diameter) and lies at the extreme anterior limit of the conjunctival sac upon a level with the margin of the lower lid. A short canaliculus leads from it into a saccus lachrymalis that opens at the anterior border of the orbit into the lachrymal duct. The latter passes downwards and forwards in the bones of the lateral wall of the nose and opens by a vertical slit-like mouth into the nose-cavity 15 mm. in front of the molar teeth. The terminal part of the duct is not encased in bone. A black bristle has been passed through the punctum lachrymale into the saccus and also along the lachrymal duct.

PINNIPEDIA.

E. 1294. The left eye of a Seal (*Phoca vitulina*). The horizontal eyelids have been removed to show the vertical nictitating membrane at the inner corner of the eye. Its border is supported by the cross-piece of a T-shaped cartilage, whose shaft extends horizontally around the anterior curve of the globe of the eye and is partially embedded in the substance of the gland of the third eyelid. The muscles of the globe and particularly the retractor oculi are poorly developed. The sphincter muscle (orbicularis palpebrarum) by which the eyelids are closed is most clearly shown on the outer part of the eye beneath the lachrymal gland. The latter is very small, as in other aquatic mammals. O. C. 1778 A *a*.

E. 1295. The injected eyelids of a Common Seal (*Phoca vitulina*), seen from within. O. C. 1778 A.

E. 1296. The eyeball and eyelids of a Sea-Lion (*Otaria* sp.). The posterior parts have been removed to show the extent of the conjunctival sac and to expose the small nictitating membrane, at whose base can be seen the gland of the third eyelid. The skin at the inner canthus of the eye is longitudinally grooved, indicating that originally the lids were disposed horizontally as in terrestrial Mammals.

O. C. 1778. *Hunterian.*

John Hunter, Essays and Observations, edit. R. Owen, 1861, vol. ii. p. 98.

CARNIVORA.

E. 1297. Left part of the nose of a Dog (*Canis familiaris*) with the eyelids of the same side, prepared to show the course of the lachrymal duct. The puncta lachrymalia, of which there is one in each lid, are connected by long (10 mm.) canaliculi to a saccus lachrymalis lying upon the orbital border of the lachrymal bone. From the saccus, the lachrymal duct runs in the bones of the face to the lower border of the attachment of the maxillo-turbinal. Here it emerges upon the deep surface of the bone and passes forward in the mucous membrane following the line of attachment of the maxillo-turbinal for 30 mm., and then communicates with the nose-cavity by an oval aperture in its mesial wall. Beyond this opening the duct still eontinues for another 20 mm., and finally opens within 10 mm. of the point of the snout just within the pigmented area of the nostril. This opening is marked by a black bristle.

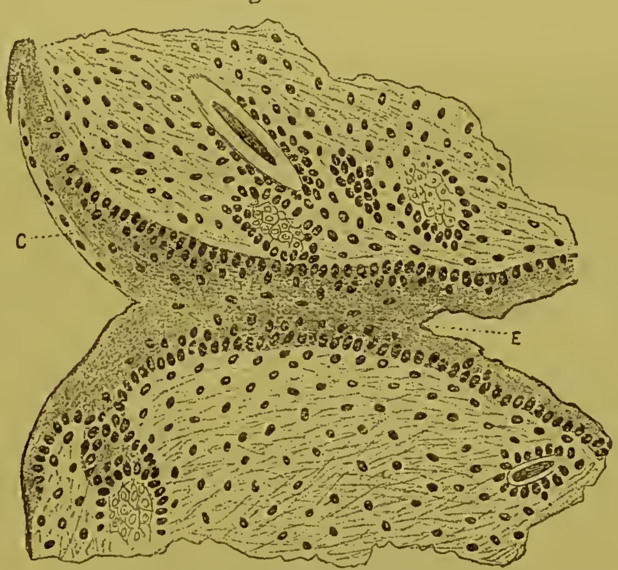
Ellenberger u. Baum, Anat. des Hundes, 1891, p. 582.

E. 1298. The skin of the head of some speeies of Cat, shortly after birth, with the eyelids still elosed. During the development of the lids, their edges become apposed and aetually grow together by proliferation of their epithelium. Either shortly before (Man) or after (Cat, Dog, Rabbit) birth the lids again become disunited, probably owing to the breaking down of the cells in the centre of the epithelial layer of union. O. C. 1778 B.

Minot, Human Embryology, 1892, p. 726.

E. 1299. The head of a Kitten (*Felis domestica*), at birth. On the left the closed eyelids have been cut through and their

Fig. 54.



Section of the united eyelids of a Kitten.

C. Conjunctiva. E. Line of fusion between the epidermis of either lid.

eonjunctival and section surfaces shown by the reflection of part of the skin.

E. 1300. The right eyelids of a Cat (*Felis domestica*), removed by dividing the conjunctiva along its line of reflection and seen from within. The lachrymal gland and that of the third eyelid have been retained showing their respective positions and the close attachment of the latter to the shaft of the nictitating cartilage.

INSECTIVORA.

E. 1301. The right eye of a Hedgehog (*Erinaceus europæus*), showing the globe, the muscles, and the glands. The lachrymal gland is large and has the usual loose texture. It can be readily separated into an outer part wholly superficial to the superior rectus and an inner that lies chiefly on the deeper side of that muscle. These parts may perhaps be compared with the superior and inferior portions of the gland in Man. The gland of the third eyelid is also large, but has a very compact texture. Its histological structure, which in some points appears to be peculiar, is described fully by Löwenthal (Anat. Anz., Bd. vii. 1892, p. 48).

CHIROPTERA.

E. 1302. Right eye of a Bat (*Pteropus poliocephalus*), showing the muscles and glands. Bristles have been inserted through the puncta lachrymalia into the lachrymal sac.

PRIMATES.

E. 1303. A vertical section of the left eye and eyelids of a Monkey, showing the pigmentation of the conjunctiva, the extent of the conjunctival sac, and the vestigeal character of the nictitating membrane (plica semilunaris).

O. C. 1788. *Hunterian.*

John Hunter, Essays and Observations, edit. R. Owen, 1861, vol. ii. p. 11.

E. 1304. Part of the face with the right eye of a Brown Capuchin (*Cebus fatuellus*), showing the eye and its muscles from the inner and posterior aspect.

The inferior oblique arises from the floor of the orbit near its central point (directly below the Rectus inferior) and runs upwards and slightly backwards and inwards to its insertion upon the hinder border of the globe near the optic nerve. The other muscles show no great difference from those of Man.

E. 1305. Left eye of a Gibbon (*Hylobates* sp.), with parts of the eyelids removed to show the nictitating membrane, which for that of an Anthropoid Ape is peculiarly large.

E. 1306. Right eye of a young Orang-utan (*Simia satyrus*), dissected to show the lids, the muscles of the globe, and the lachrymal gland. The arrangement of the several parts closely resembles that found in Man. O. C. 1787 F.
Presented by Sir Victor Horsley.

E. 1307. Two specimens of the eye of an Orang-utan (*Simia satyrus*). The specimen on the left shows the left eyelids, with the tarsal plate of fibrous tissue in the upper lid exposed. In the inner canthus the pigmented lachrymal caruncle can be seen and behind it the vestigeal nictitating membrane (plica semilunaris). In the other specimen the right eye is seen from the posterior aspect. The levator palpebræ superioris has been reflected upwards. Posterior to it lies the lachrymal gland. There is no Harderian gland.

E. 1308. The eyelids of a Negro. The upper lid is divided and the two parts are separated to show the white conjunctiva (*cf.* E. 1303), the two puncta lachrymalia indicated by white bristles, the glandular caruncula lacrymalis lodged between them, and behind this the plica semilunaris or vestige of the nictitating membrane. O. C. 1789. *Hunterian.*

E. 1309. The left eyelids and neighbouring parts of the face, showing the separation of the lachrymal gland into two lobes —the pars superior and pars inferior. The superior portion forms an isolated lobe above the upper and outer region of the eye ; it is separated from the conjunctiva by the inferior portion. Each part of the gland has its own ducts, which open together or separately into the upper and outer part of the conjunctival sac. The skin of the eyebrow and upper lid has been reflected forward showing the sphincter muscles (orbicularis) by which the lids are closed.
O. C. 1790 A *a*.

E. 1310. Part of the right side of the face, with the lachrymal duct exposed from outside. Blue rods have been inserted into the puncta lachrymalia, and the saccus lachrymalis and lachrymal duct have been filled with dark injection. Upon the reverse of the specimen the opening of the duct into the nose beneath the maxillo-turbinal is shown by the insertion of a glass rod into the orifice and by the partial removal of the turbinal. O. C. 1793 B.

SENSE-ORGANS OF UNKNOWN FUNCTION.

Organs of the Lateral Line.

Cole, Trans. Linn. Soc., vol. vii. 1896–1900, p. 115.
Parker, Bull. Bureau Fish. Washington, vol. xxiv. 1904, p. 185.

The integumentary sense-organs of the Lateral line are confined to Fishes and aquatic Amphibia. At present their function is obscure, though what evidence there is points to their being specially sensitive to vibrations of the water of low frequency (6 per second), such as those caused in the deeper water by ripples on the surface, or by a solid body falling into the water. This function is in harmony with the fact that the nerves to these organs belong to the same category as those that supply the ear, which is essentially an organ for response to material vibrations. In structure the organs of this system resemble taste-buds, each consisting of a bunch of hair-cells surrounded by an envelope of indifferent supporting cells. The buds are most numerous on the head and differ considerably in their arrangement and relations to the surrounding skin. They may occur isolated as "pit organs" sunk in little depressions upon the surface of the head and trunk, or lodged in the walls of a system of gutter-like or tubular canals that lie in very constant and definite positions upon the head and trunk, or at the blind swollen extremities (Lorenzini's ampullæ) of mucous-containing tubes that open upon the surface of the head in Elasmobranchs and Holocephali, or finally in the Torpedo in closed vesicles (Savi's vesicles).

The Pit organ is the simplest and probably the most primitive of these varieties, Lorenzini's ampullæ being simple or compound pit-organs sunk below the skin at the end of tubes of various length, and the organs of the lateral line canals being pit-organs sunk in or beneath the skin and connected together into one complex system of canals or gutters. The canals of this system have practically in all cases the following fundamental plan of arrangement. The chief canal, known as the lateral line, runs upon the side of the body from the tail to the hinder part of the head, and there joins a system of three chief cranial canals, one above and one below the orbit (supra- and suborbital) and one following the lines of the hyoid arch and mandible (hyomandibular).

The nerves that supply this system of sense-organs form with the auditory a separate group, the branches of which leave the brain in conjunction with the VIIth and Xth cranial nerves and sometimes also with the IXth. The branches of the VIIth and IXth supply the sense-organs in the cranial canals and in the Elasmobranchs and Holocephali those in the ampullæ. The lateralis branch of the Xth is confined to the lateral line and pit-organs upon the trunk.

PISCES.

ELASMOBRANCHII.

Forssell, Zeitschr. wiss. Zool., Bd. lxv. 1899, p. 725.

E. 1311. A piece of skin from the side of a Porbeagle Shark (*Lamna cornubica*) showing the lateral line canal (into which a green rod is passed) and the numerous apertures (indicated by black bristles) that pass obliquely from it to the surface. Blue and yellow rods are placed in large vessels that accompany the lateral line canals.

From an animal, 8 ft. long, taken at Rye in 1871.

O. C. 2107 A.

E. 1312. A portion of the skin of the side of the snout of the same Fish, showing the openings of the mucous tubes.

O. C. 2107 B.

E. 1313. The termination of the snout of a Spotted Dog-fish (*Scyllium canicula*) prepared "to show the manner of the nerves ramifying, as also their apparent termination in this part, each ultimate nerve appearing to terminate in the bottom of a tube or duct, the sides of which we may suppose to secrete, contain, and convey a thick mucous to the skin." The nerves, which are not very clear in the specimen, terminate in the sense-organs of the ampullæ of Lorenzini. The tubes by which these ampullæ communicate with the surface can be seen in section beneath the skin at several parts of the specimens and also where bristles have been inserted into them. Their walls, as Hunter says, secrete the mucous by which they are filled.

O. C. 1395. *Hunterian.*

John Hunter, Essays and Observations, edit. R. Owen, 1861, vol. ii. p. 399.

E. 1313 a. A piece of skin from the head of a Greenland Shark (*Læmargus borealis*), upon the deep surface of which a nerve-trunk belonging to the lateral line system has been exposed to show the innervation by it of some ampullæ of Lorenzini and the sense-organs in a short portion of one of the lateral line canals. The canal and the tubes connecting it with the exterior have been cut open. The sense-organs form a thickened cushion along the floor of the canal. Their number as shown by the number of nerves connected with them is far in excess of the external openings. Several ampullæ of Lorenzini are shown upon the left side of the specimen, each with a fine nerve in connection with its blind extremity. Further down several ampullæ have been cut across, showing that the blind end of each is divided into separate chambers by radiating septa. Near the lower edge of the specimen one of the mucous canals leading to an ampulla is cut across obliquely, showing its wide calibre and sudden narrowing towards its external opening.

E. 1314. A wax model * of a group of ampullæ with their tubes of communication with the exterior and their nerves and blood-vessels, and a row of five Savi's vesicles, from a

* One of a series of wax models prepared by Prof. Calamai, of Florence, to illustrate the anatomy of the Torpedo, and preserved in the Rail Case of Room V. (lower gallery).

Torpedo (*Torpedo galvanii*) × 15 ; also a wax model of a single ampulla × 120 showing a network of nerve-fibres upon its surface.

Savi's vesicles are oval bodies situated beneath the skin upon the ventral surface of the Torpedo united together by a fibrous cord. They probably represent degenerate lateral line canals which are otherwise absent on the ventral surface of fishes of this genus.

Coggi, Arch. Ital. Biol., t. xvi. 1891, p. 216.

E. 1315. A small Starry Ray (*Raia radiata*), with the skin removed from the left side of the back to show the arrangement of the lateral line canals and the mucous tubes.

The canals are narrow and relatively thick-walled tubes that branch out close beneath the skin over the surface of the head and expanded pectoral fins and along the sides of the body to the tail and open at intervals by short branches to the exterior. The usual four chief canal-systems are present—the lateral canal upon the body and hinder part of the pectoral fin, the supra- and suborbital canals above and below the eye, and the hyomandibular canal external to the suborbital and connected to the lateral canal by a long backwardly directed loop that follows the anterior margin of the pectoral fin. The majority of the mucous tubes radiate to the margin of the pectoral fin and to the shoulder from a cluster of ampullæ situated just external to the spiracle. Black paper has been placed beneath the mucous tubes, and the lateral line canals are injected with blue. O. C. 1437 c.

Ewart & Mitchell, Trans. R. Soc. Edinburgh, vol. xxxvii. 1895, p. 87.

E. 1316. A similar specimen showing the lateral line canals and the mucous tubes upon the ventral surface. The lateral line canals, which, as in the previous specimen, are injected with blue, are direct continuations of those upon the dorsal surface, but differ from them in having a much greater calibre and more delicate walls. The limits of each canal and its branches can best be traced in the two following specimens by reference to their innervation. The ampullæ of the mucous tubes are collected into three main clusters, one beneath the snout between the sub- and supraorbital canals, one external to the nasal capsule, and one (the same as that seen in the previous specimen) in front of the outer end of the first gill-cleft. The mucous tubes radiate from these centres and open irregularly upon the ventral surface of the head and fore-part of the body and fins.

O. C. 1437 D.

E. 1317. The left half of the fore part of a Skate (*Raia batis*) dissected from above to show the innervation of the lateral line and ampullary sense-organs upon the ventral surface of the head. The sense-organs of the lateral line are arranged at fairly regular intervals along the canals, each being supplied by a small nerve-filament derived from one of the lateral line branches of the facial. Thus, the supraorbital canal is innervated by the superficial ophthalmic VII, the suborbital by the buccal VII, and the hyomandibular by the hyomandibular VII. The three clusters of ampullæ are also supplied by the same three branches.

Black paper and bristles have been placed beneath the clusters of ampullæ and under many of the nerve-filaments that supply the individual organs of the lateral line canals.

O. C. 1437 E.

Ewart & Mitchell, *l. c.*, p. 94.

E. 1318. A similar preparation of the right half of the same Fish, showing the innervation of the canals and clusters of ampullæ upon the dorsal surface. In this specimen the nerve-supply to the anterior part of the lateral canal by a branch of the lateralis vagi is shown. The innervation of the cranial canals and clusters of ampullæ is the counterpart of that shown in the previous specimen, the several canals being the main trunks, of which those on the ventral surface are branches. O. C. 1437 F.

HOLOCEPHALI.

E. 1319. The head and shoulders of a Sea-Cat (*Chimæra mediterranea*), showing the course of the lateral line canals and the position of the openings of the mucous tubes. The lateral canal runs forward along the side of the body to a point about 2 cm. behind the eye and then branches towards the dorsal and ventral surfaces of the head, arching forward above and below the eye to form supra- and suborbital canals. A transverse connection unites the supraorbital canals across the crown of the head. Immediately below the eye the suborbital canal gives origin to the hyomandibular, which consists of two branches, one running downwards towards the edge of the gill-cover, the other passing forwards. This latter again branches below the eye and upon the surface of the snout, and in the mid-anterior line unites with the suborbital canal. In *Chimæra* the canals are gutter-shaped and not tubular. Upon the swollen gelatinous snout they are considerably enlarged and at intervals their margins widen out to form large diamond-shaped openings, between every two of which lie the sense-organs. The openings of the mucous canals are marked by red rods. O. C. 1437 B.

Cole, Trans. R. Soc. Edinburgh, vol. xxxviii. 1896, p. 63.