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THE ANATOMY OF TARSIUS SPECTRUM.

By H. H. WOOLLARD, M.D., Anatomy Department, University College, London.

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Contents.

Introduction.

Tarsius, though unquestionably a lemuroid, is an annectant form with the Anthropoidea. This conclusion by Professor Elliot Smith suggested the need for a review of the anatomy of *Tarsius* to provide the material for a reliable estimation of its zoological rank and affinities, which within recent years have been the subject of considerable diversity of opinions. While some writers have claimed it as the nearest living representative of man's progenitors, others have regarded it as a creature of no special significance in his evolution. The object of this review is to confirm and correct, if possible, the existing accounts of the anatomy of *Tarsius* and fill in any gaps that may exist in our knowledge.

The material available consisted of a male and female specimen presented to Professor Elliot Smith by Dr. Charles Hose, to whose scientific enthusiasm this department is deeply grateful for many valuable specimens. Our material was further supplemented by Mr. Le Gros Clark, who gave to the department

* Communicated by Prof. G. Elliot Smith, F.R.S., F.Z.S.

a male and a female specimen of *Tarsius* and a series of brains collected and preserved by himself. This material was beautifully preserved, and on it is based our histological studies.

A male and a female were carefully dissected and the other specimens used for special confirmation of particular points. Complete serial sections were made of the snout and front half of the head, and other series were made of the male genito-urinary organs. The ductless glands, the trachea, larynx, and tongue were also studied in serial sections. The facial musculature was first studied by dissection, and doubtful points were cleared up by using sections.

We have freely used the existing works on the Prosimiæ. We would like to add our tribute to the skill and accuracy with which Burmeister wrote his wonderful account of the anatomy of *Tarsius*. In fact, if it had not been for the encouragement of Professor Elliot Smith we should have abandoned this enterprise, since there seemed so little to add or correct. But as Burmeister did not deal with the male genitalia and many of his observations have been questioned by subsequent workers, it seemed to be desirable to give an independent account of the anatomy of *Tarsius* based on new observations.

We have freely used Mivart and Murie and Duckworth for accounts of the anatomy of other Lemurs. In the nervous system Professor Elliot Smith's work has been freely drawn on for comparisons with the Primate brain. Special points have been reviewed in the light of the researches of many other writers, particularly the voluminous comparative work on facial muscles and the viscera by Ruge. For general views we have found the publications from the American Museum of Natural History of New York of the greatest value. Even if it were possible, no very good purpose would be served by quoting all the voluminous literature on the Prosimiæ with their innumerable references to *Tarsius*. Constant references to authorities in the text would have unduly confused the account without any compensating advantage. The list of works actually consulted and used in preparing this review will be found in the bibliography, but the report here submitted is essentially a record of personal observation.

External Form.

Tarsius habitually progresses in the upright position. The anatomical terms used in the description are based on this upright position.

The *Head* would be almost perfectly spherical if the snout did not protrude from the anterior surface as a rounded hillock.

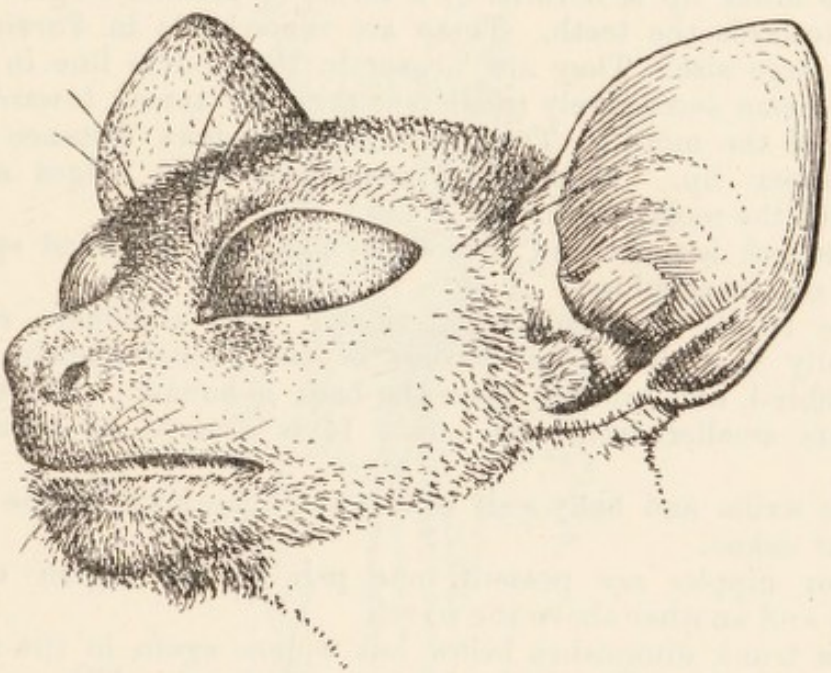
The head is covered by thick fine white hair. In the neck region the hair colour becomes grey. Over the snout, anterior nares, and mouth borders the hairs are short, fine and sparse.

and they might be called naked without actually being so. *i. e.* there is really no rhinarium.

The *Nose* has many peculiarities. It is low, rounded at the bridge; pressed flat; broadened at the end; the nasal openings are kidney-shaped and directed away from each other. The interval between the nostrils is broad and somewhat depressed and covered with fine hairs. The depression extends up on to the dorsum of the nose.

Vibrissæ are present at several points on the head and along the lips. In the upper lip they extend from the margins of the nose to the angle of the mouth, but are not very long—the longest are $\frac{1}{2}$ inch. In the lower lip they suggest

Text-figure 1.



Face of *Tarsius*.

a small beard at the angle of the chin. The longest vibrissæ are found on the nose. Two long vibrissæ grow between the nose and the inner canthus of the eye. Another group is present between the eye and the ear (1–3). The margins of the eyelids bear fine lightly coloured eyelashes.

The *Eyes* are large, and the eyelids bound a circular space which is 16 mm. transversely and 12 mm. from above downwards in a preserved specimen. In photographs of the living animal the eyes are perfectly circular. The iris is a coffee-brown colour and the pupil is round.

The *Ears* are very remarkable. They resemble a large broad spoon which is borne by a short round handle. The outer surface is covered by short hairs which are particularly grouped from the base to the middle. The cranial surface bears only fine hairs at the base, but is naked in the middle.

The helix begins as a broad appendage which soon fuses with the anterior border. The margin of the ear where it begins posteriorly is divided, thus presenting helix and antihelix. The tragus and antitragus are well marked—the tragus large and rounded, the anti-tragus short and stumpy. The ear is traversed by four transverse ridges. Three run from the anterior to the posterior border, and a fourth oblique ridge passes downwards towards the concha and is elevated into a large overhanging lapel. These ridges are peculiar and are said to be found only in some Rodents. (The external ear is more fully described with the sense organs.)

The *Mouth*, not very large, appears so owing to the short snout. The upper jaw does not overhang the lower. The corner of the mouth ends opposite the middle of the eyes The margin of the lower lip is covered by a series of parallel ridges which pass towards the teeth. These are remarkable in *Tarsius* for their large size. They are largest in the middle line in front and become successively smaller as they are traced towards the angle of the mouth. They extend for a short distance on to the upper lip. From these elevations short ridges extend towards the molar teeth.

The neck is short and covered by hair, and the head appears to sit on the shoulders.

The trunk is broadest anteriorly. The shoulders extend laterally and the upper borders of the shoulder-blades stick out behind, and between them the back is sunken. The thorax appears smaller from the back. It is covered by short fine hairs.

The axilla and belly wall in the neighbourhood of the navel appear naked.

Four nipples are present, one pair in the region of the axilla and another above the navel.

The trunk diminishes below but widens again in the region of the pelvis. The belly is not prominent. The external genitalia in the female form an enclosed sheath of elevated but small lips whose anterior margins enclose an anteriorly directed clitoris.

The *Penis* is short, protruding but a short distance from the scrotum. Its free end is covered by a large prepuce.

The body of the penis is incorporated in the anterior wall of the scrotum. The scrotum is large and contains the testicles, which lie behind the penis. The perineum is naked and protrudes above the surface owing to the well-marked muscles of this region.

The *Fore limbs* are as striking through their shortness as the hind limbs are through their length. They are flattened, with rounded borders. Towards the axilla they are naked, but thickly covered with hair externally. The backs of the hands and the fingers are covered with very fine hairs.

A large oval pad lies along the thumb side of the hand

shaped like a figure of eight. At the root of the middle and following fingers appear elevated rounded pads. Finally each finger shows a small crescent-shaped pad which bears the nail. The nails are triangular in shape and in the middle drawn out to a point. The lateral margins are rounded, and the nails are curved.

The *Hind limbs* are much longer than the fore limbs and exceed the trunk in length. The thigh is very thick owing to the powerful vasti muscles. On the inner side as far as the knee the hair is scanty. In the neighbourhood of the knee the hairiness becomes feebler and lighter in colour

Text-figure 2.

External Genitalia (male).

Beyond the knee the inner and outer margins of the leg and foot as far as the toes are covered by fine hair. The dorsum of the foot is covered by fine sparse hair. The sole of the foot is quite naked and is quite flat until the heads of the metatarsals are reached. The foot broadens at this point and diverges to the toes. The pads form here three dissimilar elevations. The largest corresponds to the hallux and extends along the free portion of that digit. The middle and smallest corresponds to the second and third toes, and the third corresponds to the fourth and fifth. This last extends along the fourth and fifth metatarsals to the origin of the free portions of

fourth and fifth toes. Each toe ends in a large terminal expansion which bears the nail. Of these that for the hallux is much the largest.

The nails on the hallux and fourth and fifth toes resemble those of the hand is every way, though that of the hallux is broader. The other toes, the second and third, bear claws. In the hand the third digit is the longest, while the fourth is the longest in the foot. The third and fourth are both larger than the second. The second toe is the shortest, while the hallux is about as long as the third. None of the toes reach the length of the corresponding fingers with the exception of the hallux, which is as long as the thumb but much thicker.

In *Tarsius spectrum* the tail, which is extremly long, shows no sign of scales. The small hairs present are without any regular arrangement.

We have consulted the work of Mr. R. I. Pocock on the external characters. Other features such as the tongue and external genitalia are described with their respective systems. Mr. Le Gros Clark confirmed the appearance of carpal vibrissæ in the fœtal Tarsius. Duckworth has figured the palmar and plantar pads.

List of some of the more important Measurements.

The crown-rump length (junction of tail and body)	115 mm.
Length of the tail	210 ,,
The length from the anterior superior iliac spine to the fourth digit	200 ,,
The length from the tip of the snout to the occiput	42 ,,
The transverse diameter between the external auditory meati	36 ,,
Length of the brachium	32 ,,
Length of the antibrachium	44 ,,
Length of the manus (to the extremity of the third digit)	38 ,,
Length of the thigh from great trochanter to the lower extremity of the femur	62 ,,
Length of the leg from the upper extremity to the tuberosity of the os calcis	65 ,,
Length of pes from the tuberosity of the os calcis to the end of the fourth digit	68 ,,
Length of the palpebral fissure	16 ,,
Length from the articulation of the nasal with the frontal to the external occipital protuberance	32 ,,

The Skeleton.

The account of the skull was made possible by the very great kindness of Mr. Le Gros Clark, who lent me amongst other material a disarticulated fœtal skull for study. The principal authorities we have consulted in this account have been Burmeister and Van Kampfen.

Description of the Skull.

The *Frontal bone* is single. It is double in *Nycticebus*, The coronal suture converges behind to an angle between the parietals—in this resembling the South American monkeys and differing from *Nycticebus*, in which the coronal suture is transverse. The frontal is prolonged forwards between the orbits as a very slender plate forming the medial wall of the orbit and meeting the nasals in front. The single olfactory foramen lies between the plates of either side. In front of the olfactory foramen the bones contain a wide cancellous tissue, but there is no frontal sinus. Tracing the bone laterally it forms the inner and upper boundary of the orbit, and half-way round the outer side of the orbit it articulates with the malar. Its orbital plate forms the roof of the orbit and articulates externally with the orbital surface of the great wing of the sphenoid above the optic foramen. Along the medial wall of the orbit it articulates widely with the palate, and in front of this with the lateral mass of the ethmoid. Finally in front it reaches the lachrymal and the nasal process of the superior maxilla.

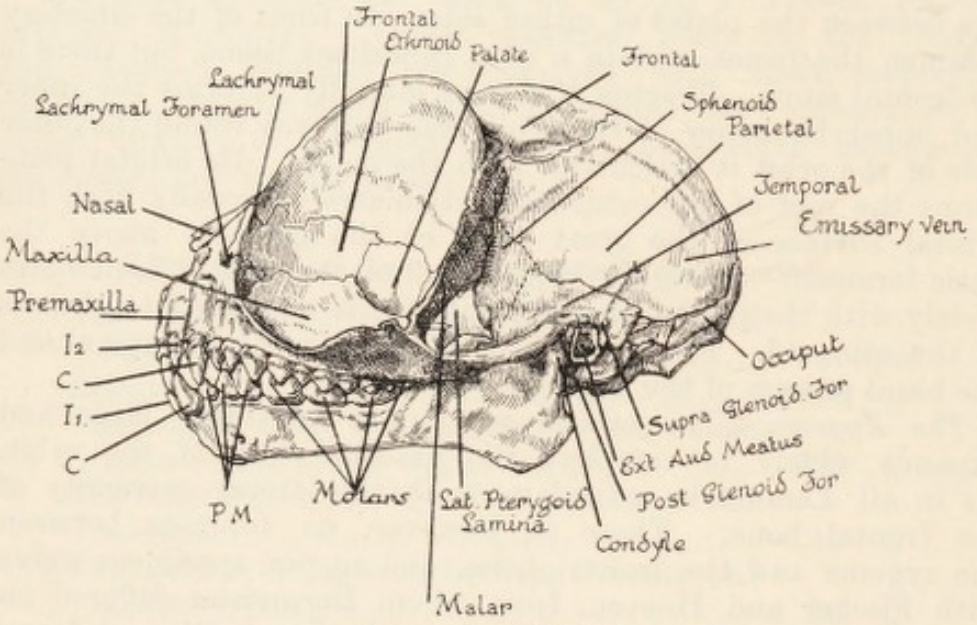
The Zygoma.—The orbital portion is relatively large and expands widely to complete the external wall of the orbit. As in all Lemurs it articulates with the lateral extremity of the frontal bone. There is, however, no foramen between the zygoma and the frontal bone, and so our specimens agree with Fischer and Hoeven, from whom Burmeister differed on this point. It articulates narrowly with the maxilla and forms the lateral boundary of a relatively narrow inferior orbital fissure. A slender zygomatic process joins with the similar process of the temporal and completes the zygomatic arch.

The malar foramen is represented by a notch on the front border of the zygoma.

The Temporal bone.—The squamous portion is short and somewhat tri-radiate in form. It articulates with the parietal and great wing of the sphenoid but does not reach anywhere near the frontal. The posterior root of the zygoma forms an elevation above the external auditory meatus. Where the tympanic tube is deficient the middle root of the zygoma descends and forms the posterior wall of the glenoid cavity. This arrangement occurs not only in *Tarsius* but also in the Galagos and Lorisinæ. The mastoid forms only the slightest elevation on the surface. The expansion of the tympanic bulla descends far below it. The petrous temporal is very prominently elevated in the floor of

the skull, and the superior and posterior semicircular canals stand out above its surface. In the angle between the superior and the posterior canals the lobus petrosus of the cerebellum is lodged. The tympanic bulla is markedly inflated, and shows externally a constriction which corresponds to an internal partition dividing the bulla into a medial and a lateral compartment. Just a little in front of this constriction on the ventral surface of the bulla is the foramen which transmits the internal carotid artery. Laterally the bulla is continuous with the external auditory meatus which is fashioned out of the tympanic annulus. Along the anterolateral margin is a deep conical glenoid cavity. The anterior root of the zygoma is flattened in front of the glenoid cavity. As already mentioned,

Text-figure 3.



Lateral view of Skull.

the middle root runs almost directly posteriorly to fuse with the tympanic annulus, and the posterior root is slightly marked above the external auditory meatus. Between the tympanic and the glenoid cavity is a large venous foramen through which the cavernous sinus continued over the front of the petrous temporal reaches the external jugular. The great wing of the sphenoid is curled up against the anterolateral margin of the tympanic. This curled up margin of the sphenoid runs on into the pterygoid processes, and thus appears to join these to the bulla. The course of the lateral semicirculur canal is visible through the lateral compartment of the bulla. Along the posterior margin of the bulla a deep excavation separates the bulla from the raised margin of the foramen magnum. At the middle of this margin there is a small foramen for the ninth, tenth, and eleventh nerves. Between the bullæ of the opposite sides the

basi-sphenoid and basi-occiput are compressed to a slender rod. The lateral pole of the bulla ends bluntly, and there is only the faintest suggestion of a mastoid process. Above the external auditory meatus there is a large venous foramen. There is no indication of a tympanic process near to the stylomastoid foramen.

Parietal bones.—These are large quadrilateral bones forming the side wall of the brain-case. They articulate together in the middle line. In front, where they meet with the frontal, the anterior margins of the parietals incline backwards towards the middle line, thus forming an angle with each other. Below and in front, the parietal articulates with the great wing of the sphenoid and more posteriorly with the squamous portion of the temporal. The lambdoidal suture as it runs along the occiput is almost horizontal.

The Occipital bone.—In the middle line posteriorly the supraoccipital portion of the bone is prolonged upwards as a narrow tongue of bone into the lambda. From this point a slight elevation is prolonged down to the external occipital protuberance, and from there onwards to the anterior margin of the foramen magnum as an extremely faint occipital crest. The superior nuchal line and muscular impressions are well marked. The median portion of the bone is elevated and indented by the cerebellum. The foramen magnum is situated at the junction of the posterior and middle thirds of the base of the skull. It lies in a horizontal plane. Its anterior margin is rolled into a thin crest. The occipital condyles are long and narrow and the convex surface looks outwards. Posteriorly the condyles are sharply elevated, thus giving them as a whole a conical form. Anteriorly the condyles approach each other, but there remains relatively a considerable interval between them. The basi-occiput, triangular at the foramen magnum, is long and narrow in front and its margins are rolled inwards towards each other by the tympanic bulla. The exoccipitals are triangular in shape, and the base of the condyle is perforated by the hypoglossal foramen.

The only points that need reference at this moment in the *superior maxilla* are that the maxillary nerve lies in an infra-orbital groove, not in a canal; that the infra-orbital foramen is usually single (in one fœtal skull on one side it was double); that the antrum is small and confined to the nasal portion of the bone; that the tuberosity of the maxilla is very large; and that the roots of the molars lie just beneath the floor of the orbit. The *premaxilla*, fused in the adult, bears two incisor teeth, its thin nasal process forming the anterior bony margin of the nose, its body taking part in the formation of the floor of the nose. It joins the anterior boundary of the nasopalatine foramen.

The *Palate* is relatively much larger. Its horizontal plate is long owing to the great length to which the posterior chamber

of the nose is produced. Its vertical plate approaches the member of the opposite side, and both lie apposed on the large septum of the orbito-sphenoid reaching up to the frontal. It articulates with the ethmoid and sphenoid, and contributes largely to the formation of the medial wall of the orbit. The post-palatal spine is very prominent.

The *Ethmoid* resembles this bone in the bird. The septum and lateral portions are mere plates without any sinus formation, which converge above so closely that no definite cribriform plate is formed. Its articulations are easily seen in text-fig. 3, the turbinates being described with the nasal fossæ.

Sphenoid.

The presphenoid is large and shaped like a butterfly. The anterior margins of the wings articulate with the posterior margin of the frontal. Below it carries a septum articulating with the frontal septum of the ethmoid and vomer. On either side this septum of the presphenoid is overlapped by the vertical plate of the palate, and the optic foramen leaves the skull. The body of the sphenoid contains the fossa for the pituitary gland.

The great wings are deeply indented and displaced forwards by the great enlargement of the tympanic bulla. The cranial surface is deep and narrow and its anterior margin is elevated to form a broad expansion, which articulates with the frontal and forms part of the posterior wall of the orbit. On this surface of the wing a small foramen entirely separate from the optic foramen transmits the ophthalmic, 4th and 6th nerves, while slightly above and medial to this is a separate foramen for the third nerve. A foramen rotundum transmits the maxillary nerve. The posterior margin of the great wing is expanded upwards against the antero-lateral face of the bulla, between which are found the mandibular nerve and middle meningeal artery. There is no true foramen ovale or spinosum.

In the wing, lateral and in front of the mandibular nerve is a large foramen which transmits a large venous channel to the pterygoid region.

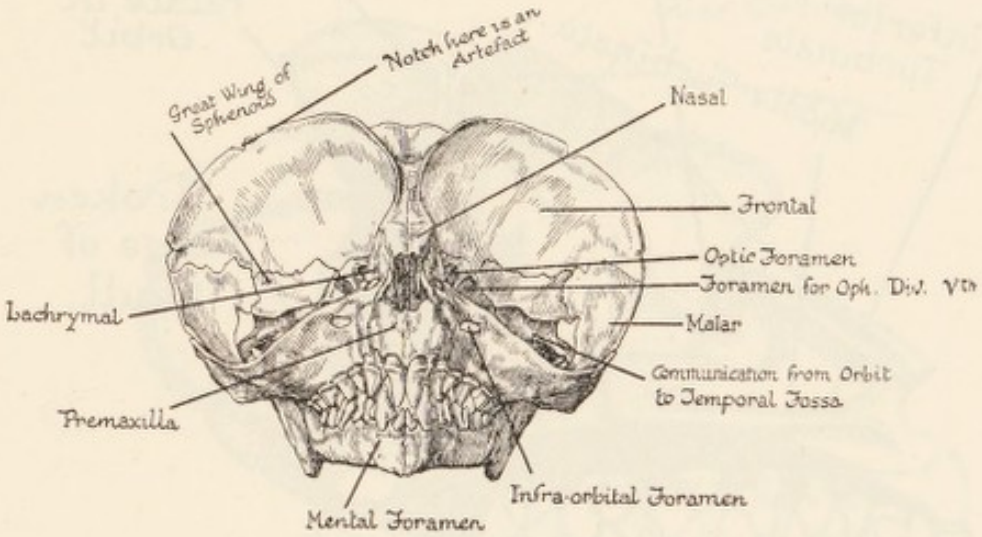
Between the great wing and the orbital portion which articulates with the frontal and maxilla, there intervenes a relatively narrow communication between the orbit and the temporal fossa. The under surface takes part in the formation of the infratemporal fossa, and is then produced into a flange of bone that embraces the anterolateral margin of the bulla. The lateral margin of the great wing articulates widely with the parietal and also with the temporal.

The pterygoid processes embrace a pterygoid fossa. The medial plate is slender. The lateral, prolonged by the flange of the great wing, appears to reach the bulla. The basisphenoid is reduced to a mere rod by the bullæ.

The orbit is perfectly circular in outline and its diameter measures 17 mm. The mesial wall is formed in its upper

half by the immense prolongation of the frontal septum. Below the frontal from before backwards the wall is formed by the lachrymal, the ethmoid, and the vertical plate of the palate, and finally by the small wing of the sphenoid medial to the optic foramen. The lachrymal is small and possesses a small facial and a somewhat larger orbital surface. It forms only the superior margin of the lachrymal canal. The floor is formed by the orbital surface of the superior maxilla. In its mesial portion it becomes expanded by the antrum, which occupies the lateral wall of the nose. Elsewhere it is reduced to a mere plate of bone so that the roots of the teeth are visible in the floor of the orbit. The lateral wall is formed by the

Text-figure 4.



Front view of Skull.

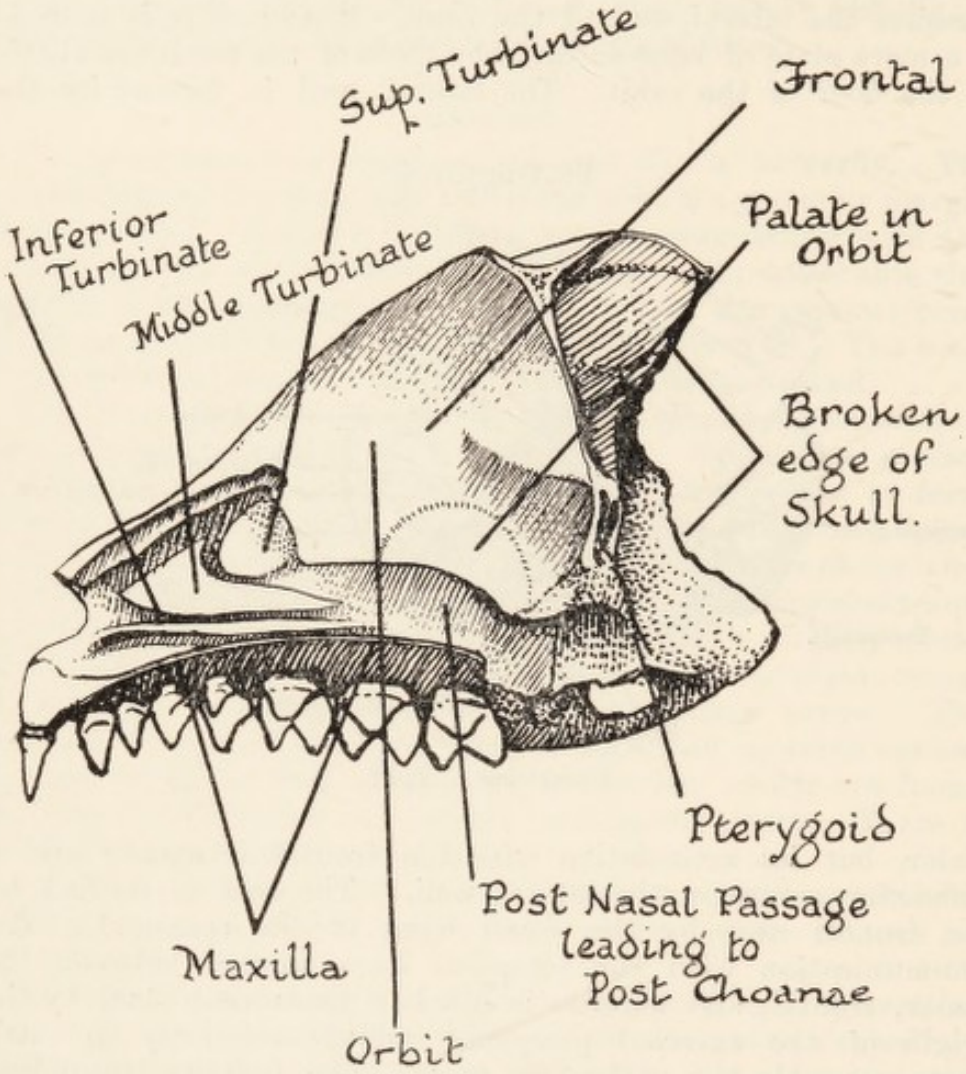
malar, but its articulation with the frontal is narrow and a deficiency occurs in the lateral wall. The roof is formed by the frontal and by the small wing of the sphenoid. The communication with the temporal fossa formed between the malar, frontal, and maxilla is filled in the recent state by the origin of the external pterygoid, and is relatively so small as to resemble the anthropoid orbit. The foramen rotundum opens separately, and there is no true superior orbital fissure. The lachrymal duct is situated in front of the orbital margin. The infraorbital canal for maxillary nerve is an open groove. In the medial part of the orbital surface there is a small deficiency which in the recent state is closed by a fibrous membrane.

Nasal Cavity.

The nasal cavity is situated very far forwards in front of the brain-case. Fischer remarks that the retention of this primitive reptilian feature is probably due to the exaggeration of the size

of the orbits. This anterior position of the nasal capsule is apparent in the development of the chondrocranium. The nasal cavity in the adult is extremely compressed and narrow. From the lateral wall to septum the width of the nasal cavity is only 1·5 mm. Hanging into the middle of this cavity are the turbinate bones. From anterior to posterior nares the distance is 18 mm.

Text-figure 5.

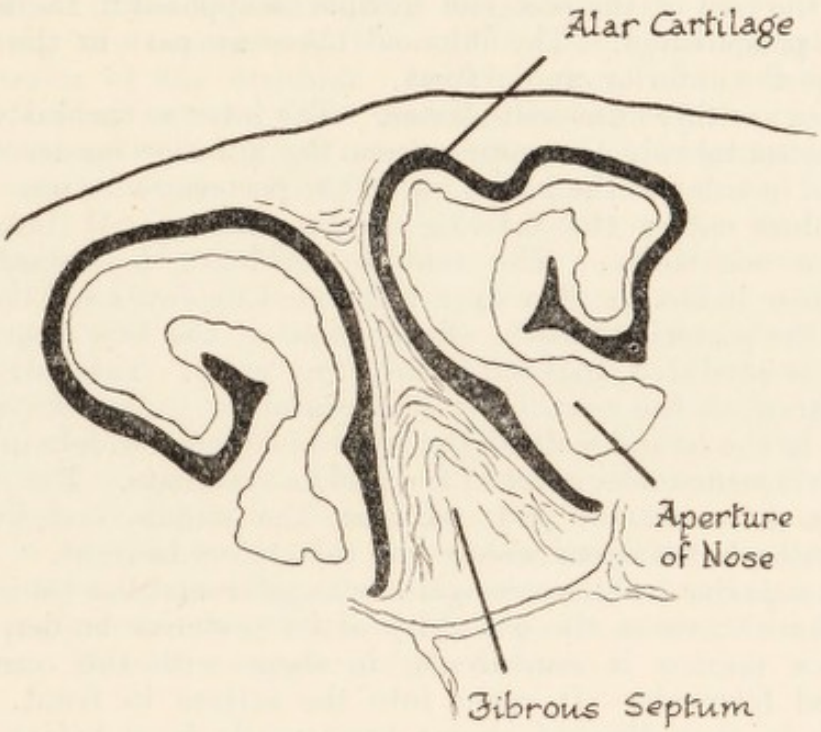


View of lateral wall of Nose

The anterior nares in the recent state are extremely divergent. This is due to the soft parts, for when these are removed the condition is not repeated in the bony parts. The cartilage forming the anterior nares is at first bilateral and is complete laterally, dorsally, and medially, but deficient ventrally. As the bony parts are approached the cartilages fuse together medially and form a single cartilaginous septum, and, on a level with the incisor teeth, the ventral wall becomes complete. This anterior cartilage where the lateral portion of the cartilage turns inwards

bears on the inturned portion a prominent elevation which is covered by epithelium and is extremely rich in widely open blood-vessels. Close to the position where these cartilages are fusing together there appears on the medial portion of the cartilage a similar projection which is covered by epithelium rich in widely dilated blood-vessels. In the septal elevation a spur of cartilage is also present. In both numerous glands appear. The cartilage first begins to disappear in the floor when the naso-palatine duct appears. This duct is very oblique and bends downwards and forwards, the mouth opening being far in front of the nasal opening. The cartilage extends farther back in its dorsal portion, and is replaced in its ventral portion by the bony

Text-figure 5 *a*.



External Nares.

nasal crest of the superior maxilla. At this point appears the organ of Jacobson, and the nasal opening of the naso-palatine duct.

The roof of the nose is formed behind the alar cartilage by the nasal bones, and then by the ethmoid. The posterior wall of the nose then descends behind the superior turbinate vertically downwards for about half the depth of the nose to meet the posterior choanæ. The posterior choanæ have the form of a long canal equal in length to that of the actual nasal cavity itself. The septum is formed by the perpendicular cartilage, by the vertical plate of the ethmoid, and by the vomer which is very long. The lateral wall is formed by the maxilla, the lateral plate of the ethmoid, and the palate.

The form of the ethmoid is curious. Its lateral mass is reduced to a thin plate of bone; only where the lateral plate joins the medial plate does it become cancellous, but nowhere are there any air sinuses in it. The lateral mass is roughly quadrilateral in outline, and articulates in front with the maxilla and above with the frontal. The frontal process becomes drawn out into a thin plate of bone which forms about one half of the medial wall of the orbit. This thin plate meets the ethmoid from above. Just behind the frontal it touches the septum of the orbito-sphenoid for a moment and then along its posterior border it is in contact with the palate. Below, it articulates with the maxilla. The posterior choanæ are formed by the palate, the medial pterygoid plate, and by a small part by the body of the sphenoid. The two vertical plates of the palate above the roof of the posterior choanæ lie apposed to the septum of the presphenoid. The ethmoid takes no part in the formation of the anterior cranial fossa.

There are three turbinate bones. The inferior turbinate bone is a horizontal ridge extending from the anterior border of the maxilla in front to the beginning of the posterior choanæ. The nasal duct enters the inferior meatus immediately below its anterior extremity. The middle turbinate is smooth and triangular in shape. The apex is directed forwards and the base forms the posterior border. Each angle of the base above and below is produced backwards to a fine point. The antrum of Highmore of the maxilla is compressed to a narrow vertical cavity in the lateral wall of the nose and opens widely into the middle meatus under cover of the middle turbinate. The middle meatus is a narrow slit between the middle and inferior turbinates, but it opens widely into the atrium in front.

The superior turbinate is again triangular and lies behind the middle turbinate in the concavity of its posterior border. The superior meatus is semicircular in shape with the convexity directed forwards. It opens into the atrium in front. The atrium is thus directed almost horizontally from before backwards. Posteriorly all three meatuses open into the extremely long posterior choanæ. The total length of the nasal cavity in the macerated condition is about 18 mm., of which ten belong to the nasal cavity and eight to the posterior choanæ.

The form of the vault of the skull is almost completely spherical, *i. e.* it is mesaticephalic. The bones are extremely thin and the sutures persist. The temporal crest starting in the region of the junction of the frontal and malar sutures extends over the parietal bone and fades away as it approaches the mastoid region.

The base of the skull as a whole needs no further description than that included with the individual bones, but a summary of the foramina for the cranial nerves is necessary. The foramen for the olfactory nerve situated on either side of the enlarged crista galli is single.

The optic nerve passes through a foramen which is the largest of all the foramina transmitting the cranial nerves. The fourth, sixth, and ophthalmic nerves pass through a foramen in the great wing of the sphenoid which is separated from the optic foramen by a spicule of bone.

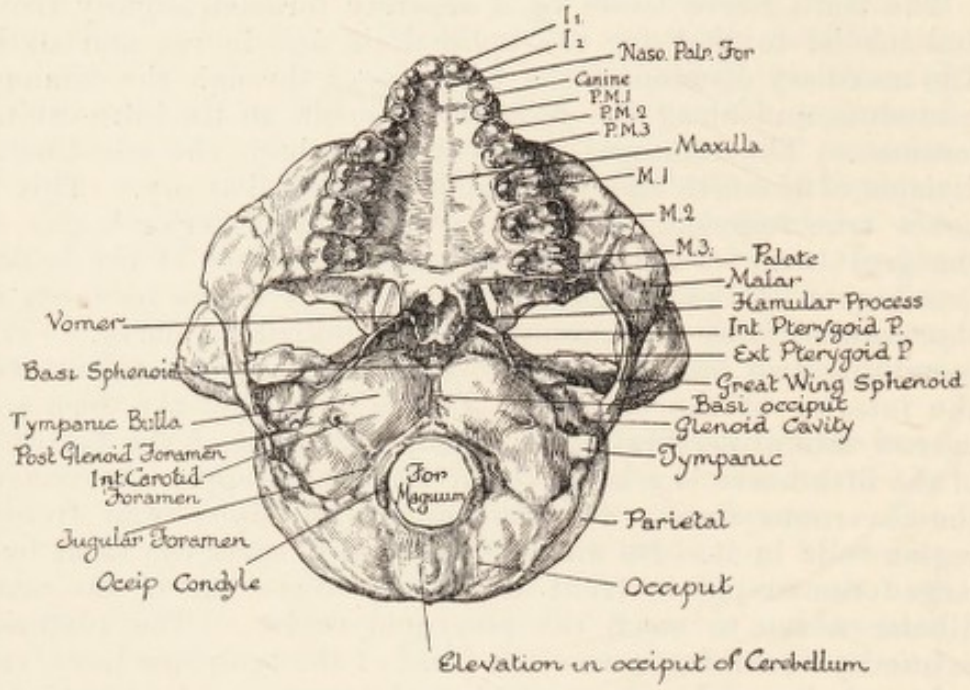
The third nerve issues by a separate foramen slightly above and medial to that for the ophthalmic and fourth and sixth. The maxillary division of the fifth passes through the foramen rotundum and along the floor of the orbit, to the infra-orbital foramen. The foramen ovale transmits both the mandibular division of the fifth and the middle meningeal artery. (This is not a true foramen, but lies between the posterior border of the great wing of sphenoid and anterior surface of the bulla.) One branch of the middle meningeal artery passes forwards in the cranial fossa to accompany the maxillary nerve. The remaining two branches of the middle meningeal extend over the interior of the cranium. In the bottom of the deep and narrow lateral cerebral fossa crossing the exits of the branches of the fifth nerve is a large venous sinus. It appears to receive the cavernous sinus. In addition a large sinus from frontal region ends in it. Its anterior extremity leaves the skull by a large foramen just in front and lateral to the exit of the mandibular nerve to reach the pterygoid region. The posterior extremity continues across the front of the tympanic bulla, and a branch leaves by the post-glenoid foramen. In addition a venous channel is continued above the external auditory meatus in the bone and joins with the small lateral sinus, and then issues by a supraglenoid foramen. The ninth, tenth and eleventh nerves pass through the jugular foramen. Under cover of and medial to the fossa for the lobus petrosus, lies the internal auditory meatus which transmits the seventh and eighth nerves. The hypoglossal as two fila passes through the anterior condyloid foramen. There is no post-condylar foramen.

The Basis cranii interna.

The immense convexity of the orbits reduces the anterior cranial fossa to a narrow slit out of which passes the single olfactory. It diverges and enlarges posteriorly above the orbitosphenoid. The lateral cranial fossa is a deep gutter between the elevated orbits in front and the elevated petrous temporal behind. The middle of the fossa is occupied by the pituitary, the optic chiasma, and the internal carotid artery. Between the free and attached margins of the tentorium cerebelli pass the third and fourth nerves. The anterior wall of the petrous temporal is occupied by the Gasserian ganglion, and the foramina already mentioned pass out from it. The posterior cranial fossa is roughly circular and passes almost vertically downwards. The superior semicircular canal on the superior border of the petrous temporal, and on the posterior surface the posterior semicircular canal are

visible. In the middle of the posterior wall is the internal auditory meatus. The central root of the Gasserian ganglion passes over the apex of the petrous temporal under cover of the

Text-figure 6.



Ventral view of Skull.

ligament of dura mater. The jugular foramen at the posterior border is the merest slit. The hypoglossal foramen pierces the base of the occipital condyle.

Tympanic Region.

The tympanic region of *Tarsius* has been described in great detail by Van Kampfen. Our observations agree entirely with his. The tympanic in the young animal has the form of a thin ring which, as in all the Lemuroidea, lies in the outer margin of the bulla. It is almost a complete ring, the ends being adjacent. As the bulla grows in size the ring also increases.

In the bulla of a full-grown Tarsius two compartments are to be observed, the anterior large and broad, and more markedly expanded than the small posterior one. It is with the posterior compartment that the tympanic fuses. It takes no part in the formation of the middle ear, but of course contributes to the formation of the external auditory meatus.

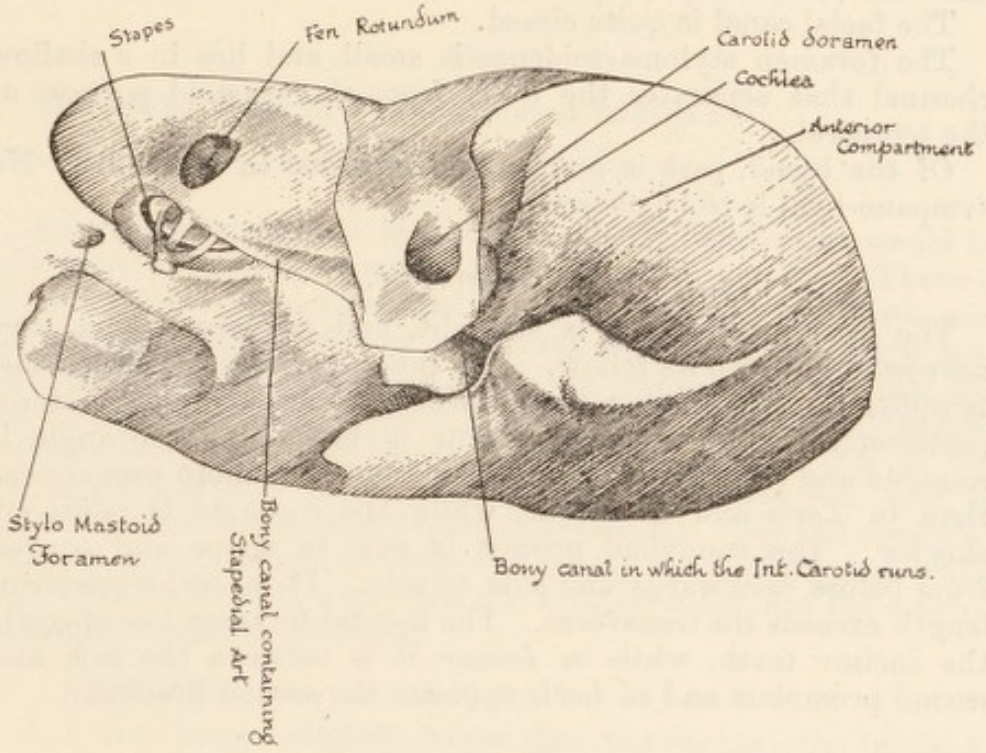
The anterior compartment of the bulla is separated from the posterior by a shallow groove on the inferior surface. In this groove runs the foramen for the internal carotid artery.

The posterior boundary of the bulla is formed by the mastoid and the exoccipital. Between the bulla and mastoid region is

the stylo-mastoid foramen. The bulla does not reach the basi-occipital, which with the foramen magnum lies further in front. The foramen lacerum posticum is small and funnel-shaped. The bulla extends in front towards the basi-occiput and the basi-sphenoid, and expands towards the pterygoid fossa. In its forward extension it covers over the eustachian tube, and as in the Lemuroidea generally the wall of the eustachian tube is formed partly by the tympanic bulla and partly by a process of the ali-sphenoid.

The bulla is separated internally by a septum which runs forwards in a direction at right angles to the long axis of the bulla. In the smaller posterior portion lie the two fenestræ, the

Text-figure 7.



Dissection of the Bulla from below.

opening of the eustachian tube and ear ossicles. The antero-internal wall of this posterior chamber is formed by the septum. The septum ends in a thickened margin which contains the internal carotid artery and forms the medial boundary of the eustachian tube. Under the tube is a second small opening which gives access to the middle ear. In contradistinction to the Lorisidæ the septum is imperfect. The anterior part of the bulla is to be considered a subsidiary cavity of the middle ear. It is a large space which extends not only to the exterior but also to the interior, forming part of the cranial wall. The small opening which gives access to the middle ear lies in the postero-external corner of the bulla.

The course of the Internal Carotid Artery.

The artery enters at the ventral surface of the bulla and runs in the septum to the apex of the cochlea, where it enters the cranial cavity. Winge believes that the carotid gives off its stapedial branch before it enters the bulla. Kampfen does not agree with this, nor do our observations lend support to this origin of the stapedial artery. This artery arises from the carotid canal in the septum after it has entered the middle ear. The stapedial artery then passes backwards behind the promontory, and then winds in front of the fenestra vestibuli, entering the stirrup of the stapes. In this way the stapedial artery in *Tarsius* resembles the same artery in *Lemur*.

Hyoid and Facial Canal.

The facial canal is quite closed.

The foramen stylomastoideum is small, and lies in a shallow channel that separates the bulla from the mastoid portion of the temporal.

Of the hyoid, part is ossified and included in the bulla. No tympano-hyal is to be observed.

The Lower Jaw.

The horizontal ramus is straight, and converges in a very narrow angle with its fellow. The junction bears a well-marked symphysis. The incisor teeth form a series arranged antero-posteriorly. The ascending ramus is broad and the angle is rounded and slightly inflected. The condyle is more pronounced than in *Loris* and in *Lemur*, while the coronoid is relatively shorter. The condyloid process is oval in shape and convex from before backwards and side to side. Its anterior-posterior length exceeds the transverse. The mental foramen lies opposite the incisor teeth, while in *Lemur* it is between the first and second premolars and in *Loris* opposite the second premolar.

Summary.

The bones of the skull are exceedingly slender, and can be cut easily with a sharp knife. The spherical shape of the head is heightened by the largeness of the eyes and the shortness of the nose. No other Lemur presents such a combination. *Otolicnus* has the large eyes,but the skull-form in all other respects resembles that of the other Lemurs. The orbits are especially characteristic of *Tarsius* in that the lachrymal canal is situated on the face in front of the orbital margin and the orbital margins themselves are extremely sharp. The breadth of the superior maxilla where it forms the posterior part of the floor of the orbit is a noteworthy feature of *Tarsius*. It gives the posterior opening of the orbit an eight-shaped form, which is more narrowed than in the other Lemurs.

All recent Prosimiæ have a well-marked bulla, and two groups can be distinguished: (*a*) the Lemuroidea and Cheiromyidæ—*i. e.*, all the Madagascar species—in which the tympanic is rounded and small, and remains free from the bulla throughout life; (*b*) the Lorisidæ and the Tarsioidea, in which the tympanic fuses with the bulla and forms an external auditory meatus.

Van Kampfen furnishes a detailed comparison of the morphology of the bulla and internal carotid artery amongst the Lemurs. He believes the arrangement in *Tarsius* to be secondary.

The *hyoid* bone is extremely slender. The body is narrow and from the body are prolonged the two cornua. Of these, the so-called greater cornu of human anatomy is the smaller of the two in *Tarsius*, much exceeding in size the lesser cornu.

The tympanic process does not emerge on the base of the skull.

Teeth.

The dental formula of *Tarsius* is as follows:—

$$\frac{2 \quad 1 \quad 3 \quad 3}{1 \quad 1 \quad 3 \quad 3}.$$

Burmeister remarked that *Tarsius* on its teeth alone would be placed in a separate category from all other Lemurs. There is great variation in the Lemurs in regard to the incisor teeth, and in *Tarsius* there is only one incisor on each side in the lower jaw. The teeth are very simple, and the cheek teeth retain the primitive tritubercular pattern. The front teeth have changed very little, and the order of implantation is retained in the primitive fashion. Alterations in size have occurred, and in the lower jaw one incisor has been suppressed. The tritubercular pattern is still the prevailing one among the Lemuroidea, while the Anthropoidea radiate from the tritubercular into the quadritubercular pattern (Osborn).

Upper jaw:—

I. 1 very large; slightly larger than the canine; the implantation is vertical. Near its neck this tooth diverges from its fellow; at its middle it converges towards this tooth and finally diverges again from it.

I. 2 is very small, about half the size of incisor 1.

C. is vertically implanted. The outer surface is convex. The inner surface is traversed from base to apex by a thin ridge. The area in front and behind the ridge is concave. The base is surrounded by a cingulum.

PM. 1–3. The first premolar is a simple pointed tooth.

2 PM. is somewhat larger, and has a sharp pointed outer and a small inner cusp.

3 PM. is molariform in shape, with a small inner cusp and a large outer cusp. Behind the outer cusp is a small third cusp

The *molars* of *Tarsius* are peculiar in that the cusps have very sharp points and that the teeth themselves have a relatively large size. The third molar is relatively larger in *Tarsius* than in the other Lemurs.

The individual molars are all constructed on the same plan, and in the upper ones increase in size from before backwards. The protocone is triangular in section and is sharply pointed. The anterior buccal cusp, the paracone, is similar in form but not so large. The metacone is similar in form to the paracone. The cusps are joined by sharp ridges which are only slightly elevated in the middle. Between the paracone and the protocone a tiny protoconule is present. The teeth are much wider transversely than antero-posteriorly. The crown is completely surrounded by a cingulum which is best marked in front and behind.

The Teeth of the Lower Jaw.

The single incisor is slightly procumbent.

The canine is large and slightly recurved, its anterior surface meeting the large incisor of the upper jaw. Its point comes in contact with the second upper incisor.

The premolars are simple conical teeth, gradually increasing in size from the first to the third. They are triangular in section, with anterior, lateral, and medial borders.

The molars are relatively very large, the third being the largest. The trigonid is small but markedly elevated, and the talonid is low. The protoconid is very conspicuous. The metaconid is also very large, and in front of it is a somewhat smaller paraconid. The talonid is basin-shaped and surrounded on the buccal side by a well-marked hypoconid and on the lingual side by an entoconid. Between the two is a small hypoconulid. The hypoconulid is most prominent in the last molar. These molars are longer antero-posteriorly than from side to side.

VERTEBRAL COLUMN AND APPENDICULAR SKELETON.

The vertebral formula is as follows :—

Cervical	7	
Thoracic	13	
Lumbar	6	
Sacral	3	
Caudal.....	21–23	(3 coccygeal and 18+ caudal.)

This vertebral formula is in agreement with that for the Lemuroidea and for *Tupaia* and Marsupialia. It is the primitive number, and in this *Tarsius* exhibits a primitive mammalian character.

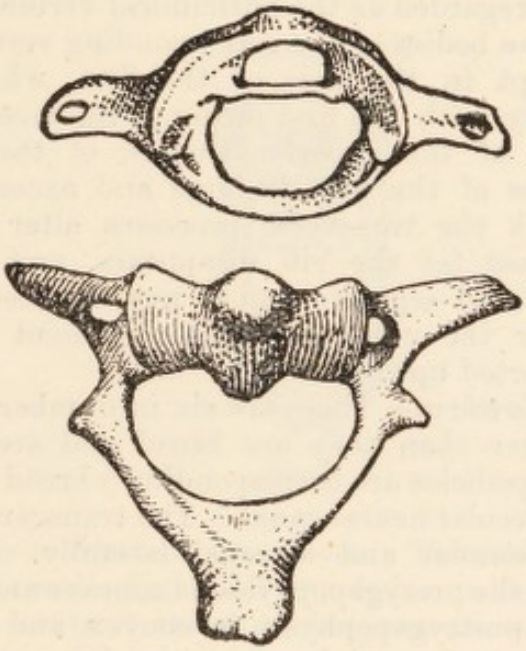
The Cervical Vertebræ.

The Atlas.—The articular surfaces for the occiput are directed medially, and the posterior margin bears a flange of bone whose

elevation converts the articular surface into a groove in which the occipital condyles run. The ventral arch articulating with the odontoid process is bounded dorsally by a bony transverse band, so that the odontoid is contained within a bony canal. The foramen for the vertebral artery on the posterior arch is completely bony, while the dorsal spinous process is reduced to a mere knob directed downwards from the lower border. The transverse processes are compressed from above downwards and bear a foramen for the vertebral artery.

The Axis.—The odontoid process is directed upwards from the body of the axis, and its articular surfaces for the atlas consist of a double facet on either side of the process. The spinous process is directed almost horizontally backwards. The extremity

Text-figure 8.



Atlas and Axis.

of the process is bifid. The transverse processes are directed backwards as well as laterally and are traversed by the vertebral artery. The intervertebral foramina between the axis and the third cervical are completed by the articular processes.

In the *typical cervical vertebræ* the body, which bears a median ridge, is thin and narrow from before backwards, but slightly elongated in the vertical direction. The anterior margin of the inferior surface of the body is produced into a downwardly directed process. At the junction of the body with the laminæ the transverse process is attached. The anterior or costal bar is large and flattened from before backwards. The transverse bar is by comparison extremely reduced, and directed backwards. The superior articular facet is a plane looking almost directly

upwards and only very slightly forwards. Similarly the inferior surface is plane and directed almost vertically downwards. The dorsal arch is thin and compressed and bears only a rudimentary spine.

The Thoracic Vertebræ.—The bodies are square and the median ridge present in the cervical region is only barely perceptible. The transverse processes are directed laterally. They are slender and their extremities bear three processes: an articular for the ribs which looks forwards and slightly upwards, one directed laterally for the ligament of the tubercle, and a third directed upwards for the superior costo-transverse ligament. The laminæ are broad, and with the spines form a deep dorsal groove. The spines are bayonet-shaped and end in blunt thickenings. They are directed downwards and backwards. The direction of the spines gradually changes in the lower members of the series, and the eleventh may be regarded as the anticlinical vertebra. The ribs articulate with the bodies of the corresponding vertebra and the one above, except in the case of the first, which seems to articulate entirely with the first owing to the facet being borne on an elevation of the superior surface of the body. The transverse process of the first is huge and exceeds all others. Beyond the sixth the transverse processes alter in character. The articular facet for the rib disappears, and the tubercle becomes enlarged and separate and is now directed downwards. The tubercle for the costo-transverse ligament also becomes separate and directed upwards.

The Lumbar Vertebræ.—These are six in number. The bodies are slightly longer than they are broad and are fairly large. The laminæ and pedicles are correspondingly broad and surround a large, almost circular neural canal. The transverse process, the diapophysis, is slender and directed laterally. The superior articular process, the prezygapophysis, is concave and looks mostly medially. The postzygapophysis is convex and looks mostly outwards. There are certainly no parapophyses on the lumbar vertebræ. The superior articular process bears a well-marked mamillary tubercle, the metapophysis. The lumbar vertebræ are as a whole exceedingly uniform.

The *Sacrum* is composed of three fused vertebræ, forming a compact mass about twice as long as it is broad. The transverse processes of the first two form the articular surface for the ilium, while the transverse process of the third, though not participating in the articular area, is fused above with the first and second. The line of the articular processes is indicated by the presence of metapophyses. These are widely separated from the articular mass for the ilium. The spinous processes are very slender and only narrowly separated from the metapophyses.

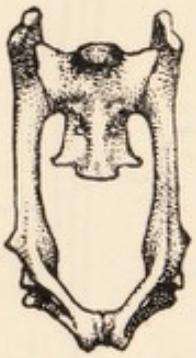
The *coccygeal vertebræ* have cylindrical bodies and transverse processes flattened dorsoventrally and directed laterally. Mamillary tubercles are present on the superior articular processes

and the spinous processes are slender. The neural canal ends in the third. At the junction of the first and second and the second and third caudals there is a well-developed hæmal arch. It is not present in our specimen in the case of the third. The arch is complete and articulates with the adjacent sides of the vertebræ. The two bars fuse together ventrally, and in the case of the second is produced into a little sharp spine.

The remaining tail vertebræ, eighteen in number, are characterised by the absence of the transverse processes, of the dorsal processes, and of the neural canal. The body of the first increases in length and the succeeding vertebræ become longer, thinner and more slender as far as the eighth. Thereafter there takes place a gradual diminution in size.

The vertebral column as a whole is widely arched in the dorso-lumbar region, the sacrum is straight, and there is a slight arch in the cervico-dorsal region concave backwards.

Text-figure 9.



Pelvis.

The *Sternum* consists of five pieces. The manubrium is long. Where it receives the first rib it broadens considerably. Between the clavicular facets it bears a triangular piece of bone with its apex pointing upwards, which represents the interclavicular. This is not fused with the manubrium.

The mesosternum consists of three segments, of which the third is imperfectly differentiated into two. The first segment is long and narrow, and at its junction with the manubrium articulates with the second rib and at its junction with the second piece articulates with the third rib. The second segment is shorter and broader, and at its junction with the neighbouring segments articulates with the third and fourth ribs. The third segment is imperfectly differentiated into two segments and articulates with the fourth and fifth and sixth ribs.

The seventh rib articulates with the xiphisternum, which is long, narrow and straight.

There are thirteen ribs. The first is very thick and articulates with the first thoracic vertebra and its extremely long transverse process. The first to the seventh articulate with the sternum.

The facets on the ribs for articulation with the transverse processes are flat and not elevated at all. The seventh rib is the longest, but is more slender than the preceding. Each rib is rounded on cross section. The eighth, ninth, and tenth are fused together. The eleventh, twelfth, and thirteenth are free.

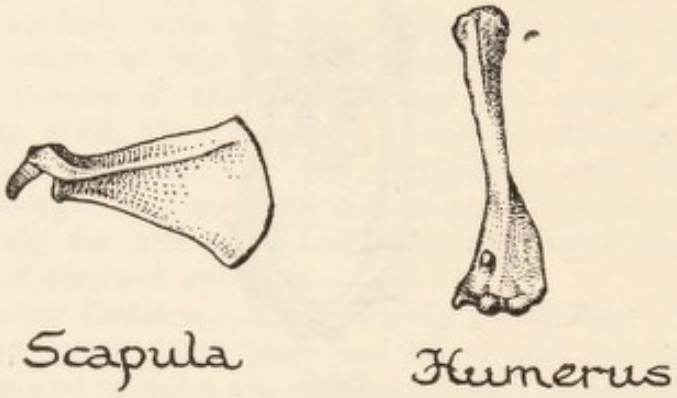
The shape of the thorax as a whole is oval; the transverse almost equals the sagittal diameter. The transverse width seems to be greatest near the front of the chest.

The Shoulder-Girdle and Upper Extremity.

The *Clavicle* is a slender rod-shaped bone, feebly S-shaped in outline. It is thickened at the sternal extremity, while its outer extremity is flattened and somewhat pressed back.

The *Scapula* is triangular in shape; the apex is at the glenoid and the base corresponds to the vertebral border. The spine

Text-figure 10.



Scapula, Humerus.

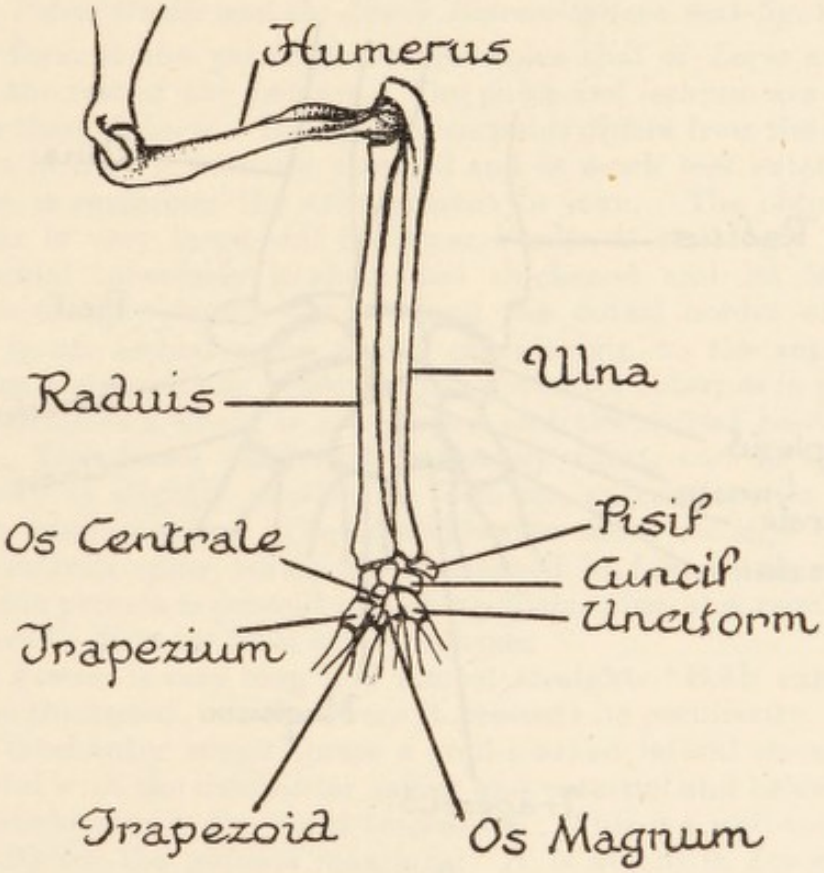
runs from the upper basal angle parallel with the upper border to the glenoid, over which it is prolonged as the acromion process. The processus coracoideus springs from the margin of the glenoid and is directed horizontally outwards and forwards.

The *Humerus* is a large bone and is exceeded in thickness only by the upper extremity of the femur. The head bears the spherical articular facet for the glenoid. It is directed medially and somewhat backwards. The articular surface becomes directly confluent with the tuberosities laterally, while medially it slopes more gradually into the shaft. The tuberosities are of about equal size, the medial one being globular in outline, the lateral one more sharply elevated and continuous with a ridge which forms the lateral border of the bicipital groove. To this ridge the pectoral muscle is attached, and distally the deltoid is inserted into it. In the middle of the bone the shaft is rounded. In the lower third the bone becomes transversely expanded, and its margins form the prominent medial and lateral

epicondylic ridges. The lateral one is sharp and forms a backwardly directed ridge somewhat concave in front. The medial ridge is thicker and more prominent in its distal part. Immediately above the inferior articular surface the medial ridge is pierced by the entepicondylar foramen which transmits the median nerve and the brachial artery. *Perodicticus* is the only Lemur in which this foramen is absent (Weber). The external condyle is the smaller, the medial the more prominent.

The inferior articular surface is trochlea-shaped, for the ulna. The inner margin is prominent, but the outer margin separating

Text-figures 11 *a*.



Bones of Upper Limb.

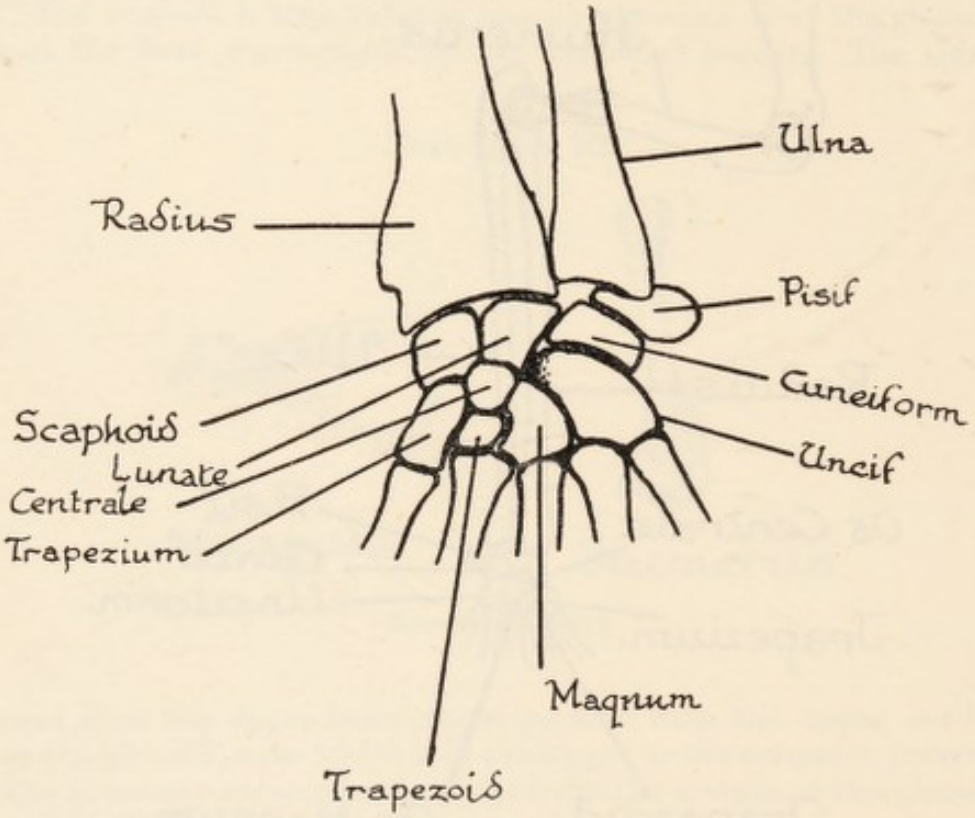
the ulnar surface from the radial is thin and ill-defined. The radial facet is globular and extends much further back than in man, and is almost as extensive on the dorsal surface as that for the ulna. There is no fossa on the ventral surface for the ulna, but the radial fossa is well marked. The dorsal fossa for the olecranon is extremely large.

The *forearm bones* are together about one-fourth as long again as the humerus. The ulna is most developed in its upper extremity, the radius at its lower extremity. The ulna has a well-marked olecranon, and in front of this a semilunar articular

surface for articulation with the trochlea of the humerus. Somewhat in front and on the lateral side is the extremely small articular facet for the radius. The bone as a whole is bowed medially and forwards. On section it is rounded. The lower extremity is small and rounded. Internally it bears a prominent styloid process. The lower extremity bears on its lateral surface a small facet for articulation with the lower extremity of the radius.

The *Radius* lies slightly in front of the ulna. Compared with the ulna it is somewhat thinner and more curved. Its upper extremity is spherical and excavated for articulation with the

Text-figure 11 *b*.



Carpus.

radial facet of the humerus. On its inner side continuous with the facet for the humerus is the facet for articulation with the ulna. The lower extremity is cube-shaped, roughened at each angle. On the outer side it is prolonged into a styloid process. The fact that the radius is more feeble than the ulna is in harmony with the feeble thumb, and suggests that abduction and adduction of the thumb is relatively limited.

The *carpal bones* number nine, and have the same relations as in man but not the same proportional sizes. The scaphoid is smaller relatively than the corresponding human bone but is of much the same shape.

The *os centrale* articulates with the scaphoid, the lunate, the trapezium, the trapezoid, and the os magnum. It has been said that there are two ossa centrales (Wood Jones). This we are unable to agree with, and have found one only both in dissection and in X-Ray photographs.

The pisiform is shaped like a dumb-bell. The constriction is embraced by the capsule of the wrist-joint, and the outer mass receives the tendon of the flexor carpi ulnaris. The inner mass is flattened and insinuated between the ulna and cuneiform, articulating with both.

The first phalanx of the third digit is the largest of these bones in the hand or foot.

The Pelvic Girdle and the Lower Extremity (see text-fig. 9).

The form of the pelvic girdle resembles that of *Loris* and is unlike the rest of the Lemurs. The pubis and ischium are more slender than in *Loris*. The symphysis pubis differs from the other Lemurs in that it is more elevated and is much less extensive. In this it resembles the arrangement in man. The obturator foramen is very large and its lower border is strikingly thin. The ischial tuberosity is short and thickened and its lateral angle is sharply drawn out. Along the dorsal border of the pelvis is an ischial spine which gives origin to the superior gemellus and holds the tendon of the obturator internus in place.

The *Ilium* as a whole is rod-shaped and the caudal border is sharp. The dorsal border is extremely short, and at either extremity is slightly swollen to form an antero-superior and postero-superior spine. The cranial border shows no sign of an antero-inferior spine, which is well-marked in *Lemur* and *Loris*. The pubic process is present as a sharp little spine at a relatively considerable distance from the symphysis.

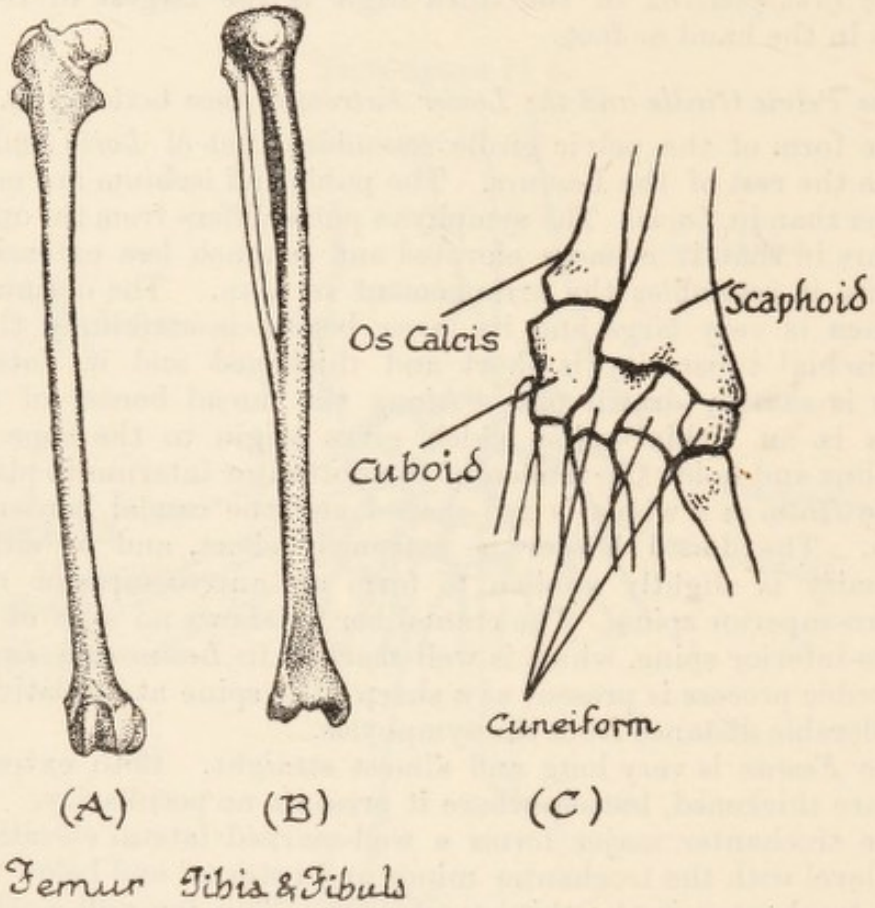
The *Femur* is very long and almost straight. Both extremities are thickened, but elsewhere it presents no peculiarity.

The trochanter major forms a well-marked lateral elevation. On a level with the trochanter minor and external and below the great trochanter is the third trochanter. This is a well-marked tuberosity for the gluteus maximus. It is absent in *Loris*, but is present though less prominent in *Lemur*. A ligamentum teres is present, and the head presents a well-marked fovea for its attachment. The lower extremity presents a deeply grooved pulley-like surface in its trochlear portion. The condylar portion shows a medial condyle which resembles that of man in that it first passes medially and then backwards.

The *Patella* occurs in two portions, one proximal and one distal. The proximal patella is much the smaller and rides in the deep furrow of the articular surface. The distal patella resembles that of man and presents a medial perpendicular facet for articulation with the medial condyle. In the joint the semilunar cartilages are very thick, and the anterior and posterior cruciate ligaments have the same attachments as in man.

The *Fibula* fuses with the tibia about the middle of its length, and in this *Tarsius* is unlike all the other Lemurs. The femur and tibia are about the same length. The upper half of the shaft of the tibia is triangular. The upper extremity bearing the tuberosities and articular surfaces is directed backwards, forming with the shaft an angle of about 45°. The anterior border is short but definitely marked; the posterior very sharp; the antero-medial rounded. The fibula commences as a small

Text-figure 12.



(A) Femur. (B) Tibia and Fibula. (C) Tarsal articulations.

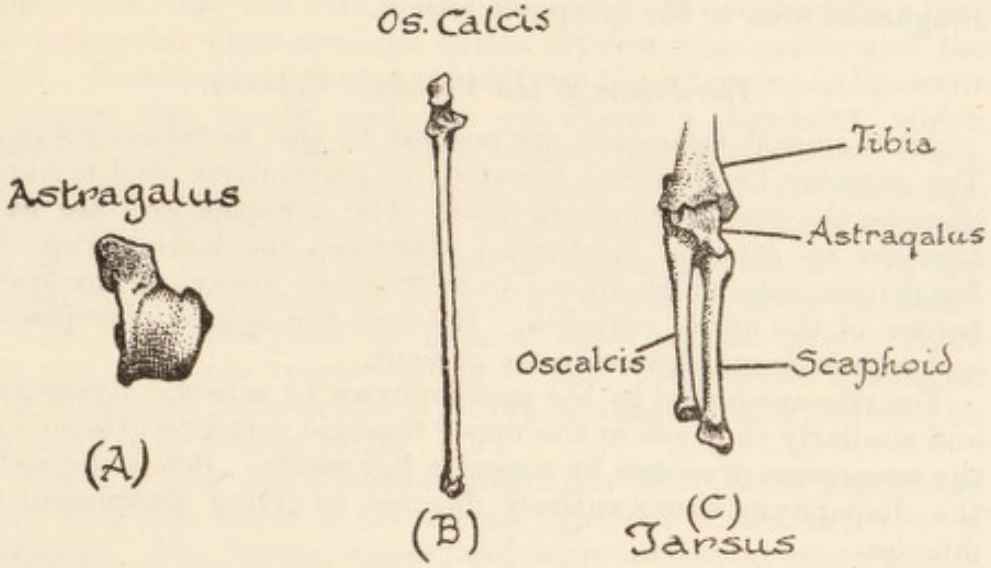
rounded head postero-external to the condyle and is joined here with the tibia over a considerable area. It descends as a slender bone gradually approaching the tibia, with which it fuses about its middle, but as a ridge can be traced still farther. At the ankle-joint it is again raised up from the surface and forms the outer malleollus of the ankle-joint.

Foot.—The peculiar construction of the foot has given to this beast its name. The foot is the longest segment of the lower limb, exceeding both the leg and the thigh. This great extension is due to the os calcis and to the scaphoid, and these in length and shape are the most individual of the bones of *Tarsius*. The number of tarsal bones is normal (7).

Astragalus has few peculiarities. The dorsal surface is trochlea-shaped and prolonged farther back at the posterior external corner (tubercle). The lateral facets for tibial and fibular malleoli are crescentic, but the fibular is nearly oval and extends farther downwards, but is smaller than the tibial. The under surface has posteriorly a post-lateral concave facet for the os calcis, and in front of this a flattened oval facet for the os calcis and sustentaculum tali. The neck is directed horizontally forwards and inwards to articulate with the scaphoid. The facet is oval and very feebly concave.

The *os calcis* is 3 cm. long. The posterior surface is deeply excavated for the tendo Achillis. The dorsal surface bears on its surface articular facets for the astragalus. Beyond this the bone, of a tubular shape, extends to its extremity where it articulates with the cuboid.

Text-figure 13.



(A) Astragalus. (B) Os calcis. (C) Tarsus.

The *Scaphoid*, 22 mm. long, articulates with the astragalus and extends forwards as thin bone which expands into an articular surface for the three cuneiforms. The medial cuneiform is the largest and bears the first metatarsal. The second is the smallest and carries the second metatarsal, and the third is intermediate in size. The middle cuneiform has its narrow border to the plantar surface. The *Cuboid* articulates with the anterior extremity of the os calcis and bears the 4 and 5 metatarsals, and has on its lateral border a large process.

The *first metatarsal* (Hallux) is broader and thicker and longer than the other four. The metatarsals are so arranged that they form an arch from side to side and are concave plantarwards.

Of the proximal phalanges the fourth is the longest, then the third, then the first, then the fifth and the second.

The terminal phalanges of the second and third toes are shorter and thicker than the others, and bear on the extremities little spurs of bone which support the claws of these two.

Syndesmology.

The Temporo-mandibular joint.—The articular surface on the mandible has a smooth facet for articulation facing anteriorly, and behind this a roughened area for ligamentous attachment. The glenoid facet faces backwards and downwards. The condyle of the lower jaw is implanted on the ramus without the intervention of any neck. The coronoid rises slightly above the condyle. In the joint there is a circular meniscus deeply excavated for the condyle of the lower jaw. The disc is very thin in the centre and its upper surface is plane. The capsule of the joint is adherent to the meniscus in front, and here receives fibres of the external pterygoid. Behind there is an accessory ligament to the joint in the form of a fibrous band passing from the roughened area to the tympanic region.

The Joints of the Vertebral Column.

All the usual ligaments are present in the vertebral column. The anterior longitudinal ligament is particularly well marked, likewise the posterior longitudinal. The zygapophyses are held together by capsular ligaments. Between the laminæ run the flaval ligaments which appear to be attached always to the lower border of the upper vertebra. Between the spines interspinous and supraspinous ligaments are present.

The ribs are bound to the parapophyses by capsular ligaments, and similarly they are in the upper thoracic vertebræ attached to the transverse processes by capsular ligaments. Below the sixth the diapophysis seems entirely devoted to giving attachment to muscles.

The first rib seems to be fused with the sternum; the succeeding ones articulate by means of diarthrodial joints.

The *Sterno-clavicular joint* is firmly embraced by a capsular ligament which is fastened to the clavicle and sternum but not to the first rib. The joint contains an intra-articular meniscus which is attached at its circumference to the capsule. It does not come into contact with the first rib. The accessory costo-clavicular ligament takes the form of a strong ligament running from the first rib to the capsule, where it is attached not only to the capsule but also to the intra-articular meniscus. Furthermore, this ligament is in direct continuity with the fascia covering the infra-hyoid muscles.

The *Acromio-clavicular joint* has both a capsule and an intra-articular disc which seems to be complete. The accessory ligament binding the clavicle to the coracoid is not separable into a trapezoid and conoid, but is a large single quadrilateral sheet of fibrous tissue between the two bones.

There is no supra-scapular ligament on the scapula.

The *Shoulder-joint* is embraced by a capsule which has no lax inferior surface. No accessory ligaments like the coraco-humeral and acromio-clavicular can be distinguished. The long head of the biceps is completely intracapsular. The tendons of the muscle do not fuse with the joint capsule as they do in man.

In the *Elbow-joint* the capsular investment is uniform and complete, and the capsule cannot be differentiated into anterior, posterior, and collateral ligaments by any change in the thickness or form of its fibres. It is noteworthy that the so-called orbicular portion of the ligament is tightly bound down to the radius, and that by manipulation of the bones practically no rotation of the radius can be effected. The interosseous membrane is very thin and delicate and is complete between the two bones, there being no gap above and no oblique ligament.

The *Wrist-joint* is invested by powerful ligaments forming dorsal and volar and collateral ligaments. It is noteworthy that no triangular fibro-cartilage exists between the radius and the ulna. Furthermore, there extends from the interosseous ligament between the lunate and the cuneiform a ligament which attaches itself to the inferior radio-ulna joint above. The intercarpal and carpo-metacarpal joints call for no comment. The metacarpal phalangeal and interphalangeal joints are formed as usual by volar and collateral ligaments and dorsally by the dorsal extensor expansions of the long digital extensor tendons.

The *Sacro-iliac joint* is invested by a capsule only. There are no ligaments corresponding to the interosseous ligaments. The *symphysis pubis* contains a fibro-cartilage, and is fastened on all borders by fibrous bands.

The *Hip-joint* has a labrum glenoidale around the acetabular rim, and this forms a transverse ligament where the rim is deficient. The femur, whose head is set almost at right angles with the shaft of the bone without the interposition of a neck, is tightly embraced by a capsular ligament. The ligamentum teres is present, and the head of the femur bears a fovea into which it is inserted.

The Knee-joint.—The supra- and infra-patellar tendons form the anterior investment of the knee-joint. By aponeuroses on each side they are united to the tibial and fibular collateral ligaments. In the interior of the joint the cruciate ligaments have the same attachments as in man. The anterior cruciate arises far forwards on the non-articular area of the tibia, and is inserted far back on the medial side of the lateral condyle of the femur. The posterior cruciate ligament arises far back, really on the posterior surface of the tibia, and ascends far forwards on to the lateral surface of the medial condyle of the femur. The semilunar cartilages are both present. The horns of the medial meniscus are far apart and embrace the horns of the lateral meniscus.

The *fibula* articulates above with the tibia, and takes no part in the formation of the knee-joint. It is surrounded by a complete capsular investment. An interosseous membrane is complete as far as the middle of the leg, where the fibula fuses with the tibia.

At the *ankle-joint* the fibula reappears and takes part in the formation of the joint. The malleolus that it forms is not so large as the medial malleolus of the tibia. The joint is completely invested by a capsule and runs from the margin of the tibia and fibula to the astragalus below, where it is attached all round the articular surface and not forwards on the neck as in man. The remaining ligaments of the foot call for no particular comment except that a prominent ligament runs from the os calcis to the cuboid. This ligament by reason of its elevation above the surrounding structure is conspicuous and corresponds to the plantar ligaments of human anatomy.

The Nervous System.

The Brain.

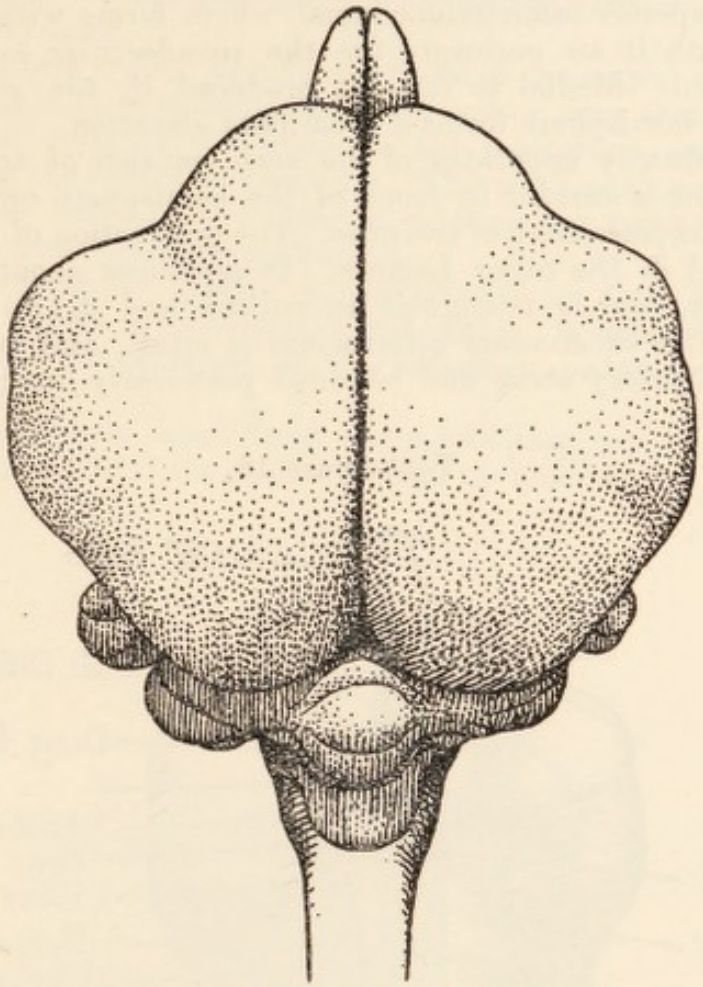
The length of the brain from frontal to occipital pole is 16 mm. and its width in the widest part is between 9 and 10 mm. Seen from above it is almost square when the hemispheres are in apposition. The cerebral hemispheres are so shaped that they resemble a cap compressed dorso-ventrally over the widely expanded midbrain. The medial and lateral surfaces are reduced to narrow limits, and the occipital and hippocampal areas are so displaced that they are situated on the ventral aspect more than on the mesial surface.

The dorso-lateral surface is gently convex. Its medial border is straight, while the lateral border is in its posterior two-thirds inclined outwards until it reaches the temporal pole. In the anterior third it turns inwards at a right angle and forms the anterior border of the temporal pole. Then it runs straight forwards as the lateral margin of the frontal pole. The frontal pole converges sharply to an apex. The occipital pole is much blunter. The entire dorso-lateral surface is quite smooth and presents no fissures whatever.

Below the corpus callosum, the mesial surface of the brain falls ventrally as well as mesially. It comprises posteriorly the occipital area with the calcarine fissure. In front of this by way of the retro splenial area this surface passes into the deep depression of the hippocampus. This is separated from the adjacent pallium by a hippocampal fissure. The brain above and in front of the corpus callosum is straight and without any fissuration at all.

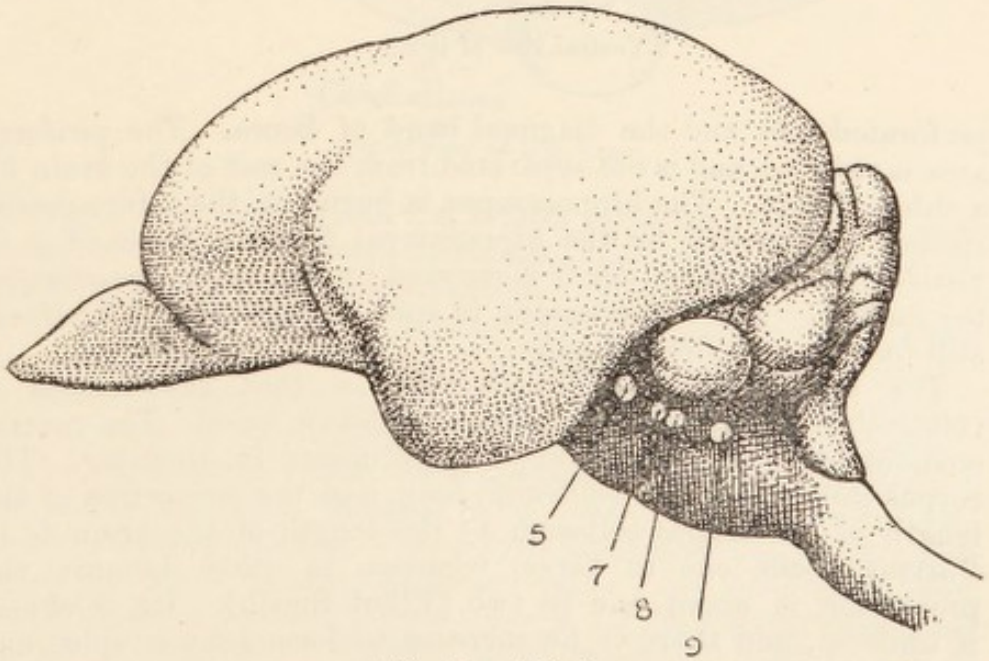
The frontal portion of the ventral surface is deeply excavated by the orbits. The posterior wall of the excavation is formed by the temporal poles. Between the temporal and the frontal poles is a short and not very conspicuous Sylvian fissure. On the

Text-figure 14.



Dorsal view of Brain.

Text-figure 15.

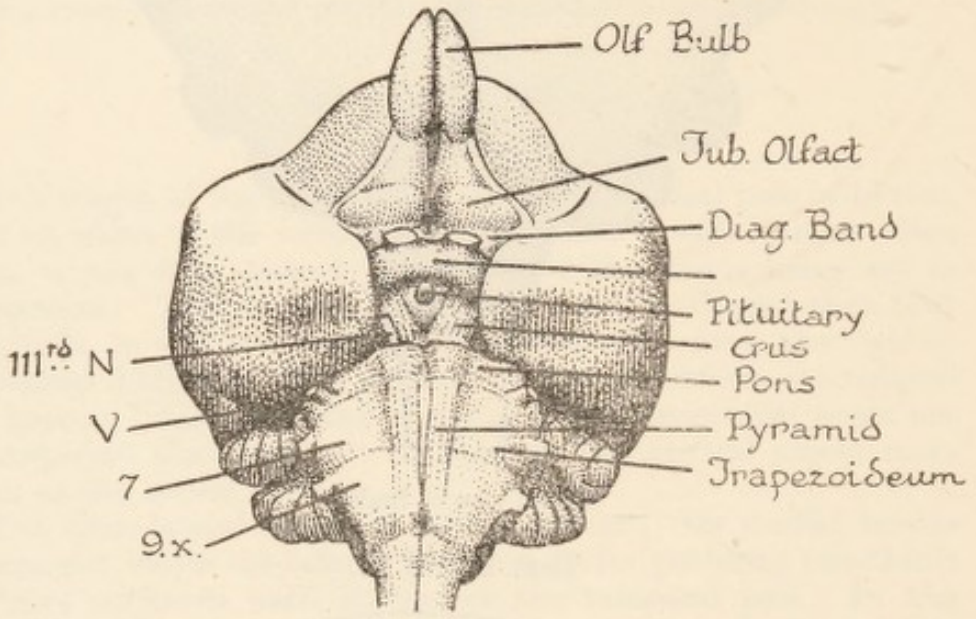


Side view of Brain.

ventral surface the area behind the temporal is deeply indented by the superior semicircular canal, which forms with the bony pit beneath it an enclosure for the parafloccular lobe of the cerebellum. Medial to this pit produced by the semicircular canal the hemisphere forms a prominent elevation.

The olfactory apparatus of the brain consists of an olfactory bulb, which is carried in front of the hemisphere owing to the anterior displacement of the nose. The protraction of the bulb is not found in the other Lemurs. It measures about 3·5 mm. in extent, and is triangular in outline and drawn out to a point. The tuberculum olfactorium is small, and is embraced by the olfactory striæ and bounded posteriorly by the anterior

Text-figure 16.



Ventral view of Brain.

perforated spot and the diagonal band of Broca. The piriform area is reduced, and is not separated from the rest of the brain by a rhinal fissure. The hippocampus is buried in the infero-mesial surface and limited by the hippocampal fissure. None of it is visible on the surface, for it is covered by the fascia dentata and the fimbria. The hippocampus in spite of the reduced piriform still forms a considerable mass.

The commissures are noteworthy in that the ventral is relatively very large and the corpus callosum small. The ventral commissure is circular, and one millimetre in diameter. The corpus callosum is about 5·5 mm. long, and the proportion of the length of the corpus callosum to the length of the brain is in *Tarsius* about one to three, whereas in other Lemurs the proportion is about one to two (Elliot Smith). Its thickness is uniform, and there is no increase to form genu or splenium.

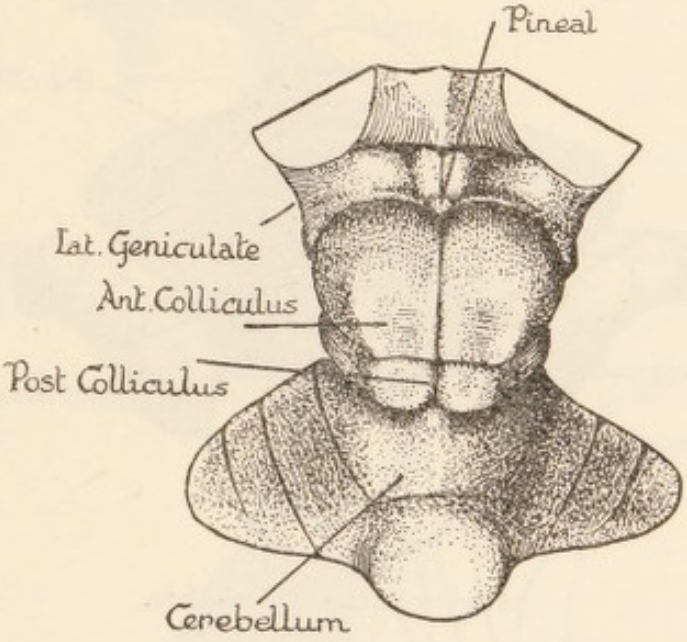
The general direction is backwards and upwards with a slight dorsal convexity.

The fimbria, owing to this shortness of the corpus callosum, is in contact with this commissure for only a very short distance. The great bulk of the fibres of the psalterium are collected just above the ventral commissure. There is a septum pellucidum freely open below in the interval between the front end of the corpus callosum and the psalterium.

The ventricular system is remarkable in that the lateral ventricle forms a posterior horn, which is unique amongst Lemurs. The ventricle of the olfactory peduncle has been obliterated.

The brain-stem apart from the cerebellum is remarkable for the immense size of the thalamus, and particularly for the size of

Text-figure 17.



Dorsal view of Mid-Brain.

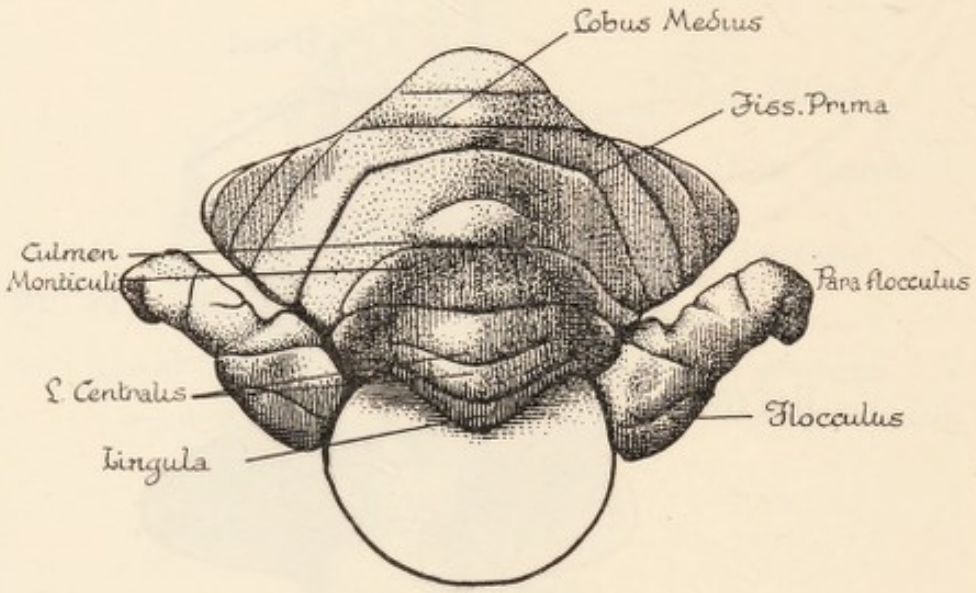
the superior colliculus and the lateral geniculate body. Though vision has been so much increased, yet the posterior and the medial geniculate are of normal size.

As a separate work, we have made a map of the cerebral hemisphere based on differences in histological detail. The map shows the enormous increase in the extent of the visual area and the increase of the width of the cortex immediately adjacent to the visual area. The visual cortex can easily be defined by the naked eye, and occupies nearly one-third of the cerebral cortex. Microscopically it presents a succession of granular cell-layers separated by paler acellular zones. The stria of Gennari is very conspicuous and is really double. The associational areas are not so extensive relatively as in the other Lemurs, nor do they show the same degree of histological differentiation.

The exits of the cranial nerves from the brain-stem call for no comment. An examination of the Weigert series of sections of the brain-stem, show that the auditory and vestibular mechanisms are well developed, particularly the vestibular apparatus. The inferior olivary nucleus is small and exhibits no increase on that found in the brain-stem of any common mammal.

The cerebellum shows with diagrammatic clearness the fundamental subdivision into three lobes. The fissura prima appears as a large conspicuous horseshoe-shaped furrow on the anterior surface just below the highest point of the cerebellum. When seen in mesial section, this furrow extends through and almost reaches the roof of the fourth ventricle. In front of it there lie the three subdivisions of the anterior lobe. The

Text-figure 18.

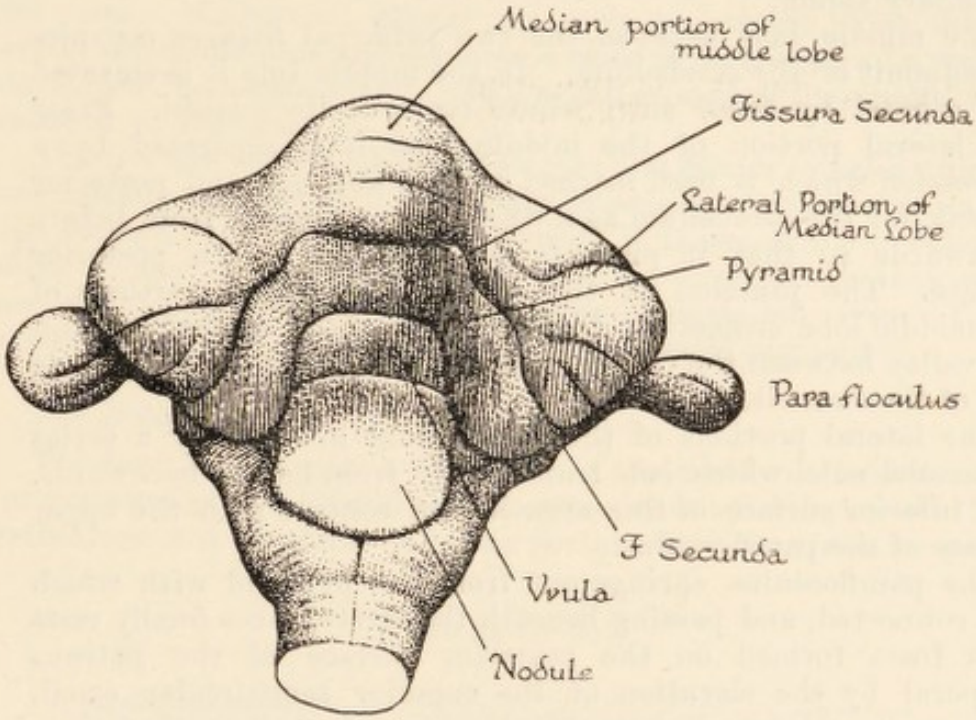


Anterior surface of Cerebellum.

lingula lies on the superior medullary velum, and is not visible from the surface except for a small portion of its extent. The central lobule is small. This is succeeded by the culmen monticuli, which is much larger and bears on its surface an incomplete sulcus.

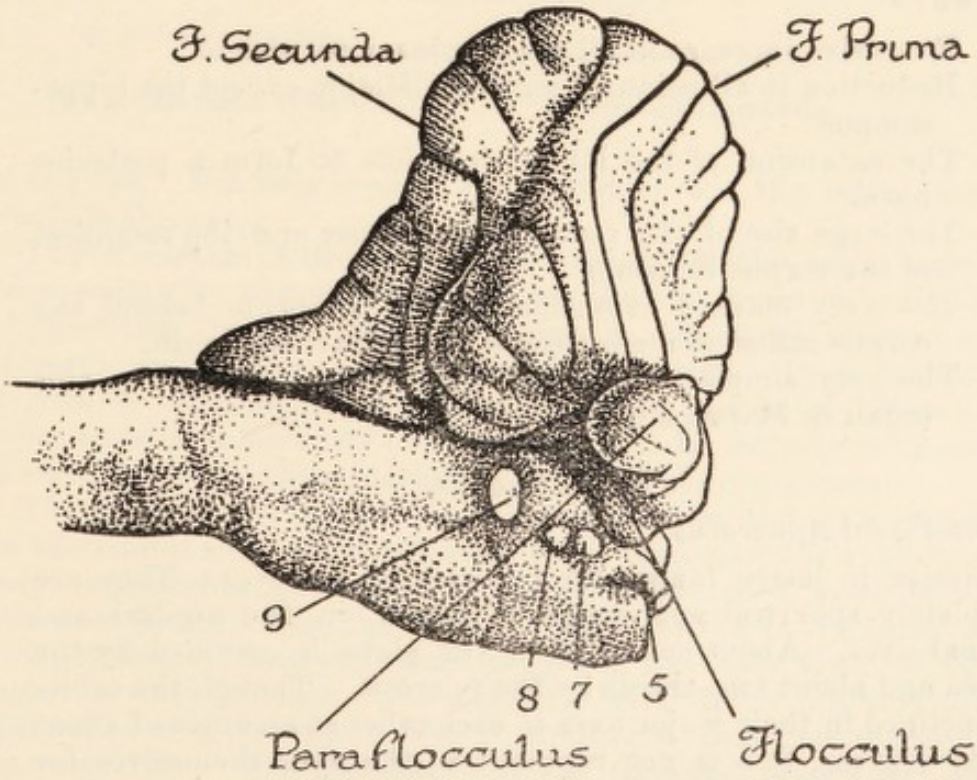
The fissura secunda or sulcus prepyramidalis lies on the sloping posterior surface of the cerebellum just in front of the pyramid. It does not penetrate the white matter so deeply as does the succeeding fissure. It separates the middle lobe from the posterior lobe behind. The posterior lobe is subdivided into three lobules. The pyramid immediately succeeds the middle lobe and in section is distinctly pyramidal in shape, laterally it is continued into the paraflocculus. The uvula follows the pyramid, and it extends on to the dorsum of the medulla by a tongue-like

Text-figure 19.



Posterior surface of Cerebellum.

Text-figure 20.



Side view of Cerebellum and Brain-stem.

projection and completely hides the nodule. The lobulus nodulus is hidden completely from view and lies on the inferior medullary velum.

The middle lobe between the two principal fissures occupies the summit of the cerebellum. In the middle line it is elevated and crossed by three sulci which cease at its margin. From the lateral portion of the middle lobe it is separated by a depression which is best marked on the anterior and posterior aspects, for the cerebellum as a whole is compressed from before backwards so that it presents an anterior and a posterior surface. The junction of the middle and lateral portions of the middle lobe crosses the highest point of the cerebellum, and the valley between the two parts is elevated along the transverse line of the summit.

The lateral portions of the middle lobe are cut by a series of parallel sulci which run transversely from before backwards. The inferior surface of this area lies in contact with the upper surface of the paraflocculus.

The paraflocculus springs out from the pyramid with which it is connected, and passing beneath the lateral lobes finally rests in a fossa formed on the posterior surface of the petrous temporal by the elevation of the superior semicircular canal. Close to its origin on the ventral aspect of its base there is a minute flocculus which overlies the medulla.

In the brain as a whole it is to be noted that the cerebrum overlaps the cerebellum except in the caudal portion.

This extremely interesting brain may be summarised as follows :—

1. Extensive increase in all parts subserving vision.
2. Reduction in all parts subserving olfaction except the hippocampus.
3. The extension of the lateral ventricle to form a posterior horn.
4. The large size of the ventral commissure and the smallness of the corpus callosum.
5. The very marked extension of the cerebrum behind the corpus callosum almost equal to one-half the brain.
6. The very simple cerebellum which closely resembles this organ in Marsupials.

Sense Organs.

The Visual Apparatus.

Tarsius is justly famed for the size of his eyes. They are completely spherical and measure 16 mm. in the sagittal and coronal axes. About one-third of the globe is occupied by the cornea and about two-thirds by the sclerotic. Though the orbits are inclined in their major axes to each other at an angle of about ninety degrees, this is not repeated in the eyes themselves for they face almost directly forwards in the same plane.

The eyelids are constructed on the usual plan except that the fibrous tissue of the tarsal-plate seems thinner than ought to be the case. Meibomian glands are very numerous. The third eyelid is considerable and contains a plate of cartilage and a well-developed Harderian gland. This organ is said to be absent or reduced in Primates.

The iris has well-developed sphincter and dilator muscles which are heavily pigmented. The ciliary muscle has been torn away, but seems to have been well developed; it is impossible to determine if any of its outer fibres reach the sclerotic, as they are asserted to do by Waldeyer in some mammalian eyes. The sclerotic is thick and the choroid is very heavily pigmented.

The Retina.

The front portion of the retina shows the usual subdivision into an ora serrata, and behind this an area where the layers of the retina are not so thick as in the portion near the posterior pole

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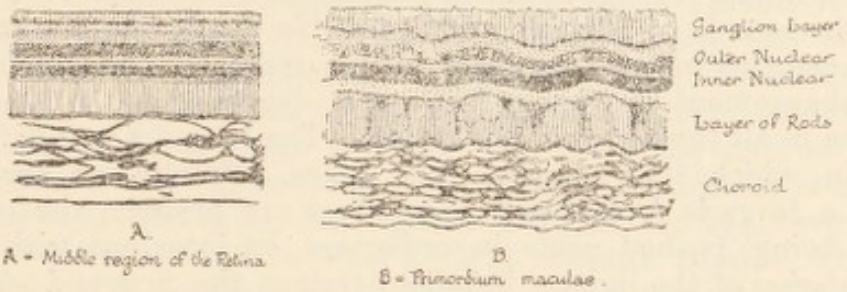


(A) Middle region of Retina. (B) Primordium maculæ.

of the eye. Not only is each layer thinner but the retina as a whole is thinner.

The characters of this more anterior part of the retina agree very well with the structure of the retina found in animals of nocturnal habits. This is shown in the large amount of pigment and in the outer layer of the retina. It is perhaps impossible to exclude the presence of cones, but nevertheless no cones have been seen and the layer seems to be entirely composed of rods. The remaining layers have the usual arrangements.

The posterior portion of the retina is thicker, and in a region on the lateral side of the entrance of the optic nerve it exhibits a very remarkable formation. In addition to each layer being increased in thickness, the layer of rods is thrown into a series of convolutions. These convolutions give to the outer layer of the retina a wavy outline. The pigment layer covers not only the surface of the elevations but is continued into the intervals between them. The pigment cells are six-sided prisms for the most part, and carry the pigment in the outer wall of the cells

and in their processes. No fat granules are to be seen, though present in many animals.

The width of the individual convolutions varies from 0·7 mm. to 0·3 mm. They seem to be composed entirely of rods. The most careful examination was unsuccessful in finding any cones in these folds. The membrana limitans externa and the outer nuclear layer form finger-like projections in the elevated part of the folds. The outer nuclear layer is much increased in thickness. The average number of cells composing it in the more anterior part of the retina is about six to eight, whereas in this part they number about twelve to fifteen. The reticular zone and the inner nuclear layer are correspondingly increased in thickness. Furthermore, the layer of ganglion cells shows a very marked change. In the ordinary parts of the retina the ganglion-cells form a flat sheet not very conspicuous. In this differentiated area of the retina the ganglion-cells form a very striking prominent layer. The ganglion cells stand up boldly, and appear to be crowded against each other and compressed so that they become elongated and arranged vertically to the surface.

This differentiated area lies on the lateral side of the entrance of the optic nerve, that is in the position of a macula, and represents the macula of *Tarsius*. It is possible to arrange in a series the transformations taking place in this region of the retina for the enhancement of vision. The first degree shows a gradual increase in all the layers of the retina. The second a well-defined area in which this increase takes place. Finally, an area in which a fovea is formed and only cones are present, the other layers being pushed aside in order not to interfere with the transmission of the light. *Tarsius* overlaps the first and second in having a well-defined area in which the layers have increased. The cones, however, are absent and a fovea is not formed.

This differentiated area is situated on the lateral side of the entrance of the optic nerve and is almost circular in outline; it measures about 2 mm. transversely and about 2·2 mm. in vertical extent.

The vascularisation, as in all Primates, is of the holangistic pattern, that is to say, the branches of the central artery are distributed freely in all directions over the retina.

There is no pecten (remnant of the hyaloid artery). The differentiated area of *Tarsius* differs from a macula in that within the area two vessels cross and supply the area.

The oral portion of retina measures about 130 μ in thickness.
The posterior portion ,, ,, ,, 220 μ ,,
The differentiated area ,, ,, ,, 350 μ ,,

Kolmer in 1911 discovered in the Megacheiroptera the most remarkable retina in the Mammalia. The retina acquires a very remarkable form owing to folds in the choroid which convolute the pigment layer and the rods and cones. The arrangement in *Tarsius* presents some similarities, but also differs in that the projections of the pigment layer are not vascularised; moreover,

the outer nuclear appears to break through the external limiting membrane and nuclei are found outside it; and finally in the arrangement of the ganglion cells. This arrangement seems to destroy the principle that the percipient elements are arranged in mosaic of mathematical regularity for the formation of images. In *Tarsius* the differentiated area obviously increases the number of stimuli that can be received in this small area, and further, by the greater number of ganglion cells a more precise conduction of the impulses so received is set up.

The Optic Nerve.

The fibres forming the innermost sheet of the retina are entirely nonmedullated and do not receive their medullary sheath until they leave the lamina cribrosa. The lamina cribrosa is entirely unpigmented.

The entrance of the optic nerve is situated almost exactly in the middle of the posterior pole of the globe of the eye. It is only very slightly to the nasal side of the posterior pole. The blind spot in man and the apes is usually on the naso-ventral side of the posterior pole. The papilla formed at the entrance of the nerve is a slightly depressed cup in man, but in *Tarsius* it forms a slight elevation which is perfectly pale without any trace of pigmentation. The lamina cribrosa is rather broad and the central artery is right in the middle of the nerve-fibres. No crossing of fibres takes place as they leave the cribrosa to be distributed over the retina, *i. e.*, there is no intraocular chiasma.

The optic nerve on leaving the globe of the eye turns very sharply inwards and runs for a short distance parallel with the globe of the eye until it enters the optic foramen. Thereafter the two nerves run parallel with each other as they approach the chiasma. The nerve in transverse section is slightly oval, and thus resembles most other mammals in which the nerve is never perfectly circular on transverse section. The diameter of the nerve is about 1·4 mm. The nerve is penetrated by connective tissue which forms septa which outline bundles of nerve-fibres of varying size. In Man they are said to number 1200 and in the Orang about 300, and to diminish progressively in number in the lower members of the animal scale. In *Tarsius* the septa are outlined by fine connective tissue which bears no pigment, and they approximately number about 400 bundles.

The nerve is covered by a prolongation of the dura arachnoid and pia. The arteria centralis retinæ enters the optic nerve in the middle line on its ventral surface, and of course carries in with it a process of pia mater. The dura appears to be homogeneous and composed of a single layer. The dura ends by becoming continuous with the sclerotic, but the termination of the pia and arachnoid cannot be made out but probably they become continuous with each other.

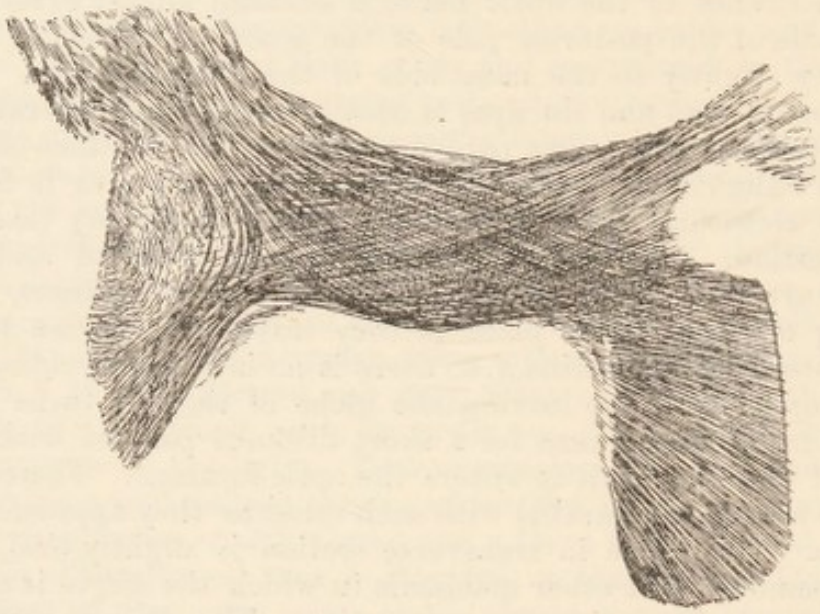
In the chiasma the complete or partial decussation of the optic nerves depends on the degree to which the visual fields overlap.

Since they overlap in *Tarsius* to a very great degree, it is interesting to note, however, that the decussation is almost complete. In the picture which is given these are shown, but in examination of a series of Weigert sections of the chiasma it is only in the section illustrated that uncrossed fibres were made out with certainty. We have not made any detailed study of the midbrain centres, but the late Professor J. I. Hunter demonstrated the presence of a nucleus of Perlia in the Oculomotorius.

Eye Muscles.

The outline drawing of the eyes indicates the relative positions of the insertions of the eye muscles.

Text-figure 22.



Optic chiasma to show few uncrossed fibres.

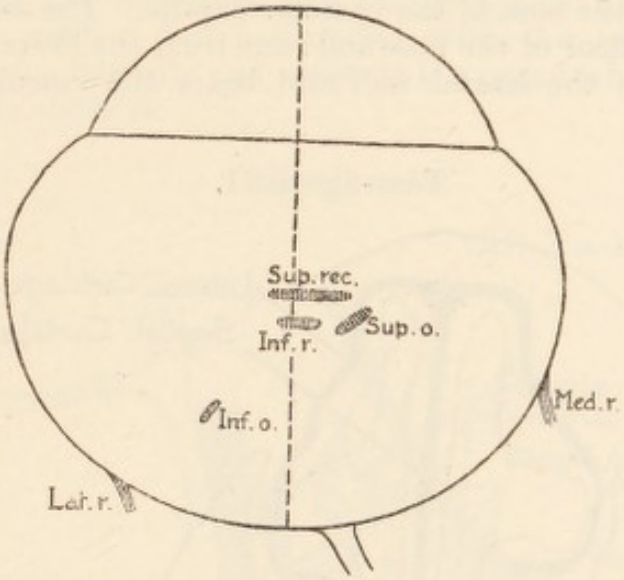
The muscles present are the same as those in man. The levator palpebræ broadens in front to fuse with the orbicularis palpebrarum.

The *superior oblique* arises from the margin of the optic foramen, and becoming tendinous passes through the trochlea pulley, which is cartilaginous, and is inserted immediately behind and under cover of the superior rectus. The *inferior oblique* arises from the upper jaw near the lachrymal canal and passes laterally to get inserted into the eyeball close to the lateral rectus. The four *Recti* muscles are disposed as indicated in the sketch, they arise from the margin of the optic foramen. They are all inserted far back in the ball of the eye, and so their ability to move the eyeball through a wide amplitude is limited. This is additional corroboration of the fact which is a matter of observation, that *Tarsius* moves his head rather than his eyes.

Organ of Smell.

The bony and cartilaginous structure of the nose has already been described along with the description of the skull. It is proposed to add under this heading some further notes on the cartilages along with a description of the organ of Jacobson and the olfactory and respiratory epithelium.

Text-figure 23.



Insertion of Eye Muscles.

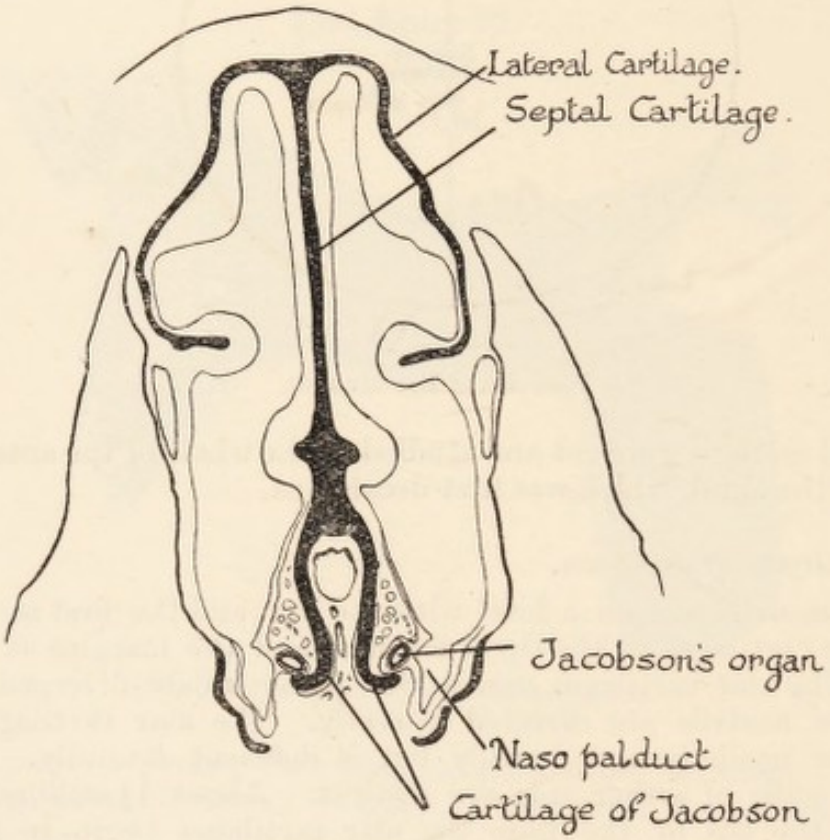
Serial sections were cut and studied of the whole of the anterior part of the skull, which was first decalcified.

The Organ of Jacobson.

The nostrils are on a level with the lips, and the first section cuts the cartilages at the tip of the nose and the margins of the lips. The alar cartilages are at this point widely divergent so that the nostrils are directed laterally. The alar cartilage is complete medially and dorsally but is deficient laterally. The medial walls of either side are distinct. About $1\frac{1}{2}$ millimetres behind the tip of the nose the alar cartilages begin to fuse together. The fusion begins dorsally and remains incomplete below. The inturned lateral margin of the alar cartilage bears on its extremity a vascular papilla that becomes continuous with the inferior concha. The divergent lower limbs of the septal portion show a slight cartilaginous projection covered by a small vascular elevation on the medial wall of the nasal cavity. In Broom's figures of *Tupaia* he shows an anterior recurrent cartilage separate from the septal and dorsal portion of the alar cartilage. Furthermore, the lachrymal duct is shown on the lateral side of the anterior recurrent cartilage. In *Tarsius* the lachrymal duct opens farther back immediately below the anterior extremity of the bony part of the inferior turbinate.

At the level of the premaxilla the septal portion of the alar cartilages have fused and are continued from the base laterally to become continuous with the other portions of the alar cartilage. The alar cartilage is now complete and is thickened in the lower half of the septal portion. It presents vascular papillæ on the medial and lateral walls. After preserving absolute continuity for a distance the nasal cartilage shows separation into two portions. The medial portion forms the septum roof and lateral wall as far as the base of the vascular papilla. The second cartilage is in the floor of the nose and runs from the lower margin of the septum to the lateral wall and bears the vascular papilla.

Text-figure 24.



Transverse section of Nose at beginning of Jacobson's Organ.

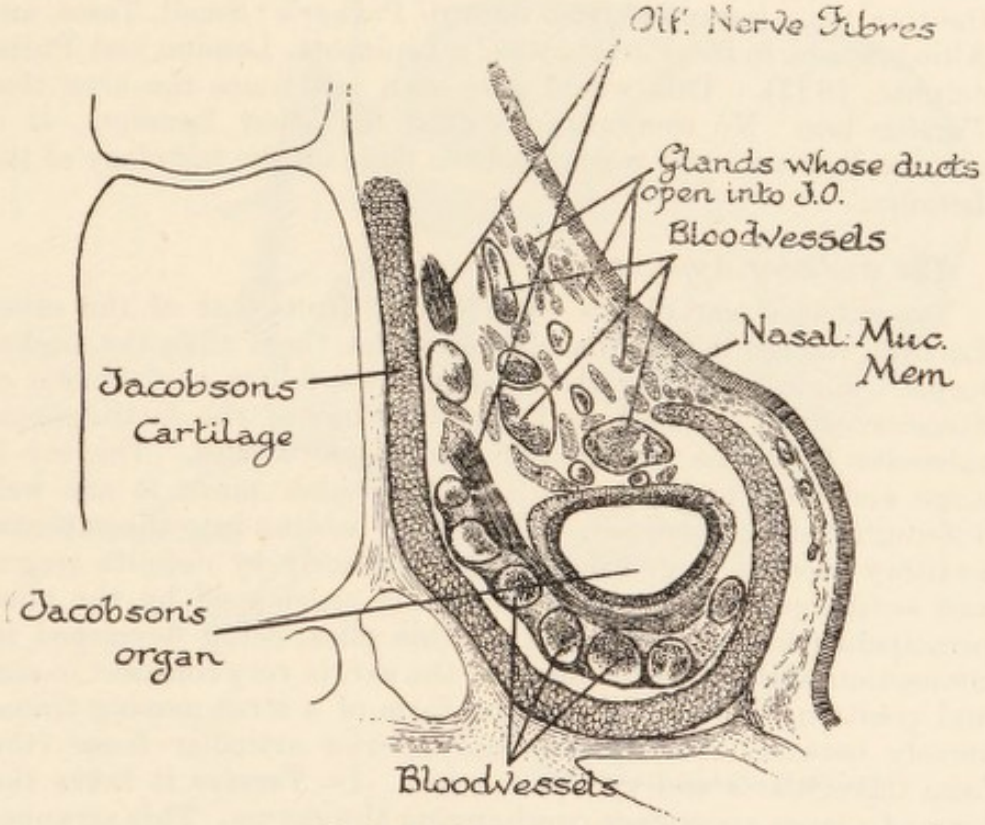
The vascular papilla on the septum contains many blood-vessels and glands. Above it another slighter elevation in the mucous membrane occurs.

As the sections are followed back to the naso-palatine duct, the cartilage of the floor of the nose disappears in its middle part and its margins, laterally bearing the papilla and medially abutting on the septum, persist. This septal portion of the floor cartilage is carried into the naso-palatine duct and forms a cartilaginous lining to it. The naso-palatine duct is directed downwards and forwards from above and so is cut very obliquely. The cartilages

in its walls are complete in front and are continued in the medial and lateral wall of the duct. The medial cartilage is the cartilage of the organ of Jacobson. The cartilage in the lateral wall of the duct persists for a considerable distance, and comes to lie immediately below the cartilage of Jacobson as this extends round the organ. It is not united with the cartilage of Jacobson's organ.

Where the organ of Jacobson opens into the naso-palatine duct, its cartilage lies on either side of the premaxillary crest and above is in contact but not united with the septal cartilage. Below it turns laterally and supports the organ which is situated immediately above it.

Text-figure 25.



Jacobson's Organ of *Tarsius*.

The cartilage continues back for about 4 millimetres. In its middle extent the outer bar is most extensive and almost completely surrounds the organ. Posteriorly the cartilage grows smaller, persisting longest in its medial part.

The organ itself is composed of a pseudo-stratified columnar epithelium, which in the inner wall is ciliated and has interspersed amongst it olfactory nerve-cells. It is interesting to note that no difference exists in the thickness of the inner and outer wall. Fibres from the olfactory nerve can be traced to the inner wall. The organ is richly invested on all sides by numerous and widely

dilated blood-vessels. Glands are most numerous above the organ and their ducts can be traced to open into the organ.

The respiratory portion of the nasal mucous membrane needs no description as it presents all the usual characters. The olfactory membrane is confined to the superior turbinate bone and to the corresponding area on the septum. This distribution repeats exactly the limitation given in the human nose. It is easily identified by being thicker, less vascular, and the presence of the olfactory nerve-cells. The olfactory nerve reaches the nose as a single trunk. Fascicles from it can be traced to the medial and septal portions of the nose and, as already remarked, fibres from it can be followed to the organ of Jacobson.

The total area of the olfactory mucous membrane in *Tarsius* measures approximately 250 sq. mm. In man 2500 sq. mm. is the total area (compiled from data in Parker's 'Smell, Taste, and Allied Senses in the Vertebrates': Lipincott, London and Philadelphia, 1922). This would give man ten times the area that *Tarsius* has. No computations exist for other Lemurs. It is curious that so little work has been done on the histology of the Lemurs.

The Auditory Apparatus.

The external ear differs considerably from that of the other Lemurs, though it more nearly resembles them than the higher forms. In interpreting the structure we follow the scheme of Streeter, which is based on the embryology of the cartilaginous tubercles from the mandibular and hyoid arches. The ear is large and very mobile. The muscles which move it are well differentiated and defined. The cavum leading into the external auditory meatus is guarded antero-inferiorly by definite tragus and antitragus. Above, the cavum is overlapped by the plica principalis (the crus antihelix). This plica, being developed in connection with the attachment of the ear, is very constant in size and position, and usually has the form of a strut passing transversely between the superior and inferior articular fossæ (the fossa triangularis and cymba concha). In *Tarsius* it takes the form of a large appendage overhanging the cavum. This arrangement resembles what is found in the Bats, and is in keeping with the suggestion of considerable auditory acuity as evidenced by the development of the cochlear nuclei and other nervous centres. The crus helix is less developed than in *Lemur*. Above and behind the plica principalis the concha—the superior articular fossa—is bounded by an inconspicuous ridge which represents the antihelix. The area outside this as far as the rim of the ear is the helix. This is very extensive and roughly triangular. It represents the portion of the ear most given to variation in size. The external ear is then, on the whole, much more like the Prosimian than the Simian ear.

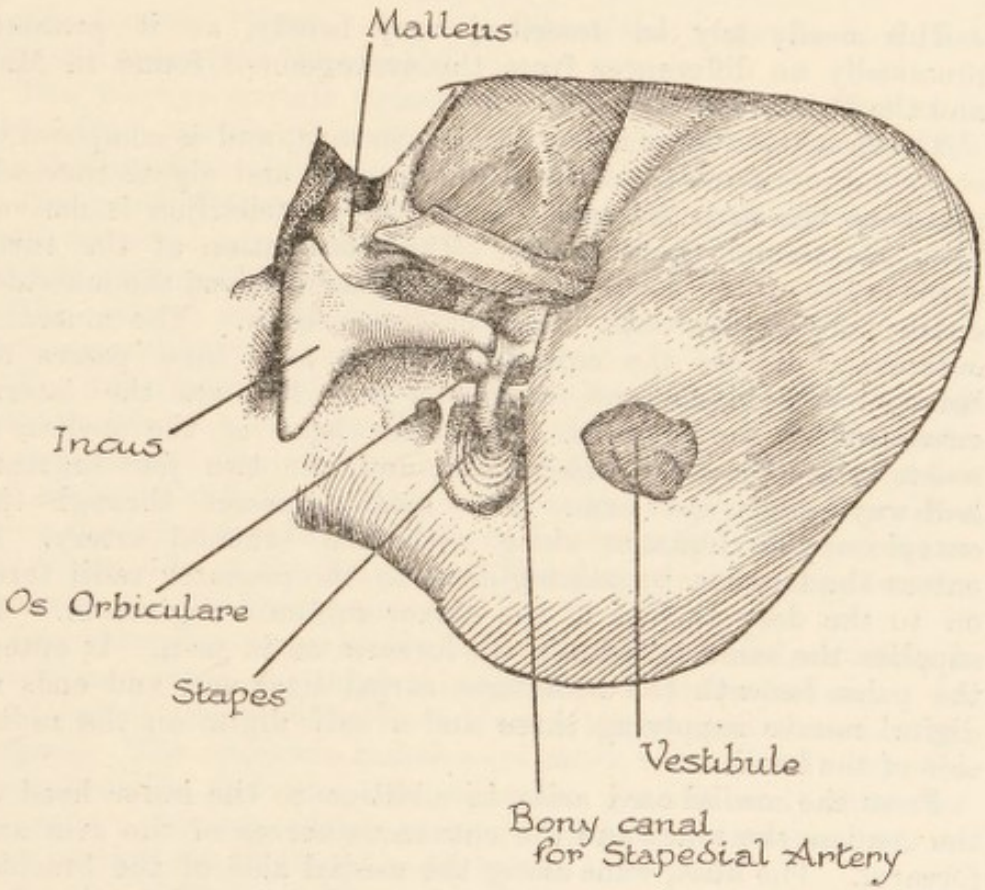
The tympanic and ento-tympanic bulla along with the relation of the internal carotid have already been dealt with.

The form of the ear ossicles was most extensively studied by Dr. Doran.

The *Malleus* may be summarised as follows:—The head is compressed from above downwards and is very thin, and possesses no neck; the articular cavity is deeply notched. The processus gracilis is slender and the manubrium is straight. The tensor tympani muscle is inserted half-way down the malleus.

The *Incus* has a large body with the processes of usual length. A small os orbicularis is present at the articulation with the stapes.

Text-figure 26.



Ear ossicles.

The *Stapes* is very small and the limbs are not markedly curved. The foot-piece is straight. A complete foramen is formed through which the stapedial branch of the internal carotid passes.

The ear ossicles closely resemble these structures in the Lemurs.

No detailed study has been made of the organ of Corti or of the vestibular apparatus. The central connections of the cochlear and vestibular nerves have been examined in Weigert preparations of the brain-stem. It may be recorded that the dorsal and ventral cochlear nuclei are well developed, and the trapezoidal

fibres visible on the surface of the brain-stem form a considerable lateral fillet. The inferior colliculus and the medial geniculate body are of ordinary size. The auditory cortex of the brain is of the usual dimensions. Although the receptive area is better defined histologically than in the Lemur, yet the differentiation of the secondary auditory areas is not so well defined.

The only central connection of the vestibular nerve we have examined is the vestibular nucleus, and it seems to us surprisingly large, forming medial to the inferior peduncle a nuclear mass that extends more than half-way to the median raphe.

The Peripheral Nervous System.

This need only be described very briefly, as it presents practically no differences from the arrangement found in Man and the Primates.

The *Brachial Plexus* is the same as in man, and is composed of contributions from the fifth, sixth, seventh, and eighth cervicals and from the first thoracic. A slender contribution is derived from the second thoracic also. The distribution of the three cords is the same. From the outer cord are derived the musculo-cutaneous and the outer head of the median. The musculo-cutaneous pierces the coraco-brachialis, and then passes on between the biceps and brachialis and becomes the lateral cutaneous of the forearm. The outer head of the median is much larger than the inner head, and the two join together half-way along the arm. The median passes through the entepicondylar foramen along with the brachial artery. It enters the forearm by passing deep to the pronator radii teres on to the deep surface of the flexor sublimis digitorum. It supplies the same muscles in the forearm as in man. It enters the palm beneath the transverse carpal ligament, and ends as digital nerves supplying three and a half digits on the radial side of the hand.

From the medial cord arise, in addition to the inner head of the median, the ulnar and the cutaneous nerves of the arm and forearm. The ulnar runs along the medial side of the brachial artery, and then passes behind the medial condyle and enters the forearm under cover of the flexor carpi ulnaris. It passes deep to the transverse carpal ligament on the radial side of the prominent elevation formed by the medial carpal bones. It supplies one and a half digits on the medial side of the hand, and contributes a communicating branch to the digital nerve for the middle finger.

From the posterior cord arises the musculo-spiral. The posterior cord furnishes three subscapular nerves. The musculo-spiral nerve gives off a large circumflex nerve which winds around the humerus. The nerve itself descends along the arm, and comparatively low down winds between the components of the triceps muscle to reach the outer side of the arm. It

nowhere comes into contact with the bone. On the lateral side of the humerus the musculo-spiral divides into radial and dorsal interosseous. The radial at once passes into the forearm under cover of the deep fascia, and eventually supplies the dorsum of three and a half outer digits. The dorsum of the inner one and a half digits are supplied by the dorsal branch of the ulna.

The dorsal interosseous pierces the supinator brevis and supplies all the extensor muscles. It differs in one point from the corresponding nerve in man in that it supplies the extensor carpi radialis longus and brevis after it has passed through the supinator.

The medial cutaneous of the forearm divides into volar and dorsal branches.

The Lumbar Plexus.—Issuing below the last rib is a last thoracic nerve (the thirteenth).

The ilio-hypogastric arises from the first lumbar, and as it issues from the lateral margin of the psoas it communicates with the ilio-inguinal which also arises from the first lumbar.

The genito-femoral arises from the first and second lumbars, both roots piercing the psoas and joining together on the ventral surface of that muscle.

The lateral cutaneous arises from the second and third lumbars and has the usual distribution.

The anterior crural arises from the second, third, and fourth lumbar nerves. In the front of the thigh it divides into superficial and deep divisions. The superficial division supplies the sartorius and then continues on as the long saphenous nerve along the inner side of the limb, and eventually reaches as far as the inner side of the first toe. The deep portion supplies the rectus femoris and vasti muscles.

The obturator nerve arises from the second, third, and fourth nerves and enters the thigh through the obturator foramen. In the thigh it lies between the adductor longus and the adductor magnus. The adductor muscles are much reduced. It supplies these muscles and also the adductor gracilis and obturator externus. Its superficial portion becomes cutaneous and its deep portion can be traced as far as the knee-joint.

The Sacral Plexus.—The great sciatic is formed from the sacral plexus, and comprises contributions from the fifth and sixth lumbars and from the first, second, and, with a very small contribution, from the third sacral. The contribution from the first sacral is much the largest.

The upper roots of origin are covered over by the psoas, and the trunk emerges from the pelvis by passing below the caudal border of the ilium. On the back of the thigh the nerve is covered by the cauda femoralis muscle. Just above the knee it divides into internal and external popliteal. The external popliteal winds round the outer side of the fibula, dividing in the peroneus longus into anterior tibial and musculo-cutaneous. The anterior tibial is entirely used up in supplying the muscles

on the front of the leg. The musculo-cutaneous becomes cutaneous and supplies the digits on the dorsum of the foot with the exception of the medial side of the great toe, which is supplied by the great saphenous nerve.

The internal popliteal is continued on in the usual way and becomes the medial and lateral plantar nerves, and supplies the digits in the proportion of one and a half to the medial plantar and three and a half to the lateral plantar.

The four ilio-coccygeal nerves join together, and form a thick group of nerves extending along the ventral aspect of the tail.

The phrenic arises from the third, fourth, and fifth cervicals. The contribution from the fourth is much the largest. The nerve has the usual relation to the front of the root of the lung in its course to the diaphragm.

The Sympathetic Nervous System.

The trunk of the sympathetic has the usual arrangement, and forms a gangliated chain lying on either side of the vertebral column. The cervical portion remains quite distinct from the vagus. The ganglia are the stellate, the middle and superior cervical. The white rami communicantes of the first and second thoracics communicate with the stellate ganglion. The succeeding white rami extend as far as the thirteenth thoracic ganglion. The great splanchnic arises from the sixth to the twelfth thoracic ganglia and enters the abdomen under the arcuate ligament of the diaphragm, and reaches the very large semilunar ganglion. The small splanchnic arises from the eleventh to the thirteenth ganglia, and enters the abdomen through a special foramen in the diaphragm. Below the diaphragm the small splanchnic joins with other branches from the abdominal ganglia, and these are distributed to the aorta. The solar plexus is considerable, and is arranged around the cœliac and superior mesenteric arteries. It contains the large semilunar ganglion, and branches from it are distributed to the mesenteric and renal vessels, and the plexus is continued along the aorta. The solar plexus receives branches from the vagus.

The trunk of the sympathetic can be traced down as far as the caudal vertebræ.

The Circulatory System.

The Cardio-vascular System.

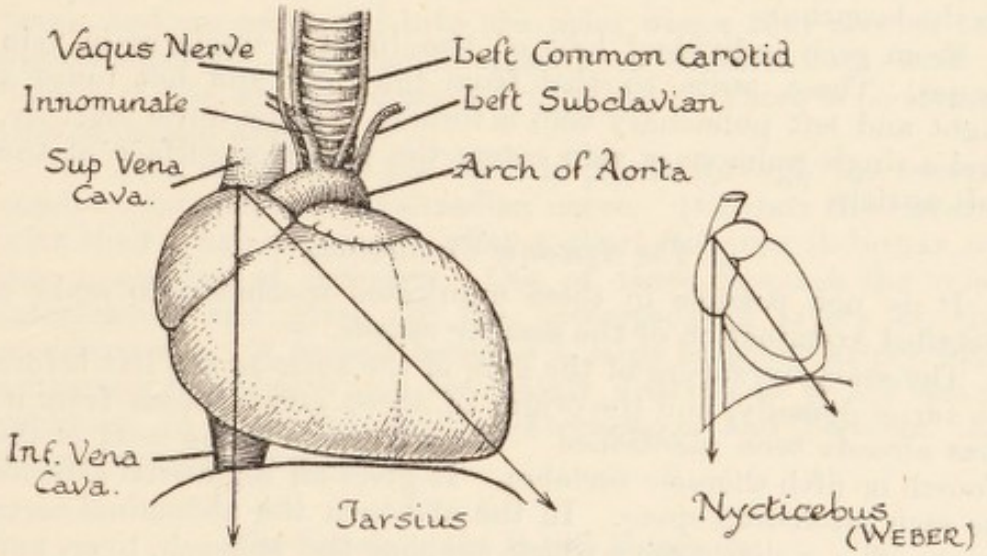
The pericardium is a thin membrane investing the heart and fusing above with the great vessels. Below it is attached to the diaphragm over an area that is much smaller than the area of the heart in contact with it. Incorporated in the pericardium along the right and left margins there are two large masses of fat. Well marked sterno-pericardiac ligaments are present attaching the pericardium to the deep surface of the sternum.

When the pericardium is opened the dark-coloured right auricle is seen above and to the right. It forms about one-half the right border of the heart. The remainder of the right border is formed by the right ventricle. The right ventricle forms the greater part of the ventral surface of the heart, the inferior border and part of the diaphragmatic surface. The apex is formed entirely by the left ventricle. The auriculo-ventricular sulcus is well marked, but the inter-ventricular sulcus is exceedingly faint.

In front the heart is on a level with the articulation of the sixth rib with the sternum, and above reaches slightly beyond the articulation of the second rib.

The interior of the heart calls for no particular comment. The auricular appendices, smooth externally, are thick and rough

Text-figure 27.



To show the relation of the Heart to the Diaphragm.

when opened. The right auricle presents a prominent tubercle of Lower and a low feeble crista terminalis. The fossa ovalis is easily seen and has a well-marked limbus fossa ovalis. The Thebesian valve of the coronary sinus is much better developed than the Eustachian valve of the inferior vena cava. The tricuspid valve is as usual, but the moderator band was either not present or overlooked. The arrangement of the mitral, aortic, and pulmonary valves call for no remark, except that the semilunar valves have no corpora Arantii. Into the left auricle a single pulmonary vein opens. It is of interest to observe the angle formed by a line passing through the openings of the superior and inferior venæ cavæ with a line passing from the orifice of the superior to the apex of the heart. The angle thus formed undergoes a progressive increase as it is measured in forms that belong to the higher members of the Primate series. *Tarsius* is in this respect on a level with the Anthropoids,

The coronary arteries call for no particular remark. The oblique vein of Marshall is quite large.

The aorta is large, and sweeps straight to the left before it turns backwards. It gives off three great vessels as in man—an innominate which divides into subclavian and carotid, the left common carotid, and the left common subclavian. The aorta completely hides from view the pulmonary artery, which passes behind the aorta immediately after its origin from the conus arteriosus.

The Pulmonary Circulation.

As just mentioned the pulmonary artery lies, after its origin, behind the aorta. It divides into right and left branches. To each individual lobe of the lungs a particular branch of artery is distributed, and this artery in each case lies between the vein in front and the bronchus behind, but assuming as it approaches nearer and nearer to the lungs a more dorsal position in relation to the bronchus.

From each individual lobe of the lungs a single main vein issues. These unite so that from the right and left lungs a right and left pulmonary vein is formed. These unite together, and a single pulmonary vein enters the posterior surface of the left auricle.

The Systemic Circulation.

It is not possible in these uninjected specimens to make a detailed examination of the smaller vessels.

The sharp curvature of the arch of the aorta to the left before it turns dorsally, and the origin of three great vessels from it, has already been mentioned. The arch ends at the level of the fourth or fifth thoracic vertebra. It gives off segmental arteries to each intercostal space. In the abdomen the abdominal aorta gives off a cœliac artery which supplies the stomach, liver, and duodenum. The splenic branch is large, and in addition to supplying the spleen and pancreas gives off vasa brevia branches to the stomach. The mid-gut is supplied by the superior mesenteric, and the inferior mesenteric is distributed to the hind-gut, beginning at what corresponds to the splenic flexure. The remaining branches of the abdominal aorta call for no particular remarks.

The abdominal aorta divides into common and then into internal and external iliacs opposite the sixth lumbar vertebra (*i. e.*, the nineteenth thoraco-lumbar vertebra). The two branches diverge at an angle of about 60 degrees, which arrangement holds for most Lemurs, *Nycticebus* being exceptional.

The Vessels of the Head and Neck.

The common carotid divides high up in the neck well above the thyroid cartilage. The external passes under cover of the

posterior belly of the digastric, and breaks up into its branches of distribution. The superficial temporal is large and gives off a very large infra-orbital branch.

The course of the internal carotid has been described in relation with the tympanic region.

The Vessels of the Upper Extremity. (See text-fig. 48.)

The subclavian artery passes in front of the scalenus anticus, and is thus separated from the brachial plexus. It gives off a large subscapular branch which passes through what corresponds to the quadrilateral space. While still surrounded by the cords of the brachial plexus it divides into a superficial and a deep portion. The superficial branch runs in front of the median nerve, and becomes subcutaneous at the elbow. Here it divides into a radial and an ulnar branch which continue along the forearm. Just above the wrist these two arteries pierce the deep fascia, and are continued into the palm where they become the digital arteries. The radial appears to communicate with a branch of the arteria comes nervi mediani. There is no formation of palmar arches.

The deep division of the brachial passes through the entepicondylar foramen with the median nerve. It enters the forearm with the median nerve, and after a short distance it breaks up into a number of branches. One of these becomes the volar interosseous and gives off the accompanying artery of the median nerve. A second becomes a large muscular artery with numerous branches which are mainly distributed to the flexor sublimis. A third pierces the interosseous and becomes the dorsal interosseous artery.

The Vessels of the Lower Extremity.

The external iliac artery lies in front of the psoas, and as it emerges from under Poupart's ligament breaks up into a number of branches. These can be regarded as superficial and deep. The main superficial branch consists of an artery which lies in the subcutaneous tissues and accompanies the long saphenous nerve. It continues downwards over the front and medial aspects of the thigh and into the leg as a long saphenous artery which replaces the anterior tibial.

The long saphenous artery in its main continuation represents the anterior tibial artery. It enters the dorsum of the foot by passing under the tendon of the tibialis anticus distal to the dorsal annular ligament, and it forms the main source of digital arteries on the dorsum of the foot. In the upper two-thirds of the leg it gives off a medial branch which gradually winds round to the back of the leg, and this branch represents the posterior tibial. It is the main source of digital branches on the plantar surface of the foot.

The deep branches can be classified into a lateral circumflex which passes under cover of the rectus femoris and supplies the vastus externus. Branches of this artery run on the vastus intermedius and can be traced as far as the knee-joint. Another branch of this supplies the vastus medialis and also continues as far as the knee-joint. Another branch supplies the vastus lateralis. The remaining deep branch continues in front of the adductor longus and represents the femoral artery. It can be traced in to the popliteal space, where it appears to end by supplying the neighbouring muscles. From the femoral there is given off a branch which runs between the adductor longus and the adductor magnus. This represents the profunda femoris. From the internal iliac there comes an artery which accompanies the great sciatic nerve. This vessel can be traced down the back of the thigh, but appears to end in the musculature of that region.

The Venous System.

The venous system needs only a brief reference to certain features.

In the upper extremity there appears to be no representative of the cephalic vein. All the blood from the upper limb is returned by a basilic vein which pierces the deep fascia in the arm and becomes the brachial vein. It receives a large subscapular vein and a very large mammary vein in the female. As the axillary vein, before passing over the first rib and under the clavicle, it receives a very large jugular vein.

The blood from the head and neck is returned mainly by a very large external jugular which is formed out of two large veins, one coming from the submaxillary region and one coming from the occipital region. The external jugular crosses the sternomastoid, and crosses also the clavicle and joins the axillary vein. The internal jugular is much smaller than the external jugular, and joins the subclavian to form the innominate. The two innominates join together and form the superior vena cava which enters the right auricle.

The veins of the lower extremity form a short saphenous and a long saphenous. The long saphenous joins with the femoral in the front of the thigh, while the short saphenous joins with the veins in the popliteal region. It is interesting that *Tarsius* should have the human arrangement, as the terminations of these veins is subject to very great differences in the Anthropoids. The femoral veins and the external iliac are noteworthy in that they lie on the lateral side of the artery. The inferior vena cava is formed by the two common iliacs which, however, both pass behind the corresponding artery. The inferior vena cava calls for no remark as it repeats the same arrangement as in man.

The azygos system consists of two equally large veins, which makes the name azygos peculiarly inappropriate. The right reaches the superior vena cava by arching above the root of the

lung. The left azygos vein forms a large single trunk which passes up the whole length of the dorsal wall of the thorax, and finally empties into the left innominate vein.

The portal system calls for no remark, except that it seems very large considering the short length of the alimentary canal.

The intracranial sinuses have been described with the skull.

The Digestive System.

The external anatomy of the mouth has been referred to under the description of the external form, and the teeth have been described along with the skull.

The *Tongue* is long, hard and horny, and covered with blunt fungiform and conical papillæ. These are set closely together and are of fairly uniform size. The dorsum of the tip is smooth, corneous, and bears no papillæ. There is no sulcus terminalis, no circumvallate papillæ, and no foramen cæcum. On the under surface of the tongue there is a rudimentary sublingua, which is more developed in other Lemurs than in *Tarsius*. It projects laterally towards the teeth, and is separated from the under surface of the tongue by a groove. Its median ventral surface is traversed by an elevation which ends bluntly in front and rests on the interval between the plicæ fimbriatæ (the frenal folds). The plicæ fimbriatæ or frenal folds form a rigid bilateral structure free anteriorly, where each fold ends in a sharp triangular projection. The lateral margins of these folds are serrated.

On section it is found that a median raphe is present only in the posterior part of the tongue, and is there composed entirely of fibrous tissue. This raphe extends to the hyoid bone. The intrinsic musculature of the tongue can be separated into (1) superior and inferior longitudinal, (2) median and lateral vertical, and (3) transverse fibres. It should be remarked that the fibres classified as transverse are really more oblique in direction than transverse. Slightly in front of the middle of the tongue are numerous groups of glands, and adjacent to them sympathetic ganglia. These are the ordinary lingual glands. There are no apical glands of Blandin or Nuhn.

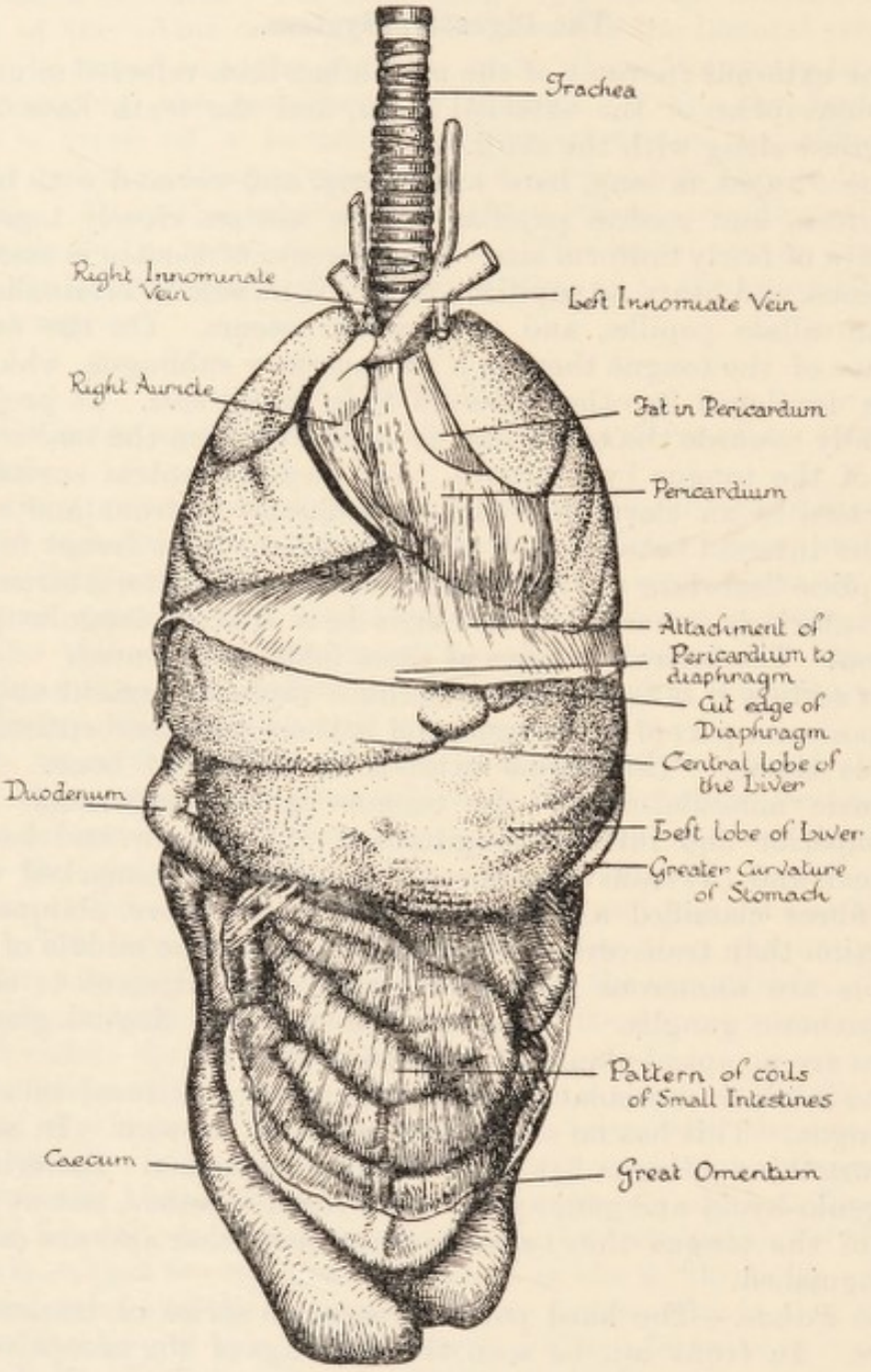
The intrinsic musculature of the tongue is continued into the sublingua. This has no supporting tissue of its own. In some Lemurs this sublingua has a cartilaginous support. Anteriorly the genio-hyoid and genio-glossus are fused together, but at the base of the tongue they separate from each other and are easily distinguished.

The Palate.—The hard palate presents a series of transverse ridges. In front can be seen the openings of the nasopalatine duct. The soft palate is very large and muscular. It arches from side to side, and as there is no elevation in the normal position of the uvula the arch of the palate is uninterrupted.

The Pharynx.—The anterior and posterior pillars of the fauces are present, and the tonsil lies between them. Above the tonsil there is a well-marked fossa supra-tonsillaris.

The walls of the pharynx are smooth. No pharyngeal tonsil is to be seen. The opening of the eustachian tubes are close together and appear in the roof of the pharynx instead of on the wall. The openings are guarded by prominent cartilages.

Text figure 28.



Viscera.

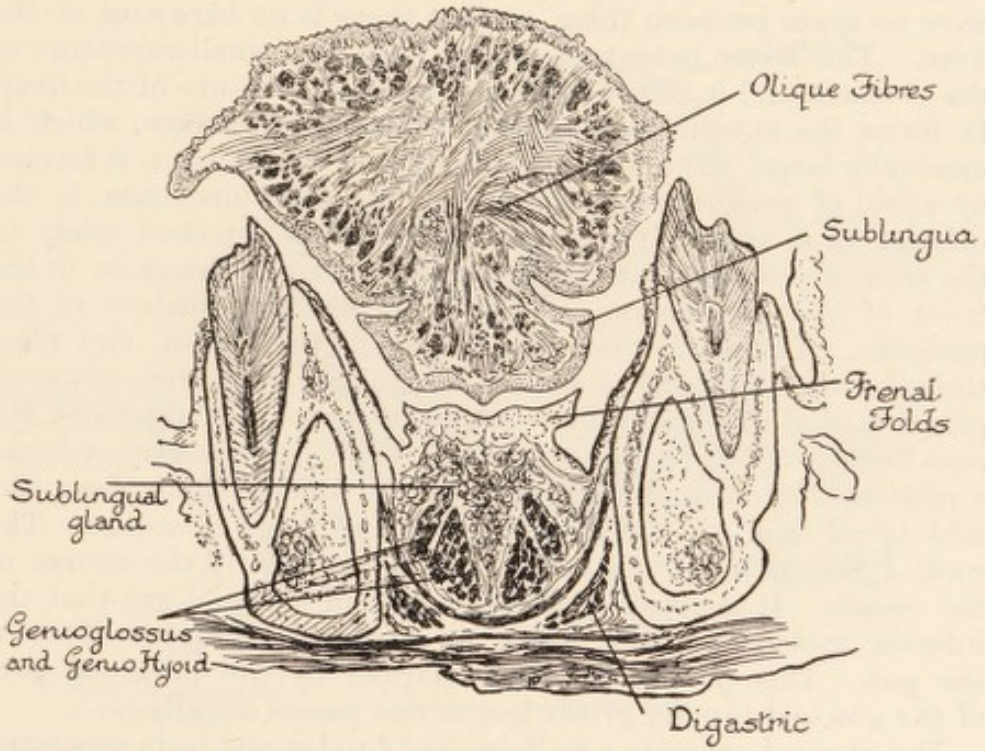
There is a cavity corresponding to the pyriform sinus between the epiglottis and the arytenoid folds medially and the medial surface of the thyroid cartilage laterally.

The Salivary Glands.—These are very well developed. The submaxillary is the largest and extends well up on to the face. It is in contact with the parotid over a considerable area. The parotid lies between the external auditory tube and the masseter but is quite superficial, and extends forwards on the face for a considerable distance. The sublingual in the floor of the mouth has several outlying clumps of acini which insinuate themselves among the muscles of the tongue. The ducts call for no remark.

The constrictor muscles of the pharynx are arranged as in man.

The superior constrictor arises from the side of the tongue and

Text-figure 29.



Transverse section of the Tongue.

the pterygoid plate, and is inserted into the median raphe and base of the skull.

The middle constrictor arises from the hyoid bone and reaches the median raphe overlapping the preceding muscle.

The inferior constrictor arises from the cricoid cartillage and overlaps the preceding constrictor as it becomes inserted into the median raphe.

Between the middle and inferior the superior laryngeal nerve and artery enter the larynx. The recurrent laryngeals pass under cover of the lower border of the inferior constrictor.

The *Œsophagus* presents no unusual features in its course through the neck and thorax. It passes through the fleshy portion of the diaphragm, and as it enters the stomach its right

border at once fuses with the lesser curvature, but its left border is separated by a considerable interval from the fundus of the stomach. The œsophagus is deeply embedded in the dorsal surface of the liver. The microscopic structure differs in no way from that found in the Primates. The surface of the stratified epithelium is almost corneous. Glands are present but do not appear to be very numerous. The investment of circular and longitudinal muscle fibres is well developed and, especially in the latter, striped muscle fibres can be distinguished for some distance from the beginning of the tube.

Of the *Peritoneum* it has been said that its arrangement is the simplest among mammals, and indeed recalls what is found in Amphibia and Reptiles. The liver is attached to the diaphragm and the vertebral column by triangular peritoneal folds which have no space between them, so that there is no bare area of the liver. The lesser omentum passes from the small curvature of the stomach and is attached to the transverse fissure of the liver. It forms the anterior wall of the foramen of Winslow, which is unusually large. The inferior boundary of the foramen is formed by a fold of peritoneum passing from the mesoduodenum to the inferior vena cava. The great omentum is attached solely to the stomach except at its right margin, where it passes on to the front of the peritoneum covering the anterior surface of the pancreas. The dorsal mesentery invests the spleen, and from the spleen is continued as a lieno-renal ligament which, however, passes medial to the kidney. Into the lieno-renal ligament the pars lienalis of the pancreas passes. The dorsal mesentery forms a mesoduodenum, and then is attached almost right along the mid-dorsal line. It invests the small and large intestine. The root of the mesentery is broad and shows clearly the course of the vessels. It is apparent in the region of the hind gut that the inferior mesenteric vein arises as a plexus on the surface of the gut. This plexus is better marked by the proximal part of the gut and rapidly grows less as one passes distally.

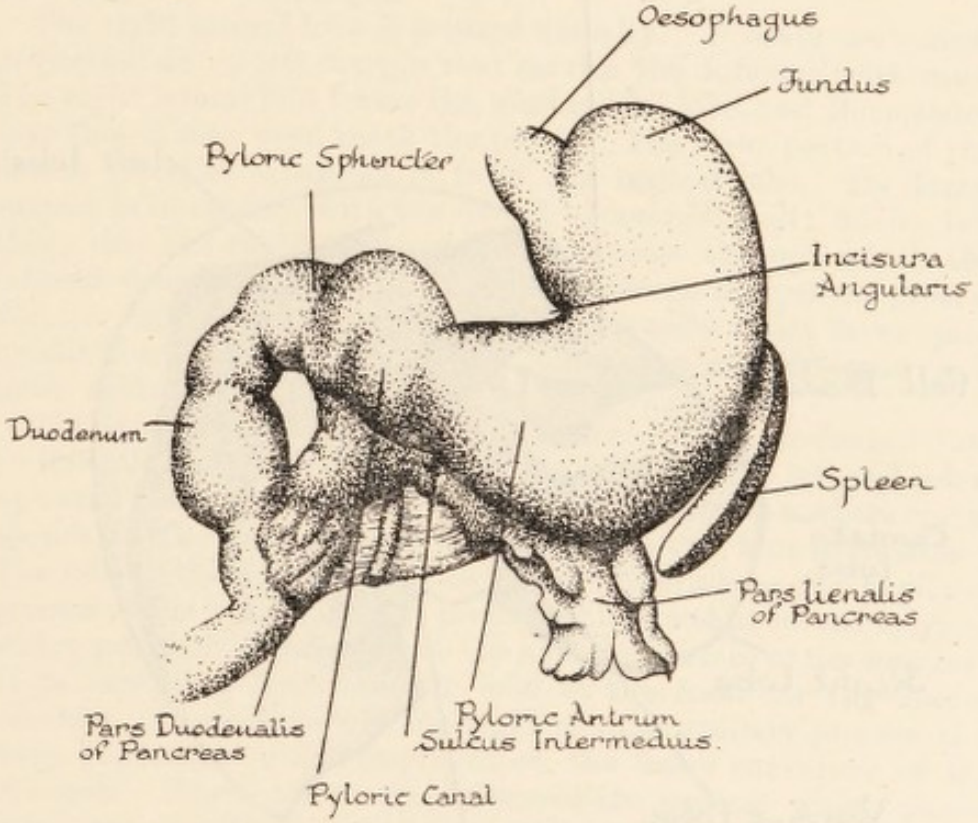
The *Stomach* presents a well-marked fundus and body separated from the pyloric portion by the incisura angularis on the lesser curvature. The pyloric canal is well defined and separated from the pyloric antrum by the sulcus intermedius. A deep constriction on the surface indicates the pyloric sphincter. As a whole the pyloric portion is tubular, the cardiac saccular.

The *Small Intestines* are extremely short and arranged in the simplest ladder pattern. There are six loops formed which are arranged in succession from the right to the left. Those on the right are nearly in the sagittal plane, the intermediate ones are more oblique, and the terminal ones horizontal. The terminal loop ends in a straight limb which ascends behind the other coils to terminate in the colon. The duodenum is easily distinguished from the stomach, but distally it passes into the jejunum without any feature to distinguish them. The duodenum is completely invested by peritoneum.

The shortness of the hind gut is very striking. The curvatures present in all mammals are wanting. The extreme primitiveness of the gut in *Tarsius* almost reduces it to the level of the Amphibia and Reptiles. The cæcum is almost as long as the rest of the hind gut, and hangs freely in the abdominal cavity on the right side. It gradually tapers a little towards its distal extremity. The cæcum joins the small intestines at right angles with a sharp constriction, but without producing any curvature.

Just beyond the junction with the cæcum, the large intestine bends down, forming a flexure just to the left of the mid-line. It

Text-figure 30.



Stomach, Duodenum, Spleen, and Pancreas.

then descends in the middle line or even slightly to the left, and pursuing a perfectly straight course reaches the anus.

The *Spleen* is described along with the ductless glands.

The *Pancreas* is in two portions. The processus lienalis ,corresponding to the tail, extends towards the left and sits in the lieno-renal ligament. The pars duodenalis descends along the duodenum and corresponds to the head of the pancreas of human anatomy.

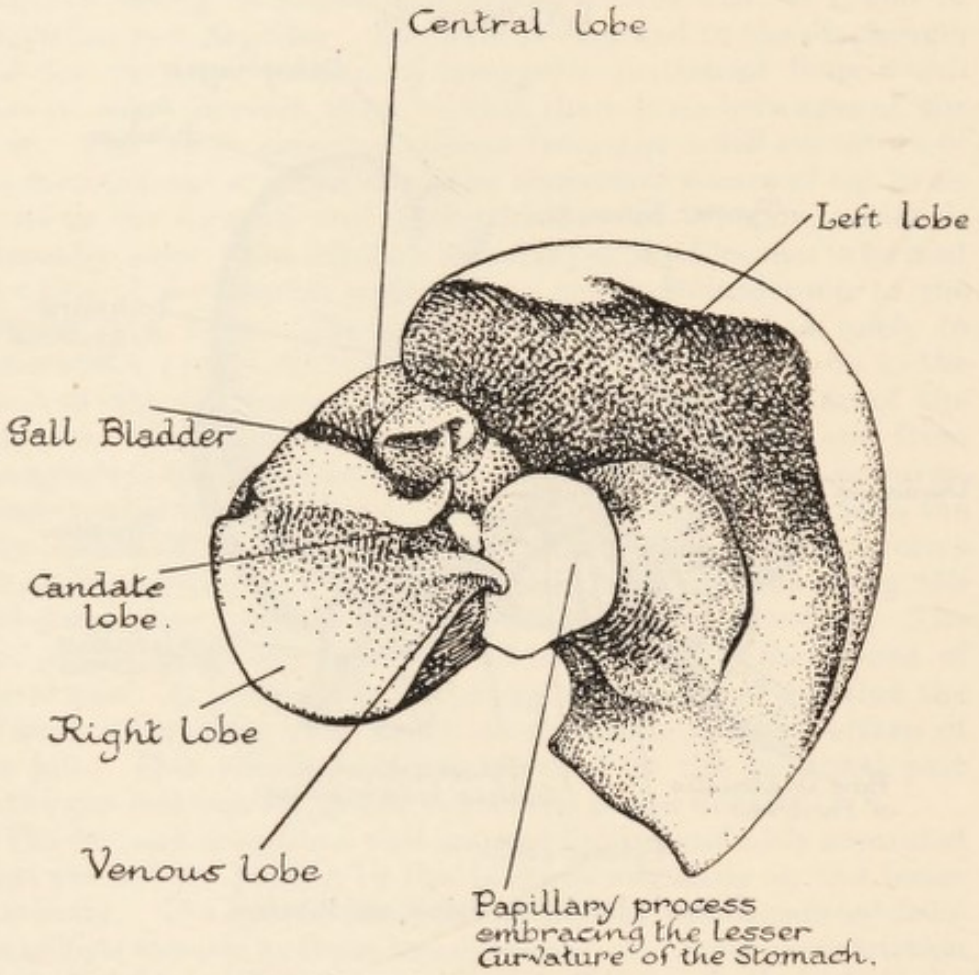
The Liver.—The form of the liver in the Primates has been most extensively studied by Ruge, and he has classified the lobes of the liver according to the main subdivisions of the portal vein. In *Tarsius* with the organs of the abdomen *in situ*, the liver is

very large, occupying nearly half the abdominal cavity. It overlaps the stomach almost entirely save for a small portion of the lateral or greater curvature.

The liver of the young *Tarsius* is more nearly human in form than the adult, and the right lateral surface is straight and not subdivided as in the adult. The transverse and the sagittal diameters are about equal. The width is about twice the vertical extent.

The greater part of the upper surface of the liver is occupied by a lobe which is in contact with the diaphragm. This is the

Text-figure 31.



Liver—visceral surface.

central lobe of Ruge. It is crossed by the falciform ligament, which Ruge says makes an impression on it. This has been denied by Leche, and we can find no evidence of its existence. By the falciform ligament the central lobe is divided into a small left and a larger right portion. On its under surface in a deep depression it bears the gall-bladder. In the young animal it is said that the gall-bladder comes into contact with the abdominal surface, but in the adult it becomes deeply buried in the liver. The right portion of the central lobe extends to the right lateral

surface of the liver. The left lobe of the liver lies below and to the left of the central, and excludes the central lobe from all contact with the viscera except for the small area that lies between the right lobe and the gall-bladder which is in contact with the duodenum. Between the central lobe and the left lobe the deep lateral fissure extends from right to left. It begins and ends on either side of the inferior vena cava.

The left lobe is certainly the largest, though Ruge speaks as if the central lobe were. Where it begins on the right of the median plane it is small, but as it passes to the left it increases in volume and as it extends it forms the greater part of the lower border of the liver. Below it is in contact with the stomach and duodenum, and bears on its dorsal border a deep incisura that lodges the œsophagus.

The right lateral lobe is pressed dorsally. It bears the venous projection on its left margin that carries the inferior vena cava. The right lateral lobe forms the most caudal lobe, and Burmeister says that it may even reach the pelvis. The right portion of the fissura lateralis separates it from the central lobe. Its dorsal surface is in contact with the dorsal abdominal wall; on its left there are the central lobe and the process through which the inferior vena cava passes. The area between the venous process and the right lateral margin forms a depression which is occupied by the kidney and the suprarenal. The duodenal impression is more ventral.

The inferior aspect of the right lateral lobe is prolonged into an irregular lobus descendens, bearing from right to left and below upwards three processes. The lobus descendens as a whole corresponds to the caudate and Spigelian lobes of human anatomy. The left of these three processes, corresponding to the papillary process of the human liver, is prolonged into a thin curved margin, which passes into contact with the anterior surface of the stomach. It is separated from the left lobe by the fossa for the ductus venosus. Immediately to the right of this papillary process is a deep depression which impinges on the lesser curvature of the stomach. Then comes the intermediate process which passes into contact with the posterior surface of the stomach. These two processes together resemble very closely a cotton reel. The third process (the one to the right) has already been referred to as the venous lobe. Through it passes the inferior vena cava.

The histological examination of sections taken from various parts of the gut brings out one or two interesting points.

The fundus glands of the stomach are well differentiated from the pyloric glands, and the line of transition is marked by the incisura angularis. The glands of the fundus show very clearly the demarcation into three zones—mucous cells towards the surface, parietal cells forming a middle area, and the peptic cells forming a basal zone. Amongst the peptic cells there are, however, a few parietal cells.

The duodenum shows only a narrow zone where Brunner's

glands are present; they end before the opening of the bile-duct is reached. The small intestine shows the usual arrangement of villi. Lymph nodes are small and only occasionally found. The large intestine is lined by the usual crypts of Lieberkühn with an abundance of goblet cells. Throughout the alimentary canal the circular muscle coat is well developed, while the longitudinal coat is extremely thin.

The pancreas shows numerous islets of Langerhans. These are most abundant in the pars lienalis.

The cæcum is smooth and thin-walled save for about one inch before it joins with the junction of the small and large intestines. It was filled with a great mass of some kind of thread-worm.

The Diaphragm.

The diaphragm arises from the crura, arcuate ligaments, the ribs, and sternum. The right and left crura are of equal dimensions and extend to the third from the first lumbar vertebra. The medial arcuate ligament arches over the front of the psoas, and the lateral extends from the first lumbar to the last rib. A costal slip of origin arises from the lower seven ribs, and from the deep surface of the xiphisternum arises the sternal slip which is single. The fleshy fibres are strongly arched and become inserted into the central tendon. The central tendon consists of a central and two lateral portions. The central portion is much the largest and is in contact and partly fused with the pericardium above. The lateral portions are extremely narrow, and extend far towards the posterior abdominal wall in a strongly-marked convex arch from above.

The central tendon is pierced by the inferior vena cava. The œsophagus is entirely surrounded by muscular fibres. The aorta passes between the two crura accompanied by the right and left azygos veins. The small splanchnic passes through the crus, and the sympathetic trunk and great splanchnic pass under cover of the medial arcuate ligament.

Ductless Glands.

The *pituitary* is shaped like a cherry and measures about 2·5 mm. in diameter. It occupies the pituitary fossa and is covered in by the diaphragma sellæ. Dorsally the optic chiasma lies directly over it. The cavernous sinus embraces it laterally, and running in the wall of the sinus are the third, fourth, and sixth nerves and the ophthalmic division of the trigeminus.

On section the principal features are the considerable size of the anterior lobe and what appears to be the very large proportional size of the posterior lobe. The remains of Rathke's pouch forms an extensive slit between the anterior lobe and pars intermedia. This slit is as extensive as the corresponding cleft in the Cat. Considering that the pars intermedia is phylogenetically the oldest portion of the gland and is said to reach its

greatest development in primitive animals, it is in *Tarsius* surprisingly small. It is represented by a lamina of cells adherent to the posterior lobe and only three or four cells thick. It contains no colloid. The posterior lobe is completely solid, and there is no trace of the infundibulum. It is composed entirely of neuroglial tissue and contains no epithelial elements at all.

The *thyroid* appears as an extremely small gland embracing the trachea. It lies entirely below the larynx. The upper pole of the lateral lobe reaches up to the second ring of the trachea, and the lower pole only as far down as the fifth ring. The isthmus is difficult to see with the naked eye, and there is no pyramidal lobe and no levator glandulæ thyroideæ muscle. The gland is plum-coloured owing to its very great vascularity, and is firmly anchored to the trachea by fascia. It is richly supplied with blood from the superior thyroid and inferior thyroid arteries. The venous return appears to be entirely to the internal jugular vein, and there appears to be no inferior thyroid veins returning blood to the innominates.

On section the gland presents the typical structure of the thyroid. The vesicles, however, are not nearly so numerous as one is accustomed to note in human glands. The amount of intervesicular tissue is very striking. These intercellular masses are composed for most part of cells which are columnar in form, and therefore may be looked on as actively secreting thyroid substance, and thus compensates for the lack of stored thyroxin owing to the relative fewness of the vesicles.

The *parathyroids* were discovered on making serial sections of the whole gland. They are not visible on the posterior surface of the gland, since they are deeply buried in the substance of the thyroid. They nowhere come in contact with the capsule of the thyroid. They are extremely vascular, many widely patent vessels being present between the columns of cells. The cells are polyhedral and are arranged in columns. They stain extremely deeply. The most striking feature of the parathyroids is their relatively very great size. The thyroids at first make the impression of being extremely minute even allowing for the diminutive size of the creature, but the parathyroids give one the idea that they are of the size that one is accustomed to in animals, say, like the Cat. The parathyroids are covered on all aspects by thyroid, but in being so invested they reach almost from the front of the gland to the back. The amount of thyroid in front of the parathyroid is, however, greater than the amount covering the posterior surface.

The Thymus.

The thymus persists in the adult animal as a large bilobed organ situated in the anterior mediastinum between the two lungs covering the great vessels. It lies below the level of the manubrium and is widely separated from the thyroid gland, which is high above the upper border of the manubrium. Below

it extends in front of the heart, lying on the pericardium. It is invested by fascia and is not connected with any of the adjacent organs. There is no elongation of either of its lobes to suggest the remnant of its original diverticulum.

On section the gland shows the usual subdivision into lobules, each consisting of a medullary and a cortical zone. It is composed of lymphoid tissue packed in the outer cortical zone and only scattered in the medullary area. In the medullary area there are numerous Hassal's corpuscles of young form—*i.e.*, capillaries surrounded by several layers of flattened cells. The gland gives the impression of undergoing atrophy.

The Suprarenals.

These have the form of relatively large globular bodies situated above and medial to the upper poles of the kidneys. They are quite separate from the kidneys.

On section they show the cortical and the medullary zones. In the cortex the usual three layers are easily distinguished. The medulla is rich in widely patent veins and the stock of chromaffin cells is abundant. No chromaffin bodies lying alongside the aorta were found.

The Spleen.

Though some of the more recent text-books on ductless glands exclude the spleen from a place among the endocrine system (Schafer), the more common practice of so doing is followed here. The spleen is shaped like a scimitar and lies along the greater curvature of the stomach. In the preserved animal it assumes a pale-yellow colour, suggesting that in *Tarsius* it may be a much less vascular organ than in other animals. Though of considerable length, the spleen is extremely narrow in cross-section.

On section the impression of its comparative avascularity is confirmed. The structure differs in no way from that of any other spleen, except that the Malpighian corpuscles do not stand out very clearly. They can be identified by the central artery, but the periphery is not clearly defined from the adjacent tissue.

Beside the anterior pole of the spleen there are two small accessory spleens.

The Respiratory System

The *Epiglottis* stands up prominently, and in fact the larynx gives the impression of protruding into the pharynx. The epiglottis is oval and bound to the tongue by median and lateral epiglottic folds and to the hyoid by a powerful hyo-epiglottic ligament.

On either side of the epiglottis and the arytenoid folds there is a pyriform sinus.

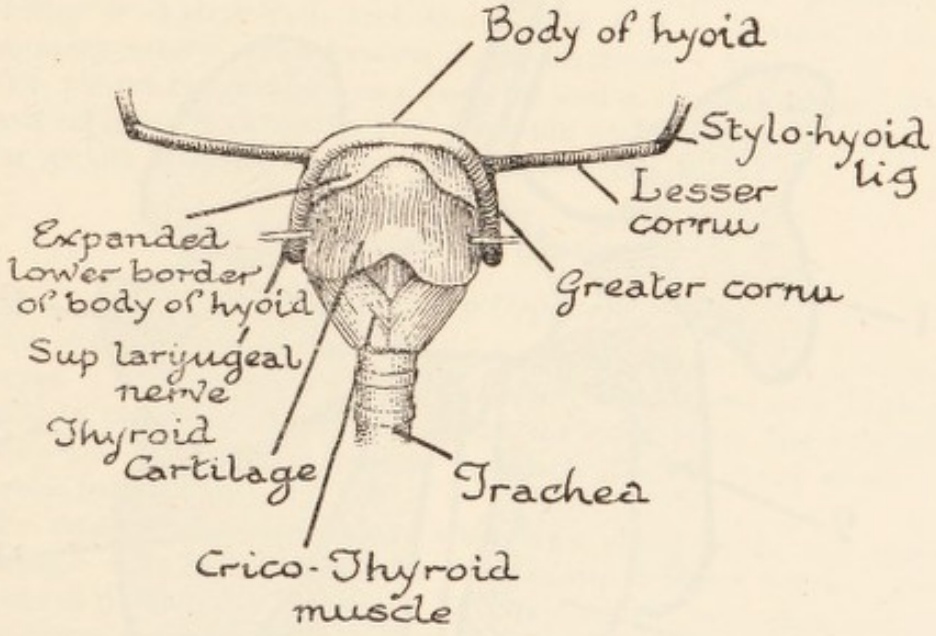
The hyoid bone has a large body whose lower border is produced downwards on either side as two broad flanges, which overlap the superior articular facets of the thyroid cartilages.

The lesser cornu is produced into a long thin ossified process, extending as such somewhat farther than the greater cornu. The amount of ossification varies, for in another specimen the so-called lesser cornu was really much shorter than the greater cornu.

The thyroid cartilage is composed of two quadrilateral laminæ which are fused in the middle line, producing at the fusion a prominence which however is slight. There is no indentation above at the line of fusion, but a slight one is produced below. The superior laryngeal nerve appears to enter through the thyro-hyoid membrane above the upper border of the thyroid cartilage.

The cricoid is substantial and articulates with the thyroid above, to which it is also joined by the crico-thyroid membrane. This bears a distinct foramen in its centre.

Text-figure 32.



Larynx.

The cavum laryngis is bounded at its superior aperture by the arytenoids, the ary-epiglottic folds, and the epiglottis. There are no corniculate or cuneiform cartilages.

The ventricle of the larynx between the false and true vocal cords contains an appendix which is fairly large and opens forwards towards the internal surface of the thyroid cartilages.

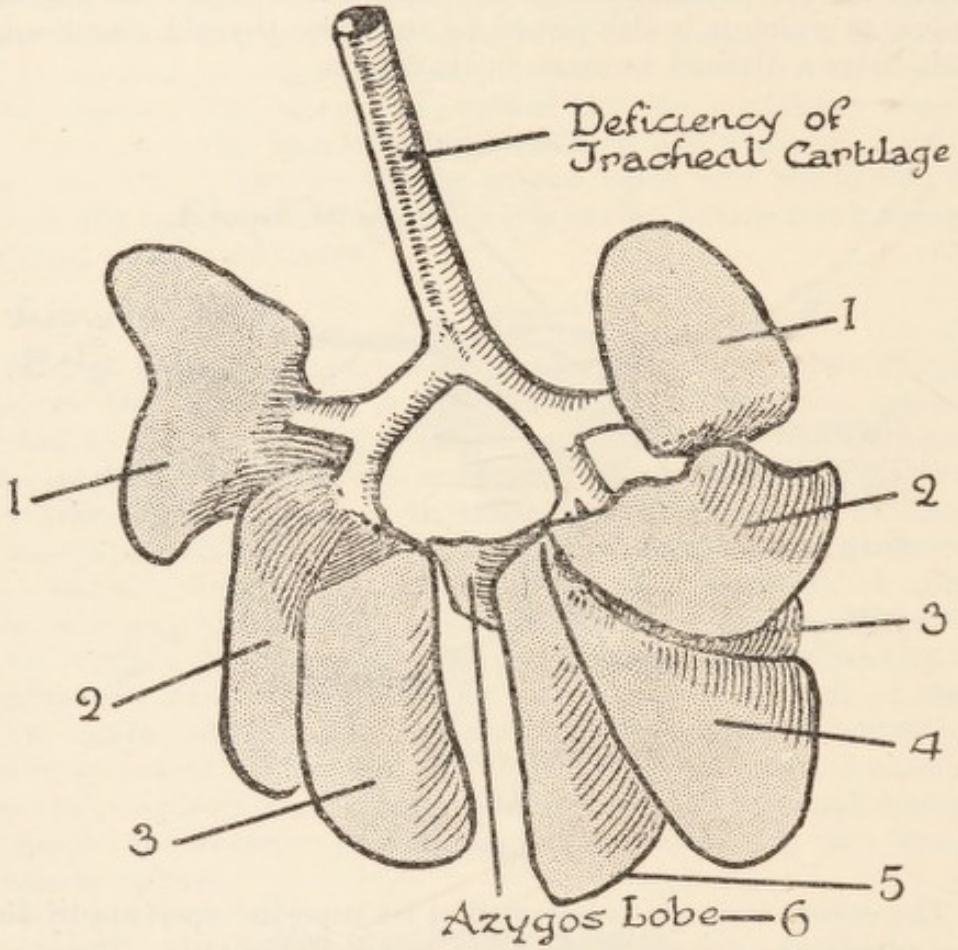
The musculature of the larynx is well differentiated. The crico-arytenoideus lateralis and posticus are attached to the muscular process of the arytenoid cartilage. A well-marked arytenoideus transversus is present. In section the thyreo-arytenoideus can be defined as a large undifferentiated mass of muscle. The appendix is large, and there are numerous glands in the plica ventricularis.

In the sections the most medial fibres of the thyreo-arytenoideus change their direction and might well reach the vocal cord.

The larynx closely resembles the Lemurine form.

The *Trachea* is long and slender and measures about four centimetres. It occupies the middle line and is composed of about sixteen rings. These are occasionally double on the right and left sides. They are incomplete dorsally. This separation of the rings dorsally is best seen in the upper and lower portions of the trachea. In one old specimen examined microscopically

Text-figure 33.



Dorsal view to show the lobes of the Lung.

the rings in the middle of the trachea overlapped dorsally without fusing together. The microscopic structure shows nothing to call attention to.

The trachea divides into right and left bronchi. The right gives off high up and above the level of the pulmonary artery a branch which passes at right angles from its origin to the right upper lobe. From its origin and relation to the artery it obviously corresponds to the eparterial bronchus.

Beyond the origin of this bronchus the right and left are about

equal in size and gradually diverge from each other to their distribution to each lobe of the lung.

The *Lungs* consist of numerous lobes. The right is indented by the right auricle and the left by the left ventricle. The right lung consists of six lobes. The upper lobe containing the apex receives the upper right bronchus, which appears to represent the eparterial bronchus. The middle lobe overlaps the right auricle. The lower lobe is subdivided into a dorsal lobe and a ventral lobe. The ventral is again divided into a superior and an inferior lobe. The azygos lobe extends below the root of the lung, projecting between the heart and the diaphragm and forming part of the diaphragmatic base of the lung.

The left lung consists of an upper lobe separated by an oblique fissure from the lower lobe. The lower lobe is split by a vertical fissure into a ventral and a dorsal portion. From the ventral of these lower lobes a fourth lobe projects in front of and below the root of the lung.

To each of these subdivisions of the lungs a particular bronchus is distributed, and along with this a branch of the pulmonary artery and a branch of the pulmonary vein.

The pleura is arranged as a parietal and a visceral layer. Its extent in front is as far as the sixth rib and dorsally it extends as far as the fifteenth thoraco-lumbar vertebra.

The Urogenital System.

The Urinary Organs.

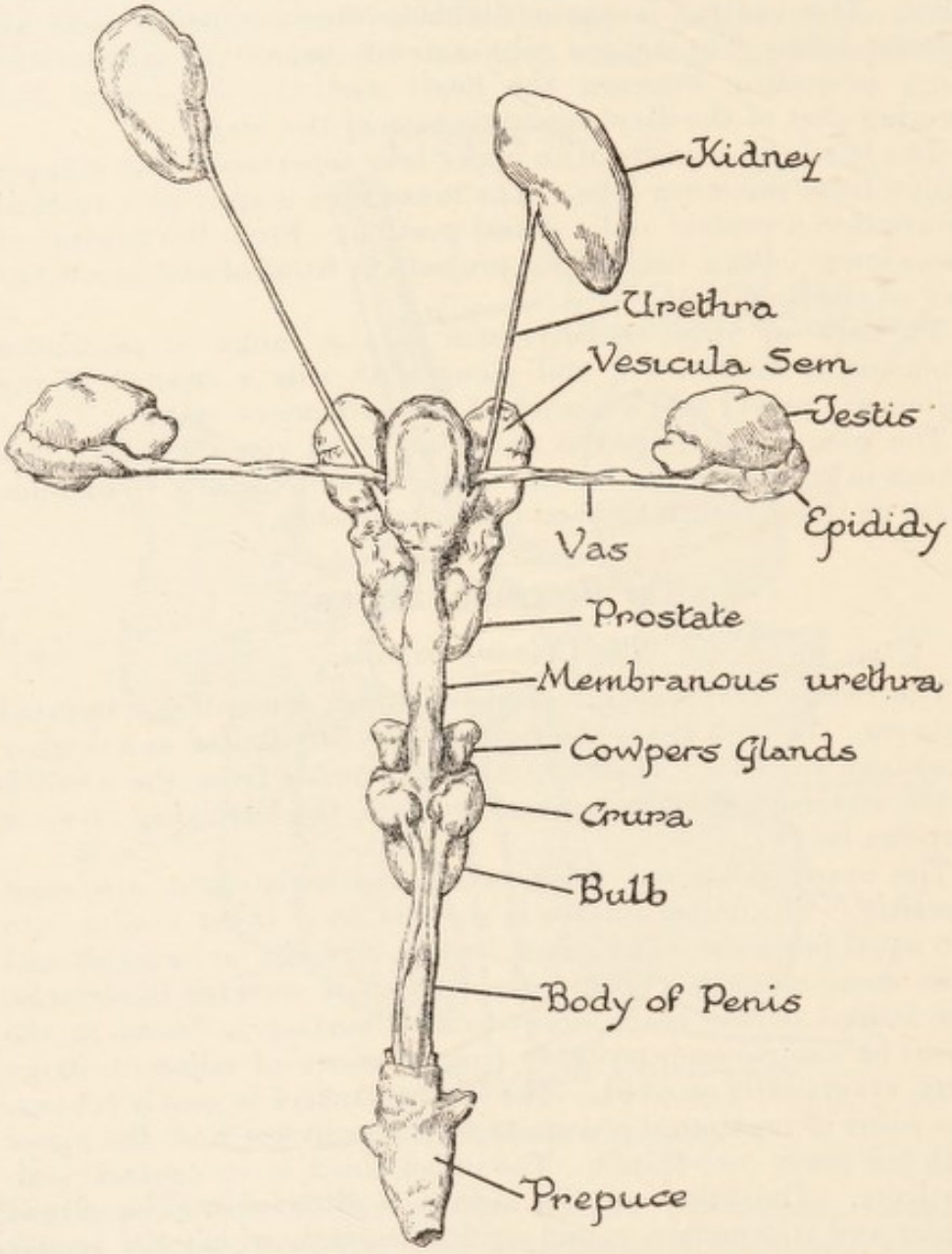
The external appearance of the kidneys presents no unusual features. In both sexes the right kidney is situated at a higher level than the left. The right kidney extends from the twelfth to the sixteenth thoraco-lumbar vertebra, the left lying about a vertebra below.

The upper poles are thick, while the lower poles are more tapering. The dorsal surface is divided by a blunt border into two equal portions. The inner half is straight and smooth and faces dorso-mesially. The outer portion is directed backwards. The lateral border really constitutes a surface as broad as the dorsal or ventral and, probably from pressure of adjacent structures, is vertically grooved. The ventral surface is gently convex. The point of maximum convexity is at the junction of the upper with the lower two-thirds. The upper third is in contact with the liver. The hilum of the kidney is situated on the mesial border and is merely a round orifice through which the vessels and the ureter emerge.

The pelvis of the kidney is buried entirely within the hilum and is not visible from the surface. When dissected out, the pelvis of the kidney expands over the blunt conical projection of the calyx. The pelvis is without any subdivision, and there is only one large calyx. This is a conical elevation that fills the pelvis very completely. Beginning from a wide base it ends in

a point that is thrust into the beginning of the ureter. On the dorsal aspect of the base of the calyx there is present a small secondary calyx. The base of the calyx expands into a superior and inferior column, and these embrace the whole of the medullary area of the kidney.

Text-figure 34.



Male Uro-genital Organs.

The ureter bears the usual relations to the renal vein and artery and to the vas deferens.

The openings into the bladder of the two ureters are situated close together and very close to the internal urethral opening.

Each ureter passes in front of the very large vesicula seminalis in order to reach the posterior surface of the bladder.

The bladder when contracted is thick-walled, pyriform in shape and flattened posteriorly. When dilated the arrangement of the musculature into longitudinal and circular bands is easily discerned. The trigone is extremely minute, measuring from the opening of the ureters to the internal urethral orifice not more than two millimetres. The transverse bar of muscle between the ureteral openings is well marked.

The urethra in the female is free for a short distance and then enters the anterior wall of the vagina, and eventually opens on this anterior wall some distance from the base of the clitoris. In one specimen the ventral surface of the clitoris was grooved and bordered by prominent elevations on either side, thus serving to direct the flow of the urine. This arrangement seemed not to be present in another specimen that we examined.

The Male Genital Organs.

The scrotum is large and voluminous and covered by hair. A septum can be distinguished externally. The transverse diameter is 17·5 mm. and the vertical extent 15·5 mm. As the scrotum approaches its attachment to the body it becomes narrower.

Both testes are enveloped in a common sheet of fascia in which there is no evidence of a dartos muscle. An external spermatic fascia from the external oblique covers each testicle, and this is succeeded by a cremasteric fascia and muscle which appears to be derived from the transversus abdominis. The tunica vaginalis is arranged in the usual parietal and visceral layers. The digital fossa is much more extensive than in man and extends from the tail to the head of the epididymis.

The epididymis is large, and the cauda is particularly conspicuous and shows clearly the coiled tube of which it is composed. The vas deferens ascends on the medial side of the epididymis and enters the external abdominal ring. The medial pillar of the ring is strong; the lateral pillar is much more indefinite. Entering the abdomen it crosses the external iliac artery and vein and passes down the medial side of the vesicula seminalis. Reaching the posterior surface of the prostate it joins with the excretory duct of the vesicula, and as a common ejaculatory duct opens on either side of the depression on the summit of the colliculus seminalis of the prostatic urethra. There are no glands developed in connection with the vas deferens.

It is to be noted that the typical Lemuroid arrangement is that the vas and the vesicula maintain separate openings into the prostatic urethra. In this matter *Tarsius* resembles the Anthropoids.

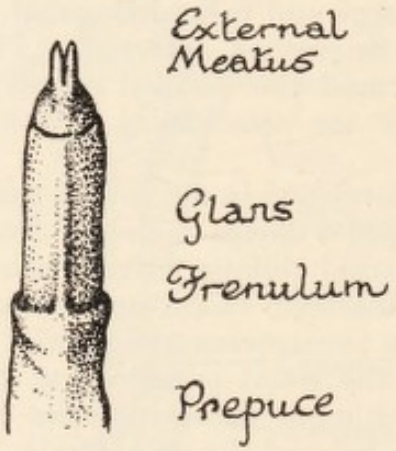
Since the male urogenital tract from the extremity of the penis to the bladder was studied in serial sections, it will be most

convenient to study the structures as they are met in the sections when followed from the prepuce.

The penis rides in front of the scrotum, in which its root appears to be imbedded. It projects directly forwards from the scrotum for a distance of 6 mm. and is completely covered by a hairy skin. The end of this skin extends far beyond the tip of the penis, and thus forms a very long prepuce. When the prepuce is pulled back over the penis, it discloses the external urethral orifice which stands out prominently from the glans penis. Its margins are elevated on either side of the orifice as two leaf-like folds. The external orifice is a vertical slit and is prolonged further on the dorsal aspect than on the ventral. It is separated from the glans by a deep furrow which completely surrounds the meatus except in the mid-ventral line, where a septum passes from the glans to the meatus.

The glans penis is extremely long, and measures from its

Text-figure 34 *a*.



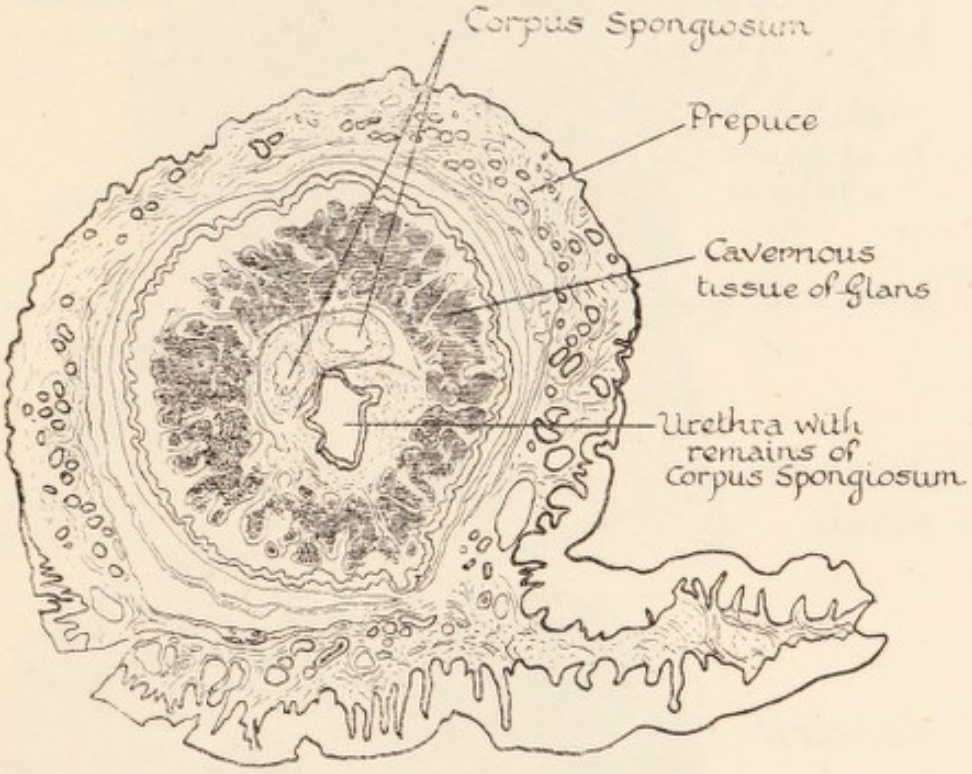
Extremity of Penis, prepuce rolled back.

extremity to the line of reflection of the prepuce 7 mm. Its surface is roughened and is a dark plum colour. Along the mid-ventral line there is a distinct elevation passing back to the reflection of the preputial skin, and at the point of junction the line of reflection is advanced beyond the remainder of the fold, and so is produced a definite though slight frenulum. The sections show that the preputial skin is thicker and more hairy on the dorsal surface than on the ventral. The inner surface is lined by a very delicate layer of epithelium. The glans is composed of a mass of cavernous tissue that completely invests the urethra and corpora cavernosæ. Ventrally a fibrous septum passes from the corpus cavernosum urethræ to the ventral surface of the glans. Both corpora cavernosa are continued right to the extremity of the glans, gradually growing smaller as they approach the tip. The corpus cavernosum urethræ is much reduced in the area of the glans, but the urethra itself is very

wide. This enlargement of the urethra continues to the meatus, so there is formed no dilatation corresponding to the fossa navicularis. The corpora spongiosa are separated by a distinct fibrous septum.

In the body of the penis the fibrous investment contains the dorsal vein, the dorsal arteries and nerves. The corpora cavernosa lie side by side separated by a septum of fibrous tissue. This septum remains fibrous everywhere and shows no organisation into any other kind of connective tissue. The cavernous tissue of the urethra increases in amount and equals in size the amount composing either of the corpora cavernosa. The artery of the crus running in the corpus spongiosum is easily identified.

Text-figure 35.



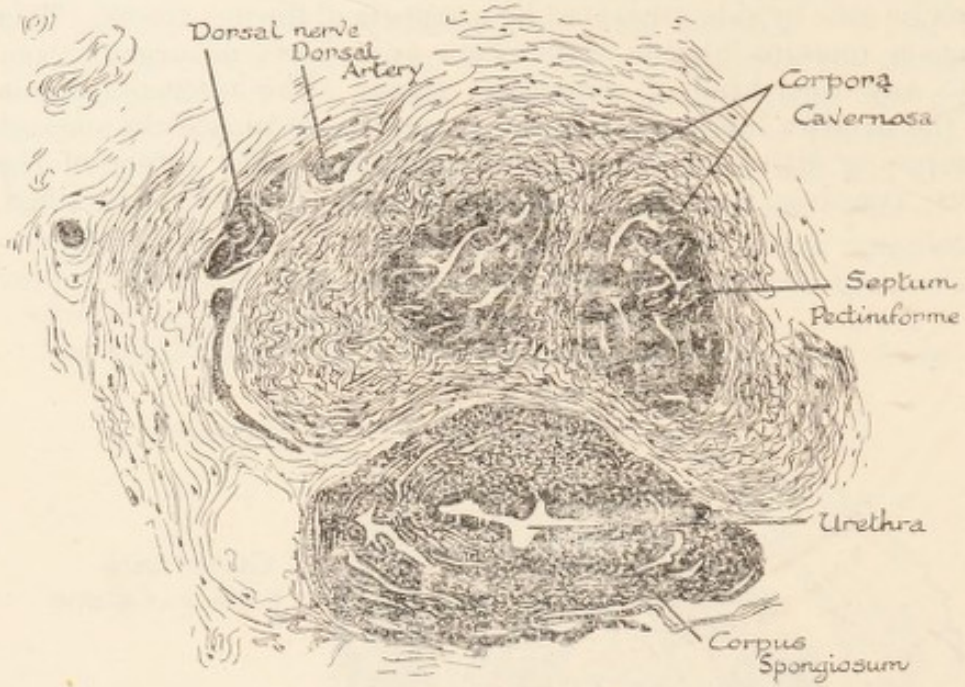
Transverse section of Glans Penis.

Throughout the penile and bulbar portions of the urethra there are no glands opening into the urethra other than the ducts of Cowper's glands. The three cavernous columns are invested completely by a dense sheath of fibrous tissue, and as the bulb is approached they begin to separate from each other. The urethra becomes narrower, and changes from its dilated form in front to a narrower lumen at first stellate in outline and then transverse.

In the region of the bulb the corpora cavernosa diverge from each other and become more and more fibrous and less and less vascular. The urethra is invested by the bulb, whose dual nature is indicated by the presence of a medial septum. The bulb is in turn invested by a relatively powerful bulbo-cavernosus

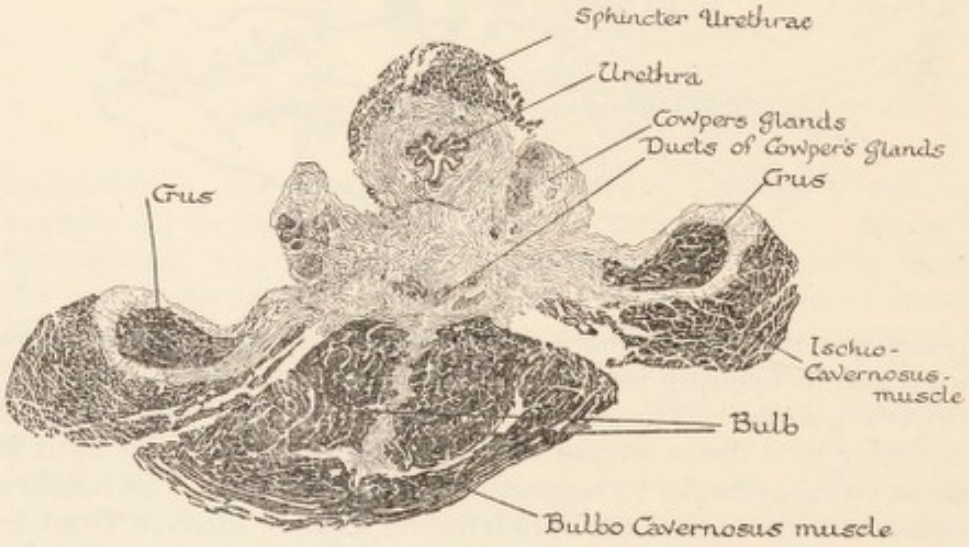
muscle. The muscle takes origin from a median raphe and is inserted into the triangular fascia, thus encircling the bulb. The diverging corpora cavernosa form the crura and obtain attachment

Text-figure 36.



Transverse section of body of Penis.

Text figure 37.



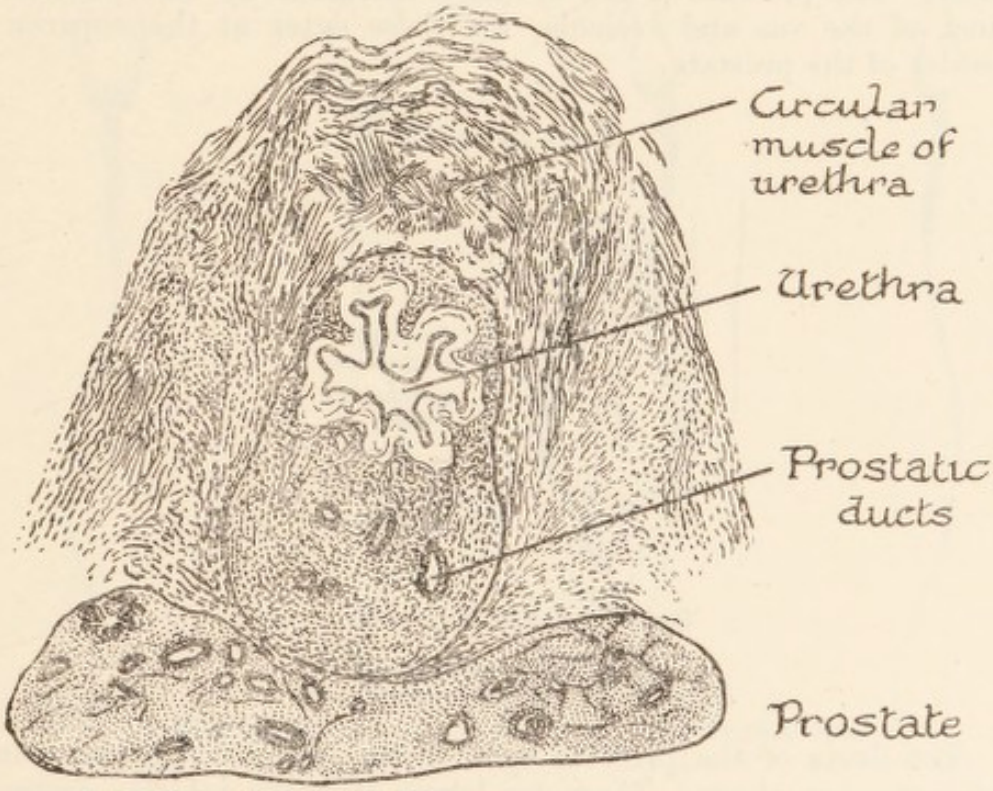
Section of Urethra bulb and Cowper's Glands.

to the pubic rami. Associated with each crus is a well-developed ischio-cavernosus muscle. On the ventral aspect of the urethra appear the openings of the ducts of Cowper's glands.

Cowper's Glands lie above the triangular fascia and are enclosed by a thin layer of striped muscle. They are quite large, and measure 5 mm. in their vertical extent and 3 mm. transversely. The gland is of the tubulo-acinous type. The acini are lined by a low columnar epithelium and the ducts have a similar epithelium. The gland as a whole is invested by striped muscle which appears to be independent of the compressor urethræ. In addition fasciculi of muscle-fibres penetrate between the individual lobuli of the gland. The ducts of the gland open into the bulbous urethra on the ventral surface.

The *membranous urethra* passes through the fascia triangularis and is invested closely by circular muscle-fibres forming the

Text-figure 38.



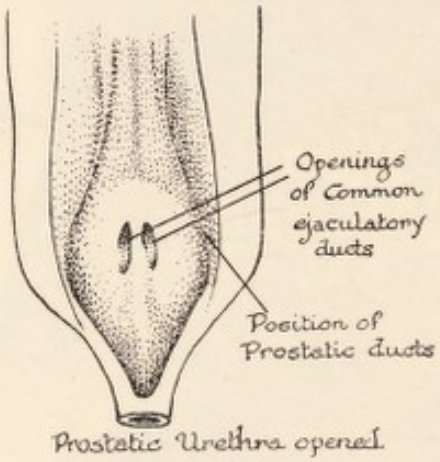
Section of Prostatic Urethra and Prostate.

sphincter urethræ. Outside these are fibres running transversely between the rami,—the deep transverse perineal. There are similar fibres on the inferior face of the triangular fascia corresponding to the superficial transverse perineal muscle. The urethra is transversely expanded and its transitional epithelium is thrown into numerous folds. The indentations on either side of the mid-dorsal line are most conspicuous.

The *Prostate* forms a transversely expanded gland lying altogether on the dorsal side of the urethra. There is no indentation on the surface suggesting that the gland is bilobed, and this is confirmed by section. The prostate in *Tarsius* is a single-lobed

gland. In Oppel's text-book it is quoted that Cuvier stated that the prostate was bilobed. The sections show that the prostate is surrounded by muscle-fibres, and that these fibres are continued into the substance of the gland and are continuous with the circular muscle of the urethra. This circular muscle of the urethra is in turn continuous with the circular muscle of the bladder. The muscular and connective tissues of the prostate form nearly one-half of the gland. This is a proportion greater than in man, where it is estimated that the glandular elements amount to three-fourths of the gland. The alveoli are lined for the most part by a single layer of columnar epithelium. The lumina of the alveoli are always small, and no dilated alveoli with prostatic concretions are present in the specimens available for examination, and further the alveolar lining is not thrown into folds. The prostate is not actually traversed by the common duct of the vas and vesicula, for these enter at the superior border of the prostate.

Text-figure 39.



Prostatic Urethra opened.

The ducts of the prostate open in two sets. A superior pair of ducts open above. These are larger than the inferior group, which consist of numerous small ducts about three or four on each side.

The prostatic urethra bears on its dorsal surface a broad low colliculus seminalis which is grooved shallowly along its face. At the distal extremity of this elevation there is a blind diverticulum directed upwards and backwards, ending blindly in a slight dilatation and covered by transitional epithelium—the uterus masculinus. The common ejaculatory duct formed by the vas and vesicula opens on the borders of the elevation of the colliculus. The prostatic ducts open in the recess on either side of the colliculus.

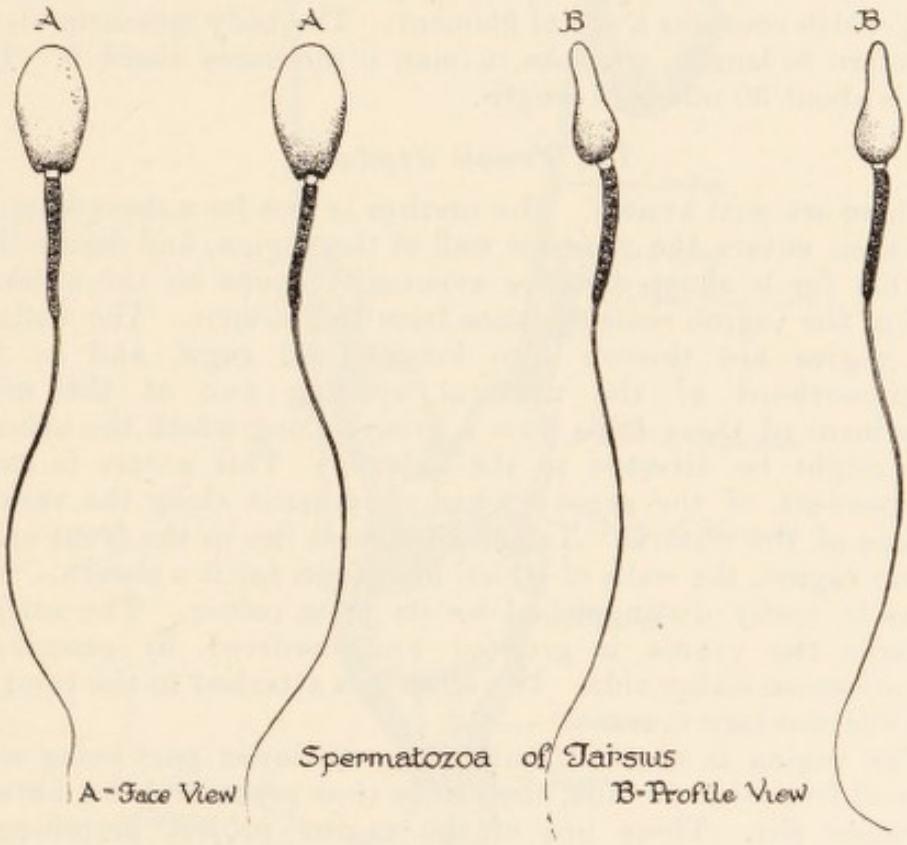
The *Bladder* needs no further description except to emphasize the continuity of the circular muscle of the bladder with that of

the prostate, prostatic urethra, and membranous urethra. The prostate as a whole is triangular in shape and measures from side to side 8 mm.

The *Vesiculæ* are large and tower up above the bladder. They are simple dilated sacs, measuring 18 mm. vertically and 6 mm. wide. They are filled with a dark brown gelatinous material. The duct is extremely short, and joins with the vas just before the latter enters the prostatic urethra.

The lining wall of the vesicula is quite thin and perfectly smooth. It is not, as is often the case in other animals, thrown

Text-figure 40.



Spermatozoa of *Tarsius*. (A) Face view. (B) Profile view.

into folds. The dark gelatinous substance which it contains is without any structure.

The total length of the urethra is 48 mm. Of this the bulb and penile portions measure 33 mm., the membranous portion 10 mm., the prostatic portion 5 mm.

The large *Testes* show the usual types of cells and all the stages in the formation of spermatozoa. We were successful in obtaining the form of the sperm, and thus could compare them with the figures of Retzius. The most interesting point that emerges is their very great similarity to the form of the spermatozoa in man. The proportions of the different elements of the sperm differ,

but there is very great similarity of outline. The length of the sperm in man is given as about 60 micra. In *Tarsius* they measure about 52 micra, thus agreeing with the law that the cells of all animals are approximately the same size.

The head is oval in shape and somewhat flattened, especially towards its extremity. Seen in profile, it is pyriform owing to the tapering of its borders. It contains near its extremity the acrosome. The narrow end joins with the neck, which appears as a transparent bar between the head and the body. Its junction on either side with the head and body is much darker than is its middle portion. The head of the human spermatozoon is about 3 to 5 micra, whereas in *Tarsius* the head measures about 10 micra in length. The neck is succeeded by an elongate body which contains a spiral filament. The body measures about 12 micra in length, whereas in man it measures about 5. The tail is about 30 micra in length.

The Female Genitalia.

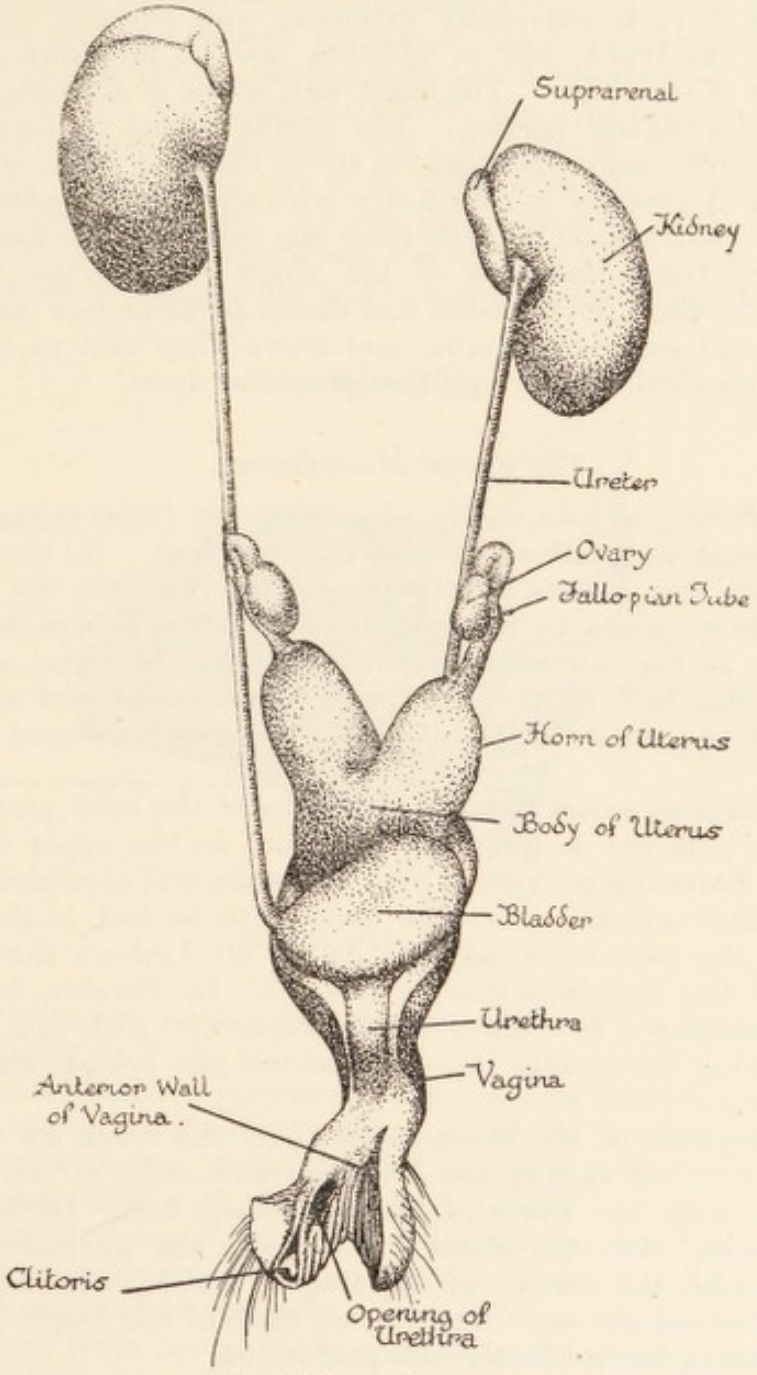
These are well known. The urethra is free for a short distance and then enters the anterior wall of the vagina, and descending in this for a short distance eventually opens on the anterior wall of the vagina some distance from the clitoris. The walls of the vagina are thrown into longitudinal rugæ, and in the neighbourhood of the urethral opening two of the more prominent of these folds form a groove along which the urinary flow might be directed to the exterior. This gutter is quite independent of the groove which is present along the ventral surface of the clitoris. The small clitoris lies in the front angle of the vagina, the walls of which here form for it a sheath. The glans is easily distinguished by its plum colour. The surface towards the vagina is grooved and bordered by prominent elevations on either side. The clitoris is attached to the rami by two rudimentary crura.

The vagina is about 15 mm. long, its lower part being compressed from side to side, the orifice thus presenting an antero-posterior slit. These lips of the vagina project prominently beyond the surface as the labia minora, whose external surfaces are covered by hair. While the lower portion of the vagina is covered by longitudinal folds, the upper portion is smooth and more circular in outline. Into this upper part the cervix of the uterus projects. The cervix is directed vertically downwards, and the external os between its lips runs transversely. The anterior and posterior lips of the cervix are of equal size.

The uterus consists of a body and two lateral horns. The body is vertical in position and about 8 mm. long, and is separated by a very deep recto-uterine pouch from the rectum. The mucous membrane of the uterus is smooth, whereas the lining of the cervix is thrown into folds and so forms a dividing line between the two structures. The horns are directed horizontally, and are about 5 mm. in length.

The Fallopian tube is short, much coiled, and ends in a single expanded fimbria. The globular ovaries lie behind the broad ligament, overlapped by this single expanded fimbria of the tube.

Text-figure 41.



Female Uro-genital Organs.

The ovarian and uterine arteries have their usual distribution, and the formation of the broad ligament and mesovarium need no comment. There seem to be no indications of the remnants of the Wolffian body or duct in the broad ligament or about the ovary.

The Muscular System.

The cutaneous musculature of *Tarsius* resembles that of the Lemurs in its extent. In the Anthropoidea this system undergoes considerable reduction.

The facial portion is described with the facial muscles. The abdominal part is extremely extensive and extends not only widely on the trunk, but in addition reaches far down on the inner side of the thigh. The sheet as a whole is divisible into a dorsal and a ventral portion. The dorsal begins in the median line posteriorly, and is continuous above with the platysma sheet and below it extends in continuity with the more ventral part. The more ventral part extends from the region of the knee, and passing up the inner side of the thigh reaches the ventral abdominal wall. Both medial and dorsal portions now assemble together and enter the axilla, and there they end in relation with the pectoralis major and the latissimus dorsi.

The Facial Musculature.

The difficulty of adequately dissecting the facial musculature in an animal so small as *Tarsius* is very great. In the region of the nose and mouth it is impossible to dissociate the musculature into its units by the ordinary methods. It was therefore necessary to supplement the ordinary method by serial sections. The anterior half of the head was so sectioned, and the finer details of the musculature about the nose were gleaned in this way.

The *Platysma* arises in the middle line of the neck posteriorly from the external occipital protuberance to the upper thoracic region. Laterally it extends over the spine and acromion of the scapula and ventrally over the clavicle to be lost in the fascia covering the pectoralis major. As in all Lemurs the medial border of the muscle is sharply defined. In *Tarsius*, however, in the sections a few fibres of the superficial platysma can be seen crossing the middle line just behind the symphysis of the lower jaw.

The majority of the fibres ascend over the lower jaw and are inserted into the skin of the lower lip and angle of the mouth, mingling with the fibres of the orbicularis oris. Other fibres mingle with the orbicularis oculi, with the auriculo-labialis inferior, with the muscles of the tragus, and with the auricular muscles behind the ear. There is no trace of the deeper layer of the platysma, the sphincter colli profundus.

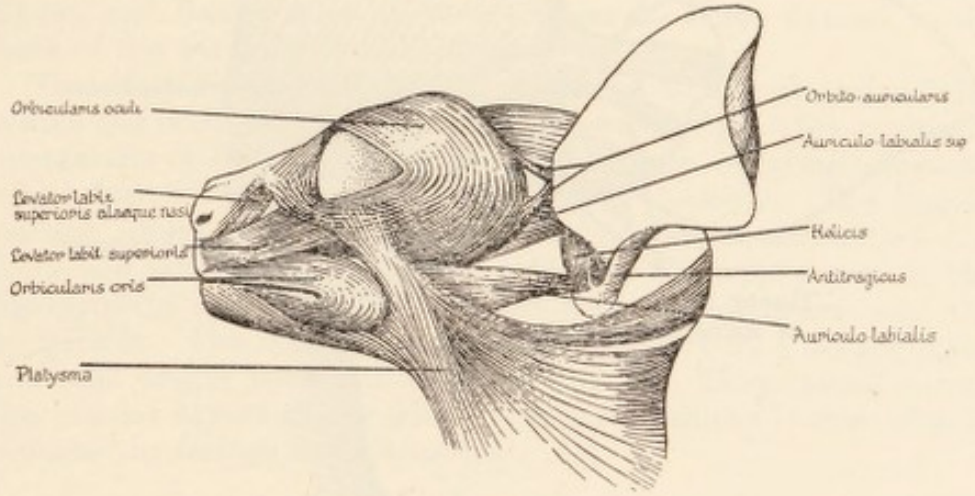
This arrangement of the platysma repeats what is found in the Lemuroidea.

The *Frontalis* begins in front on the nose and extends over the cranium, becoming continuous posteriorly with the platysma. This posterior portion may be regarded as the occipitalis where the fibres become attached to the occipital crest and occipital protuberance. In section it is found that the fibres are attached

to the nasal bone in the middle line in front. As they are traced upwards they spread laterally and become continuous with the orbicularis oculi; further back and more laterally they become continuous with the auricular muscles, and finally with the platysma posteriorly.

The Orbicularis Oculi.—The orbicularis surrounds the lids and extends on to the adjacent portion of the bony opening of the orbit. It is intimately blended with the neighbouring muscles. It can be traced into continuity with the orbicularis oris just behind the angle of the mouth. Its continuity with the frontalis has already been noted. It is blended with the auriculo-labii superioris and inferioris. At the inner canthus of the eye the fibres obtain a bony origin from the maxilla and lachrymal and there form an investment for the lachrymal sac. The muscle is

Text-figure 42.



Muscles of the Face.

extremely extensive owing to the great extent of the eyelids, but is correspondingly thin.

The Auriculo-labialis inferioris.—This muscle extends from the region of the incisura auris to the angle of the mouth, where it fuses below with the platysma, and in front with the orbicularis oris and above with the orbicularis oculi.

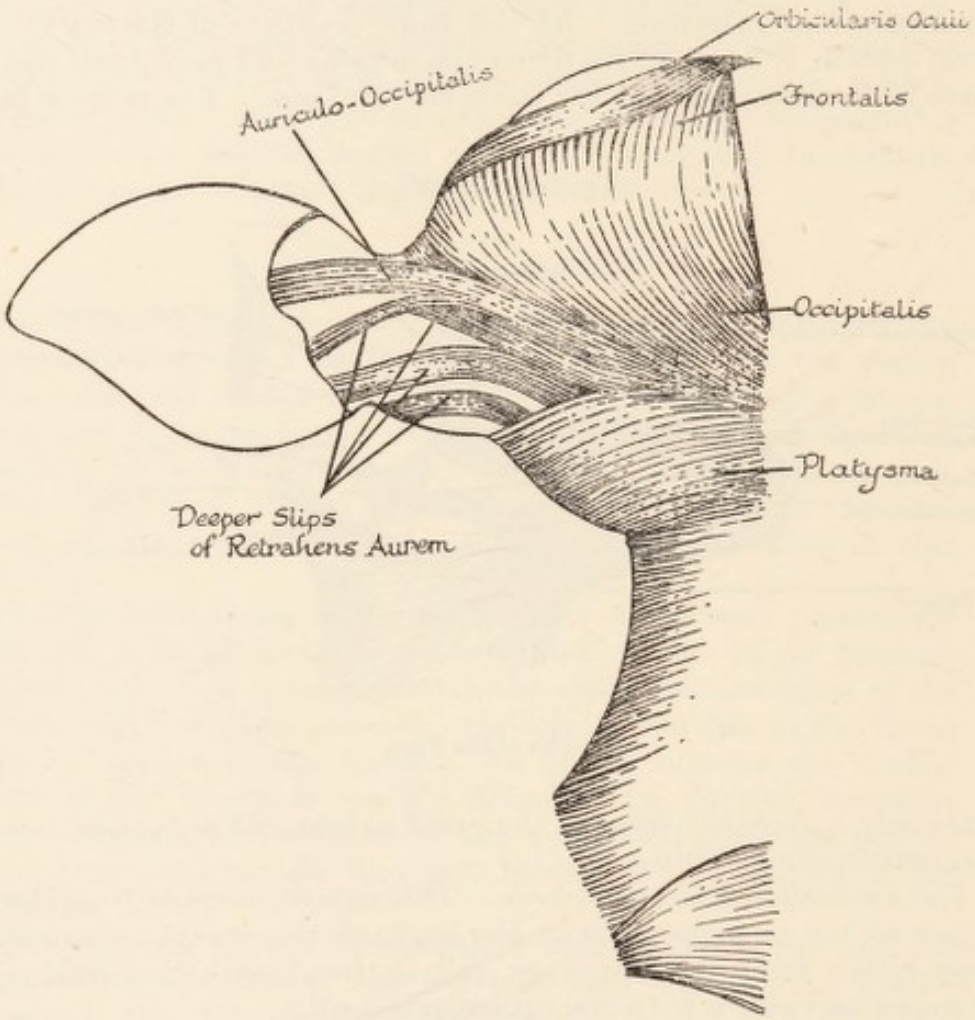
The Auriculo-labialis superioris.—In a superficial plane one prominent strand extends from the orbicularis oculi to the anterior border of the concha. In a deeper plane numerous fibres extend from the orbicularis oculi to the adjacent anterior border of the ear. This musculature is well marked in all Lemurs.

The Orbicularis Oris.—In the upper lip this muscle consists of many rows of fibres, but in the lower lip the fibres are extremely scanty. They are of course in continuity with all the neighbouring muscles and in particular with the orbicularis oculi. The fibres form a complete investment for the mouth, and mingling

with them there are fasciculi derived from the nose and maxilla. In addition there are, particularly in the upper lip, numerous fibres appertaining only to the lip—musculus labium proprius. The *buccinator* forms the usual arrangements of anastomosing fibres at angle of the mouth. Many of the fibres in the upper lip of the orbicularis are attached to the maxilla.

The *Quadratus labii superioris* consists of an angular head, the Levator labii superioris, and a more lateral portion arising from

Text-figure 43.



Muscles of the ear from behind.

the zygoma and maxilla. This latter part was called by Burmeister the zygomaticus and by Ruge the maxillo-labialis. There seems to be no good reason for distinguishing it from the quadratus of human anatomy. The *Levator labii superioris* arises from the nasal and maxillary bones and forms a number of slips arranged in superficial and deeper strata and inserted into the upper lip intermingled among the fibres of the orbicularis oris at their insertion, and among the fibres of the orbicularis oculi at their origin. The *Zygomatic portion* arises

from an extensive area of the malar and maxilla under cover of the circular muscles of the lower lid. The fibres composing it mingle with the fibres of the levator and become interspersed with the orbicularis of the upper lip.

The Muscles of the Ear.

The *Depressor Helicis* consists of two slips, one from the orbicularis oculi and a second from the zygoma. These meet and are inserted into the helix. The head from the zygoma is the erector auriculæ of Burmeister and possibly the mandibulo-auricularis of Ruge, which however is said to be supplied by the fourth nerve. Both the heads here described are supplied by the seventh nerve.

The *Musculus Tragus* and *Antitragus*.—These form an incomplete sphincter of the meatus. A few fibres run transversely on the tragus; then comes the insertion of the auriculo-labialis inferior; opposite the incisura there are transverse fibres, and finally some further transverse fibres extend to the back of the ear from the antitragus.

The *Musculus Occipitalis* lies subjacent to the platysma, with which the occipitalis is here in direct continuity. This retrahens auricularis of Burmeister is composed of four individual fasciculi which fuse at their insertions in all other Lemurs. The largest portion arises from the posterior part of the coronal suture and from the middle line of the occiput and the upper part of the ligamentum nuchæ. It is blended with the platysma and the occipitalis. The remaining three portions are on a deeper plane and take origin from the lambdoid suture. They spread out on the cranial aspect of the ear. This arrangement is most closely repeated in *Galago* and *Chiromys*.

The Muscles of the Nose.

The *Nasalis* consists of two parts. One, a thin sheet, arises on the dorsum of the nose and passes laterally, fusing with the fibres of the levator labii superioris. The other portion takes origin from the maxilla in the region of the canine fossa and incisor teeth. It spreads dorsally and becomes inserted into the dorsum of the nose. This differentiation of musculature in the region of the nose lifts *Tarsius* from the Lemuroidea into the realm of the Anthropoidea.

Around the aperture of the nose there is an almost complete sphincter. Above, transverse slips extend between the separated alar cartilages. Laterally where the alar cartilage separates them, the upper and lower margins are bridged by muscle-fibres. In the septum between the adjacent sides in the floor muscle-fibres extend from side to side.

The Deep Muscles of the Face.

The *Mentalis* is a moderately well-developed muscle in the lower lip, arising from the mandible in front of the mental foramen and fusing with the orbicularis oris.

The *Caninus* is considerable and arises from the maxilla, and mingles with the deep surface of the orbicularis in the upper lip.

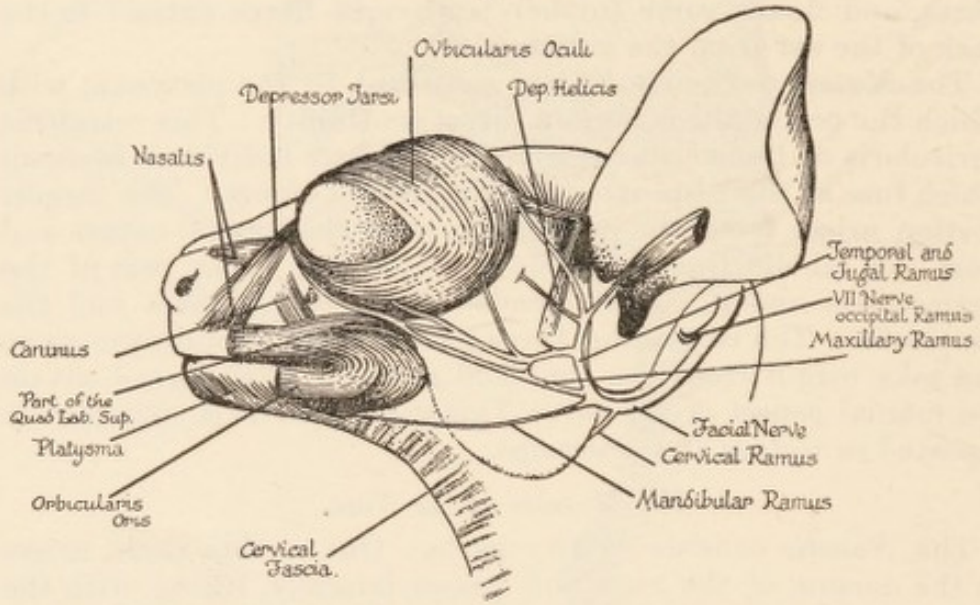
In general the facial muscles of *Tarsius*, owing to the greater differentiation of the primitive platysma sheet into distinct individual muscles, show an advancement beyond that of most other Lemurs. *Tarsius*, therefore, stands nearer the higher Primates. This is further brought out in a study of the distribution of the Facial Nerve.

Three stages have been distinguished in the evolution of the distribution of the facial nerve.

1. Simple Branches. 2. Plexiform Branches. 3. Plexiform arrangement with the Trigeminus.

In *Tarsius* the nerve has arrived at the second stage. It makes no plexus with the Trigemimus.

Text-figure 44.



Distribution of Facial Nerve.

The cervical and mandibular rami are large and simple. The posterior auricular branch begins as a single large twig which divides into four branches deep to the ear muscle.

The maxillary branch of the facial is much the most complicated, and supplies the area in which muscle differentiation is most advanced. All the Prosimiæ stand very closely together judged by the facial muscles and nerve. *Tarsius* agrees in the main with the Lemuroidea in the extent and connection with the facial muscles of the platysma. Also, as in all Lemurs, the facial nerve makes no anastomosis with the trigeminus. It shows some advance towards the higher Primates in the development of facial muscles, especially from the deeper platysma sheet *This advance of Tarsius is shared by Propithecus* (Ruge).

Muscles of Mastication.

M. Buccinator arises from the lower border of the zygomatic arch and from the surface of the upper jaw.

The fibres descend almost at right angles to the lower jaw, and become inserted into it along its whole border, covered in front by the orbicularis oris and behind by the masseter. It is of course supplied by the facial nerve.

Masseter is relatively a very large and massive muscle. The superficial portion, which is very much the larger, arises from the outer surface of the zygoma and zygomatic process. It reaches as far as the margin of the orbit. The deep head arises from the deep surface of the zygoma—very slender portion. The superficial portion is inserted into the outer and posterior surface of the ascending ramus, into the angle and into a groove on the lower margin of the mandible. The deep portion is inserted into the concave surface of the ascending ramus. Some of the deep fibres arise far back from the upper border and the medial part of the zygomatic process and swell up above the level of the zygoma and finally sweep downwards to a tendinous insertion in the antero-inferior angle of the ramus.

Temporal Muscle arises: (*a*) From the lateral surface of the skull within the temporal line.

(*b*) A posterior portion from the occiput passing immediately over the external auditory meatus, where it becomes tendinous.

The tendon thus formed continues to the coronoid process, receiving fleshy fibres along its upper border—a very powerful muscle. This muscle resembles closely in arrangement the temporal muscle of the other Lemurs and approaches the form found in some Rodents (see Mivart and Murie).

Pterygoideus Internus springs from the fossa between the two wings of the pterygoid process. It descends over the tympanic bulla to the deep surface of the ascending ramus of the lower jaw. It contains a tendon in its middle into which the fibres become inserted.

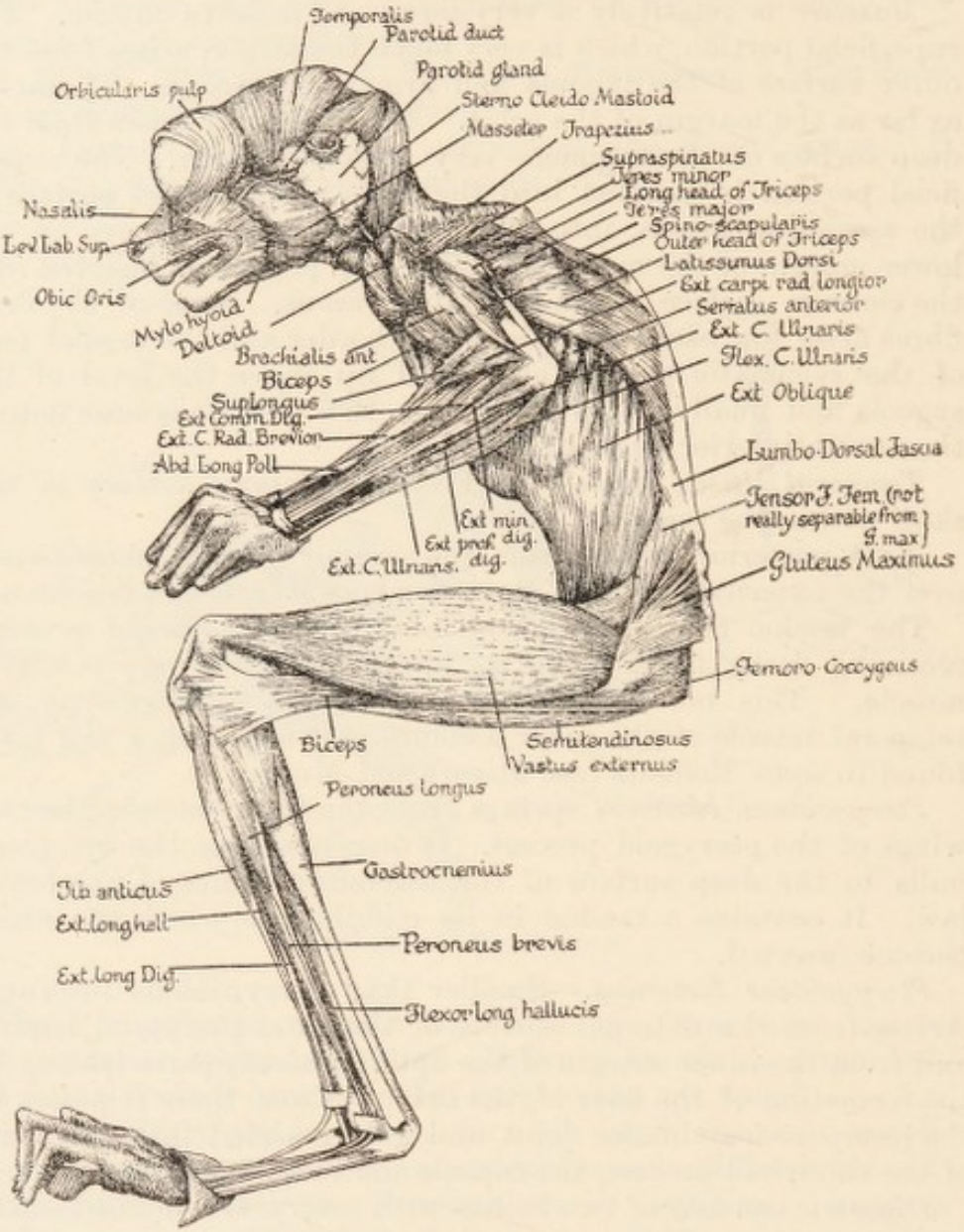
Pterygoideus Externus.—Smaller than pterygoideus internus. Arises from the external surface of the outer pterygoid lamina and from the inner margin of the optic foramen, participating in the formation of the floor of the orbit. From there it passes to the temporo-mandibular joint and gets inserted into the neck of the condyloid process, the capsule and meniscus of the joint.

Digastric consists of two bellies with a very well-defined intermediate tendon. The posterior belly arises from styloid region. No process is visible on the surface, being buried by the large inflated tympanic bulla. The course of the muscle is straight. The intermediate tendon lies behind the angle of the jaw and is not attached to the hyoid. The anterior belly is parallel with the horizontal ramus and is attached along the whole length of the lower border of the ramus as far as the symphysis. The

two anterior bellies unite across the middle line with each other. The posterior border of the fusion is crescentic and is marked by a tendinous margin, beneath which appears the mylohyoid. The anterior belly is supplied by the hypoglossal.

Wood-Jones mentions the intertendinous intersection of the

Text-figure 45.



Musculature of *Tarsius*.

Digastric as a very human feature of *Tarsius*, but Mivart and Murie record the presence of a strong intermediate tendon as being found in their dissections. It is certainly more like the same muscle in man.

The *Mylohyoid* is better marked in its posterior half. It does not quite reach the symphysis. It arises on either side from the

mesial surface of the horizontal ramus and from the hardened mucous membrane. The two fuse together in the middle line and reach the hyoid below. On reflecting the mylohyoid the hypoglossal nerve is exposed.

Muscles of the Neck and Back.

The Sternocleido-mastoid.—This is divisible into:

(*a*) Cleido-occipitalis. This part arises from the upper border of the clavicle and is inserted into the superior nuchal line from the external occipital protuberance to the region of the mastoid. The retrahens auriculæ lies superficial to it, and immediately distal to its dorsal border are the trapezius and rhomboids.

(*b*) The sterno-mastoideus. This arises from the upper border of the first piece of the sternum and is inserted in the mastoid region at the base of the ear. Its origin is narrow and covered by the cleido-occipitalis.

The *Hyoglossus* arises from the hyoid. It passes obliquely upwards into the tongue, expanding into a wider insertion than its origin. The lingual artery passes deep to the hyoglossus.

The *Geniohyoids* are relatively large and pass almost horizontally forwards to the symphysis from the hyoid.

The *Styloglossus* is a long slender muscle passing from the styloid region beneath the tympanic bulla to the upper border of the hyoglossus. The stylohyoid ligament is very slender and very long, and passes to the smaller corner of the hyoid from the styloid region. Close to its insertion there is developed in it a small "sesamoid."

The *Stylopharyngeus* passes between the middle and superior constrictor from the bulla. The *Stylohyoid* muscle is a slender muscle passing to the hyoid from the region of the bulla. It does not split to enclose the digastric tendon.

Omohyoid.—The posterior belly arises from the upper border of the scapula. The anterior belly is inserted in the lower border of the hyoid bone lateral to sternohyoid.

Sternohyoid.—Arises from the deep surface of the first piece of sternum along with sternothyroid. It is inserted into the lower margin of the hyoid bone.

Sternothyroid is situated ventral to the sternothyoid and arises from the deep surface of the first piece of sternum. It is inserted into lower border of hyoid under cover of the preceding muscles.

Thyrohyoid is the deepest of all the infrahyoid muscles and runs from the thyroid cartilage to the hyoid bone.

Like Burmeister we are unable to distinguish in the intrinsic musculature of the tongue a genioglossus (see description of tongue, p. 1125).

The Vertebral Region (anterior and lateral).

The *Rectus capitis anticus major* arises from the anterior tubercles of the fourth, fifth, and sixth cervical vertebræ and is

inserted into the basi-occiput. Burmeister gives it as arising from the upper five cervical vertebræ. In most Lemurs it is much the same, but in some, as *Nycticebus*, it is much larger and arises in the thoracic region.

The *Rectus capitis anticus minor* arises from the body and transverse process of the atlas and is inserted into the basi-occiput. Burmeister gives a more extensive origin. It agrees well with other Lemurs.

The Longus Colli.—Burmeister describes this muscle as consisting of two portions, but we think it is possible to separate three portions. The *lower oblique portion* arises from the upper five thoracic vertebræ and is inserted into the transverse process of the sixth thoracic vertebra.

The *upper oblique portion* arises from the third, fourth and fifth transverse processes and is inserted into the anterior tubercle of the atlas.

The *vertical portion* consists of fibres running from the bodies of the third to the sixth cervicals to the bodies and transverse processes of the first two cervicals.

The muscle agrees well in the Lemuroidea.

The Scalene Muscles.

The *anticus* arises from the transverse processes of the sixth and seventh cervical vertebræ and is inserted into the front part of the first rib. The subclavian artery passes in front of it and the brachial plexus behind it.

The *medius and posticus* are not to be separated. They arise from the transverse processes of the upper six cervical vertebræ and proceed to the upper surface of the first rib and to the second and third ribs, behind the brachial plexus.

The Vertebral Region (posterior and superior).

The *Splenius* arises from the ligamentum nuchæ and the spines of the upper thoracic vertebræ and is inserted into the mastoid process and the superior nuchal line in its capitis portion, while the cervical portion is inserted into the transverse process of the atlas. The muscle varies somewhat in the Lemurs. The colli portion is often absent.

The *Complexus* arises from the transverse processes of the second to the seventh cervicals and from the first to the fourth thoracic vertebræ. It is divisible into a medial and a lateral portion. The medial portion shows three inscriptiones tendineæ. In the lateral portion the uppermost inscription only is repeated. The mass of the muscle is inserted into the occiput below the superior nuchal line. A biventer cervicis is present according to our dissection, though unrecorded by Burmeister. There is considerable variation among the Lemurs. *Galago* has a biventer, but *Lemur catta* has not.

The *Trachelo-mastoid* arises from the transverse processes of all the cervical vertebræ and is inserted into the occiput. The same in all Lemurs.

The *Rectus capitis posticus major* arises from the spine of the axis and is inserted into the occiput.

The *Rectus capitis posticus minor* arises from the posterior tubercle of the atlas and is inserted into the occiput somewhat medial to and under cover of the preceding muscle.

The *Rectus capitis lateralis* runs from the transverse process of the atlas to the occiput. It is not mentioned by Burmeister, but is undoubtedly present.

The *Obliquus capitis superior* arises from the transverse process of the atlas and is inserted into the occiput.

The *Obliquus inferior* arises from the spine of the axis and is inserted into the transverse process of the atlas. The great occipital nerve appears at the lower border of the inferior oblique.

These muscles are relatively enormous, and suggest that they are so developed since the creature turns its head rather than its eyes.

Muscles of the Trunk.

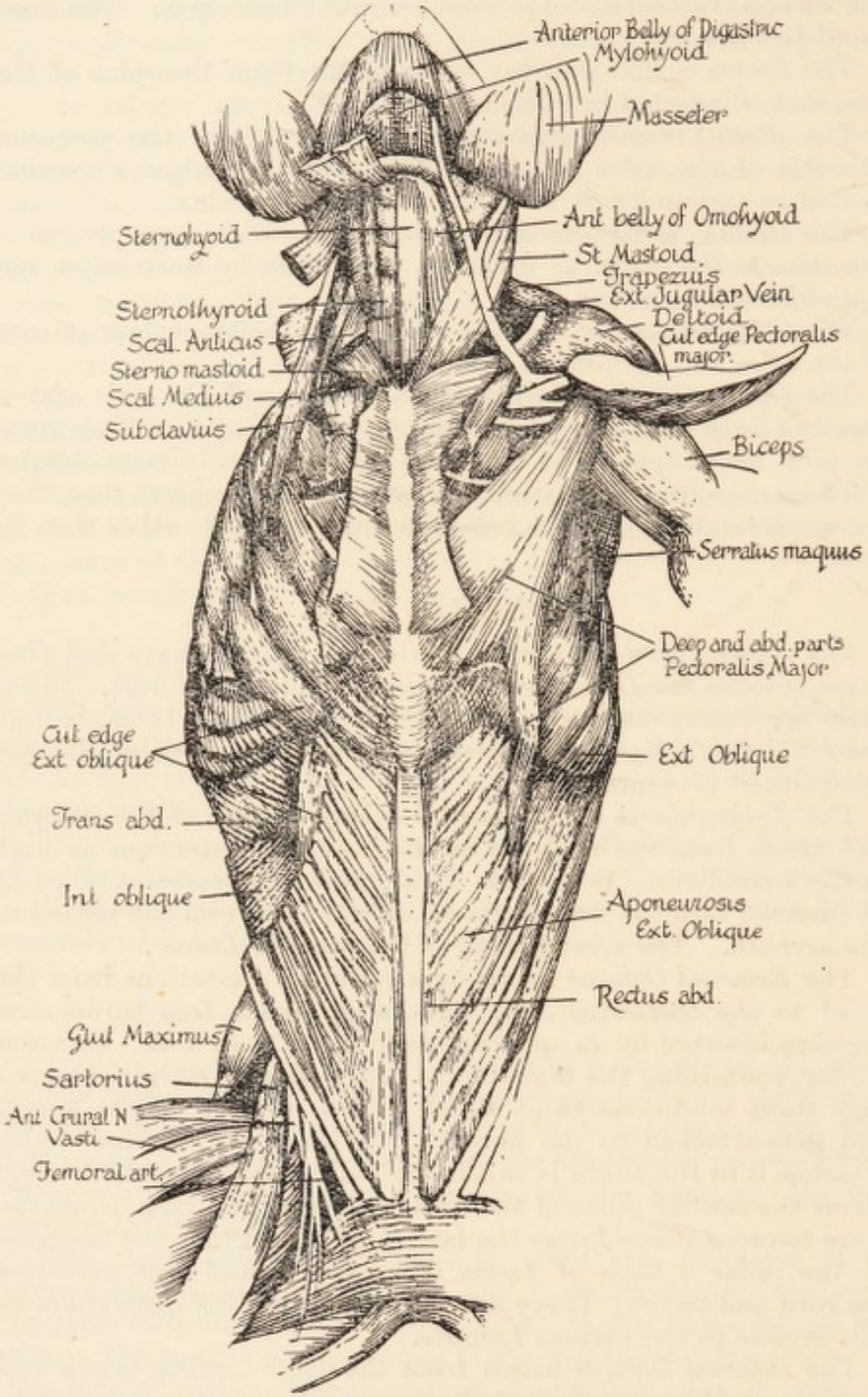
The Supra-costal muscles.—Murie and Mivart have described these muscles for *Lemur* and *Nycticebus* and other forms. In the three specimens dissected by me I have not found them, though their existence has been borne in mind. Burmeister did not record their presence.

The *Triangularis sterni* lines the deep surface of the sternum and arises from the ensiform cartilage and the sternum as high as the second rib. It extends by a number of serrated slips to be inserted into the deep surfaces of the ribs from the second to the seventh. The arrangement is the same in *Lemur*.

The *External Oblique* arises by a series of digitations from the third to the thirteenth rib. It has a dorsal free border and becomes inserted by an aponeurosis into the linea alba. Its lower border, containing the fibres of the free posterior margin, forms a very stout tendinous band which passes in front of the rectus and gets attached to the pubis. The fascia below this which attaches it to the ilium is much more slender. The thick band forms the medial pillar of the external abdominal ring, while the more tenuous tissue forms the lateral pillar. From the margins of the pillar a tube of fascia is given off, and this embraces the cord and testis. There are only the slightest differences in this muscle in the various Lemurs.

The *Internal Oblique* arises from the dorso-lumbar fascia and from the ventral margin and the outer portion of the crural arch. The general direction of the fibres is transverse, and they become attached to the lower costal cartilages and by an aponeurosis that splits to enclose the rectus in its upper two-thirds it reaches the linea alba and the pubis. The muscle is the same in all Lemurs.

Text-figure 46.



Musculature of the Trunk.

The *Transversus abdominis* arises from the dorso-lumbar fascia and from the lower six ribs. The general direction of its fibres is downwards, forwards, and inwards. They remain fleshy

in considerable part, and in the upper two-thirds of the abdomen they reach the linea alba behind the rectus. In the distal third they reach the same structure by passing in front of the rectus. Both the internal oblique and the transversalis form arching fibres above the inguinal canal. The cremaster muscle seems to be derived from both muscles, but mainly from the transversus. Its disposition is much the same in all Lemurs.

The *Rectus abdominis* arises very broadly from the pubis and adjacent portion of the ilium. It has no intertendinous intersections. Above it reaches not higher than the fourth, fifth, and sixth ribs, which is lower than recorded in any other Lemur It is given by Burmeister as reaching the first rib, but this we cannot agree with. The intersections are absent in all Lemurs. It is true that the pyramidalis cannot be separated as a distinct muscle, but there can be no doubt that it is included in the broad origin of the rectus and fibres from the lateral portion can be traced into the linea alba.

The Dorsal Region.

The *Trapezius* arises from the lower half of the ligamentum nuchæ and from the spines of the upper four dorsal vertebræ. Burmeister extends it as far as the spine of the twelfth, but our observation does not agree with this. It becomes inserted into the spine of the scapula. Its cranial margin has in front of it the levator anticus scapulæ. Except for this limitation to its downward extent it agrees in all Lemurs.

The *Depressor scapulæ* arises from the fascia covering the dorsal muscles and by fleshy fibres from the spines of the eighth, ninth, and tenth thoracic vertebræ. The muscle overlies the origin of the infraspinatus and the teres minor and lies on the latissimus dorsi. It is inserted into the superior (anterior) angle of the scapula. It is absent in most other Lemurs.

The *Rhomboideus* is not separable into a minor and major. It arises from the lower half of the ligamentum nuchæ and from the spines of the first three dorsal vertebræ and is inserted into the vertebral border of the scapula. It is undivided in all Lemurs.

The *Rhomboideus capitis* of Mivart and Murie was described by Burmeister under the name of Levator posticus scapulæ. It arises from the ligamentum nuchæ and the first and second spines of the cervical vertebræ and is inserted into the superior angle of the scapula in close apposition with the levator angulæ scapulæ, and is supplied by the spinal accessory nerve. This muscle is subject to slight variation in the Lemurs.

The *Levator scapulæ anticus*, though inserted into the acromion, is called by Mivart and Murie the Levator claviculæ. It arises from the ventral surface of the atlas and is inserted into the caudal margin of the acromion after passing under cover of the sterno-mastoid. This description of the muscle holds for *Lemur catta*.

The *Levator angulæ scapulæ* arises from the upper five cervical transverse processes and is inserted into the superior angle of the scapula. It is to some extent blended with the serratus anticus, but the extent of this blending is greater in the other Lemurs than in *Tarsius*.

Dorsal Region (*deep layer*).

The *Serratus anticus or magnus* arises from the second to the ninth ribs in the mid-axillary line and is inserted into the vertebral border of the scapula. The lower digitations converge on the inferior angle and the remainder on the vertebral border. The extent of the origin varies slightly in the other Lemurs.

The *Latissimus dorsi* arises from the lower seven thoracic vertebræ, from the lumbar vertebræ, and the cranial margin of the ilium by way of the dorso-lumbar fascia. It is inserted into the floor of the bicipital groove. It is the same in all Lemurs. There is no costal or scapular origin. The dorsi-epitrochlearis has been described with the muscles of the upper extremity.

The *Serratus posticus superior* has six serrations and extends from the second to the seventh rib.

The *Serratus posticus inferior* has six digitations and extends from the seventh to the thirteenth rib.

The *Sacro-lumbalis* arises out of the mass of the erector spinæ and is inserted into all the ribs. It agrees substantially in all Lemurs.

The *Cervicalis ascendens* continues the sacro-lumbalis to the seventh cervical vertebra.

The *Longissimus dorsi* separates out from the sacro-lumbar mass and is inserted into the transverse and articular processes of the lumbar and dorsal vertebræ. This agrees in all Lemurs.

The *Transversalis cervicis* continues the foregoing muscle to the seventh and intervening cervical vertebræ as far as the atlas.

The *Spinalis dorsi* cannot be defined.

The *Transverso-spinales* muscles include the semispinales passing from the metapophysis (mamillary process) to the spinous process and the *multifidus* in the intervals between the spines and transverse processes.

Muscles of the Tail.

Caudal Region (*dorsal and ventral surfaces*).

The *Levator caudæ externus* arises from the transverse processes of the fourth and fifth lumbar vertebræ and the adjacent portion of the ilium and is inserted into the tail vertebræ by a number of tendons. The more proximal ones are directly attached to the vertebræ, while the more distal ones pass over succeeding vertebræ to which they are attached, and ultimately they are continued right to the tip of the tail.

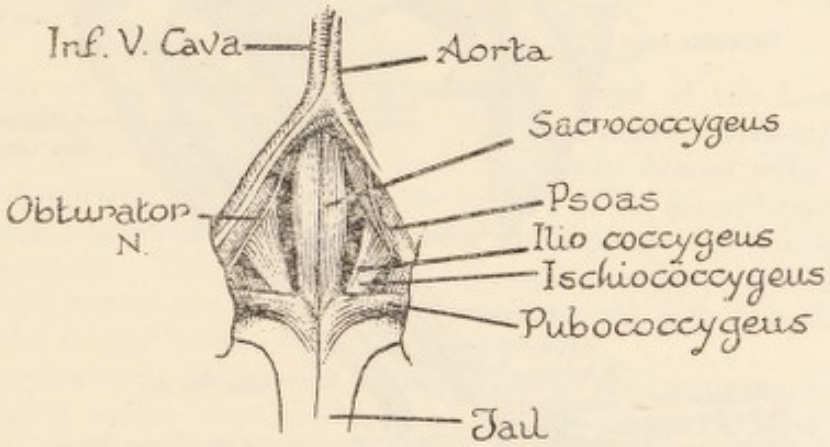
The *Levator caudæ internus* is fused above with the longissimus dorsi. It arises from the transverse processes of all the dorsal

vertebræ, from the lumbo-dorsal fascia, and the spines and dorsal surfaces of the lumbar, sacral, and caudal vertebræ. It becomes tendinous, and the tendons receive fleshy reinforcements from the more proximal tail vertebræ. The tendons are inserted into the tail vertebræ, eventually reaching the tip.

The *Pubo-coccygeus* is widely separated at its origin from the ilio-coccygeus. It arises from the pubis and lies in a more superficial plane than the adjacent muscles, and it crosses these as it passes to be inserted into the ventral surface of the third coccygeal vertebra at the chevron bones.

The *Ilio-coccygeus* arises from the cranial margin and the pelvic surface of the ilium and is inserted into the third caudal or coccygeal vertebra, and is continued by a tendon to the ventral surface of the first tail vertebra.

Text-figure 47.



Ventral view of Tail Muscles.

The *Sacro-coccygeus ventralis* arises from the ventral surface of the sacrum and is inserted by tendons into the ventral surface of the tail vertebræ as far as the tip of the organ.

The *Ischio-coccygeus* lies dorsal to the ilio-coccygeus and passes from the ischium to the transverse processes of the coccygeal vertebræ.

Muscles of the Upper Extremity.

Anterior and Thoracic Region.

Pectoralis major.—This muscle is large and powerful. It consists of three portions:—

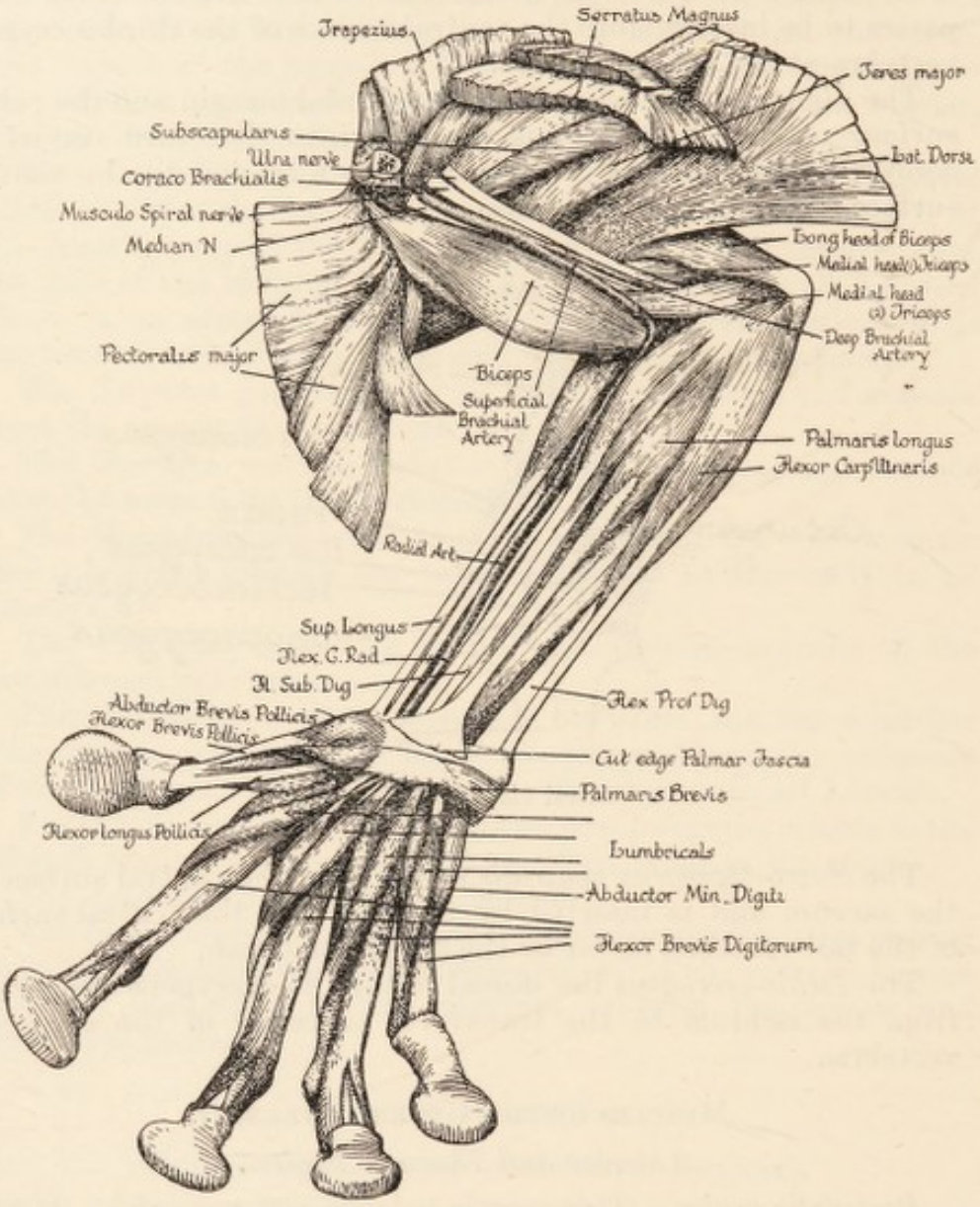
(1) A clavicular portion which arises from the inner fourth of the clavicle, where it is crossed by the cephalo-jugular trunk. This portion is at first easily separable from the deltoid, but as it approaches the insertion of that muscle it becomes intimately fused to the deltoid.

(2) The second portion arises from the whole length of the sternum. Above it is usually bound to the clavicular part.

Below it overlies the third part of the muscle. At its insertion it lies beneath the clavicular portion and becomes fused with its insertion into the deltoid ridge.

(3) This third portion seems to have been regarded by Burmeister as the pectoralis minor. It takes origin under cover of

Text-figure 48.



Flexor musculature of Upper Limb.

the preceding part from the margins of the fifth, sixth, seventh, and eighth ribs. Here at its lateral border it becomes directly continuous with the rectus abdominis by a broad fasciculus. The insertion is deep to the preceding portions on the ventral face of the broad crest forming the deltoid eminence and the lateral boundary of the bicipital groove.

Pectoralis minor.—As already mentioned, Burmeister regarded the third portion of the pectoralis major as the pectoralis minor. The origin and insertion undoubtedly relate it to the major. There is then no muscle corresponding to the minor.

The pectoralis as above described corresponds to the same muscle in *Lemur*. In *Galago* the minor is absent. To the lower border of the pectoralis major is attached the subcutaneous muscular sheet that begins on the medial aspect of the knee and runs up along the inner side of the thigh and along the abdomen and thorax, and finally in the neighbourhood of the axilla gathering itself into a very definite fasciculus and being attached to the lower border of the pectoralis major.

Subclavius arises from the first rib lateral to the termination of the external jugular vein and medial to the axillary vein. It is inserted into the under surface of the clavicle. It is a substantial muscle, and it extends beyond the middle of the under surface of the clavicle. The muscle is much the same in all Lemuroidea

Shoulder and Scapular Region.

Deltoid.—This muscle differs from that in most of the Lemurs by consisting of two portions only. The first portion arises from the outer half of the clavicle and is closely bound with the clavicular portion of the pectoralis major. The second portion arises from the acromion process and a small portion of the spine of the scapula. The two portions are separated by a tendinous raphe. By a common tendon they are inserted into the distal part of the lateral ridge of the bicipital groove.

Supraspinatus.—This takes origin from the supraspinous fossa, and passing under the arch formed by the acromion and the clavicle it is inserted into the radial or greater tuberosity of the humerus. It is the same in all the Lemuroidea save that in *Lemur* it tends to extend to the inferior aspect of the spine of the scapula.

Infraspinatus arises from the spine of the scapula and overlaps the teres minor. It passes under cover of the dorsal border of the deltoid to be inserted into the greater tuberosity of the humerus. Overlying the main mass of the muscle there is a more superficial portion arising from the vertebral border of the scapula near the attachment of the spine, separable throughout its course but fused with the main mass at its insertion.

Otherwise this muscle is constant in all the Lemurs.

Subscapularis.—This is a very large and powerful muscle. It consists of four bellies bound together by tendinous intersections. The teres major runs along its lower border. It is inserted into the medial tuberosity of the humerus.

Teres major.—This muscle arises from the whole length of the inferior border of the scapula. It is covered on its posterior surface by the latissimus dorsi. It passes behind the long head of the biceps and is inserted into the medial lip of the bicipital groove. Practically the same in all Lemuroidea.

Teres minor.—In one specimen the teres minor was absent. In others it is present as a feeble muscle coming from the inferior border of the scapula and is inserted into the greater tuberosity of the humerus. In all Lemuroidea it is a feeble muscle.

Humeral Region (*posterior and anterior*).

Triceps.—This muscle consists of six portions which Burmeister numbers the first to the sixth anconeus.

(1) The long head of the triceps, which corresponds to anconeus primus, arises from the scapula just below the glenoid cavity and extends medially alongside the lateral head and joins the common tendon of insertion which is attached to the olecranon.

(2) The lateral head of the triceps corresponds to the anconeus secundus, and arises from the great tuberosity of the humerus by a pointed tendon and joins the common tendon of insertion into the olecranon.

(3) The medial head of the triceps is in two portions, the upper corresponds to the anconeus tertius and the lower to the anconeus sextus. The upper head arises from the medial margin of the bicipital groove in a pointed origin and joins the common tendon.

(4) The anconeus proper (the A. quartus of Burmeister) comprises the lower part of the medial head as well as the anconeus itself. The whole muscle arises from the dorsal aspect of the humerus in its distal third and more to the lateral side and joins with the deep surface of the common tendon.

(5) The remaining element in the triceps is the dorsi-epitrochlearis (the anconeus quintus), which runs from the lower border of the latissimus dorsi near its insertion and joins the common tendon on its medial side and so reaches the olecranon.

This arrangement of the triceps is substantially the same as in *Lemur* and in *Galago.* Individual differences arise such as in *Nycticebus*, where the medial head is single.

Biceps.—As in man arises by two heads. The short head arises from the lateral side of the apex of the coracoid process in common with the coraco-brachialis. The long head begins at the upper margin of the glenoid cavity and traverses the shoulder-joint. This tendon is strikingly broad. The two bellies join together at the middle of the arm, and the tendon of insertion is attached to the tubercle of the radius. This muscle is much the same in all Lemurs. In *Galago* the two heads only join together just above the bend of the elbow. In *Nycticebus* the muscle has only one head.

Coraco-brachialis consists of two portions. The larger portion arises from the tip of the coracoid process and passes down the medial side of the humerus to be inserted into the medial border just beyond the middle. The second portion is much smaller and arises from the under surface of the coracoid process and passes to be inserted into the humerus on its medial aspect almost immediately. Between the two portions passes the musculo-cutaneous nerve. This muscle is practically the same in all Lemurs.

Brachialis anticus arises from the lateral margin and front of the humerus as high as the insertion of the deltoid. The origin of the muscle does not extend up beyond the deltoid on the medial side, but on the lateral side it is more extensive and reaches posterior to the deltoid and helps to bound the musculospiral groove. The muscle is inserted into the coronoid process of the ulna. The muscle is practically the same in all Lemurs.

Extensor Region of the Forearm. (See text-fig. 45.)

Supinator longus arises from the lateral supracondylar ridge of the humerus and is inserted into the radial margin of the radius near its lower end. The insertion is not far distal to the insertion of the pronator teres. This muscle is the same in all Lemurs.

Supinator brevis arises from the external condyle of the humerus and from the orbicular ligament. It does not arise at all from the ulna. The muscle winds around the upper extremity of the radius and is inserted into the anterior surface of the bone along a line that corresponds to the origin of the flexor longus pollicis and to the insertion of the pronator radii teres. The muscle is pierced by the dorsal interosseous nerve. This muscle is the same in all Lemurs. Mivart is silent as to whether it is pierced in *Lemur* by the dorsal interosseous nerve.

Extensor carpi radialis longus arises from the lateral supracondylar ridge of the humerus. It passes distally under the tendon of the abductor longus pollicis and the extensor longus pollicis. It is inserted into the base of the second metacarpal bone. This muscle is the same in all Lemurs.

Extensor carpi radialis brevis arises from the lateral condyle of the humerus and is inserted into the base of the third metacarpal. The tendon of this muscle is closely applied to the tendons of the extensor communis digitorum. This muscle is the same in all Lemurs.

Extensor communis digitorum arises from the common extensor origin and halfway down the forearm the fleshy bellies give place to tendons, the transition beginning on the ulnar side and thus affecting the fleshy belly of the extensor minimi digiti first. The tendons remain in close apposition until they have passed beyond the dorsal annular ligament. Thereafter they diverge and extend along the dorsal surfaces of the medial four digits, finally being inserted into the base of the dorsum of the terminal phalanx. As the tendons cross the interphalangeal joints they form a dorsal extensor expansion.

Extensor minimi digiti arises in series with the communis, and is not related to the extensor carpi radialis brevis as Burmeister suggests. Its tendon comes off from its muscular belly earlier than those from the communis. After passing under cover of the dorsal annular ligament its tendon splits into two, the radial one joins with the tendon of the communis for the

fourth digit and the ulnar tendon joins with the communis tendon for the fifth digit.

In most Lemurs the tendons after formation reunite and then dissociate for their ultimate distribution. However, *Galago* and *Cheiromys* and man have the same simple arrangement as in *Tarsius*.

Extensor carpi ulnaris arises from the lateral condyle of the humerus and also from the radial margin of the olecranon process of the ulna. It passes through a separate compartment of the dorsal annular ligament and is inserted into the base of the fifth metacarpal. This muscle is much the same in all Lemurs, except that in some it may divide as it occasionally does in man.

Abductor longus pollicis arises from about two-thirds of the dorsal surface of the radius, beginning just below the upper extremity of the bone. It also arises from the adjacent interosseous membrane. It passes through a special compartment of the dorsal annular ligament on the lateral aspect of the distal extremity of the radius, and is inserted into the base of the first metacarpal. This muscle is substantially the same in all Lemurs.

Neither in *Tarsius* nor in any of the Lemurs is there present an extensor pollicis brevis.

Extensor longus pollicis arises from high up on the dorsal surface of the ulna in its upper third. At its origin it is superficial to the abductor longus pollicis. In addition to being inserted into the base of the terminal phalanx of the first digit it gives a slip to the index finger. This suggests some limitation of the opposability of the thumb.

This muscle seems to be the same in all Lemurs, though the slip to the index is not usually described.

Extensor indicis arises from the ulna in its middle third from the dorsal surface of the bone. In the distal part of the forearm it becomes tendinous and forms three tendons which are destined for the second, third, and fourth digits. This tendon to the fourth digit was not mentioned by Burmeister, and it was only present in one of our specimens. In the others it was joined to the communis tendon of the fourth digit by fascia. In our specimens it does not arise from the radius at all. There is some variation in the Lemurs as to how many tendons it divides into, but the usual number seems to be two, one for the index and one for the third digit.

Flexor Region of the Forearm. (See text-fig. 48.)

Pronator radii teres arises from the medial condyle of the humerus; it has no origin from the ulna. The muscle is a very powerful one, and obtains insertion into the radius for a distance of about one inch between the supinator brevis and the origin of the flexor longis pollicis. The median nerve and

the deep brachial artery emerge from the entepicondylar foramen and pass beneath the pronator radii teres. The median nerve continues down the forearm between the flexor sublimis and the flexor profundus, while the brachial breaks up into its branches (see under Blood-vessels). This muscle is the same in all Lemurs.

Flexor carpi radialis arises from the common flexor origin from the medial condyle of the humerus. It lies immediately in front of the pronator radii teres, with which for a while it is blended. The tendon issues from the muscular part in about the upper third of the forearm and passes underneath the transverse carpal ligament to be inserted into the base of the second metacarpal. This muscle is the same in all Lemurs.

Palmaris longus arises from the common flexor origin from the medial condyle of the humerus. It is fused for a distance with the flexor carpi ulnaris. The tendon issues from the fleshy belly halfway down the forearm. Above the transverse carpal ligament the tendon flattens out and becomes inserted into the palmar aponeurosis. This muscle is the same in all Lemurs.

Flexor carpi ulnaris arises from the medial condyle of the humerus and by an aponeurosis from the ulna and from the fibrous tissue between the adjacent muscles. Its tendon appears about the middle of the forearm and becomes inserted into the pisiform bone and by extension into the base of the fifth metacarpal. This muscle is the same in all Lemurs.

Flexor sublimis digitorum is a small muscle which arises entirely from the medial condyle of the humerus. In *Lemur* it communicates by its deep surface with the flexor profundus digitorum, and in *Tarsius* a similar communication arises in the distal third of the forearm. Opposite the metacarpo-phalangeal joint the four tendons into which the muscle has divided split to allow the tendons of the flexor profundus to pass through them. They then reunite and are inserted into the base of the second phalanx. The arrangement in *Tarsius* is the same as in *Lemur*, *Galago*, and *Loris*.

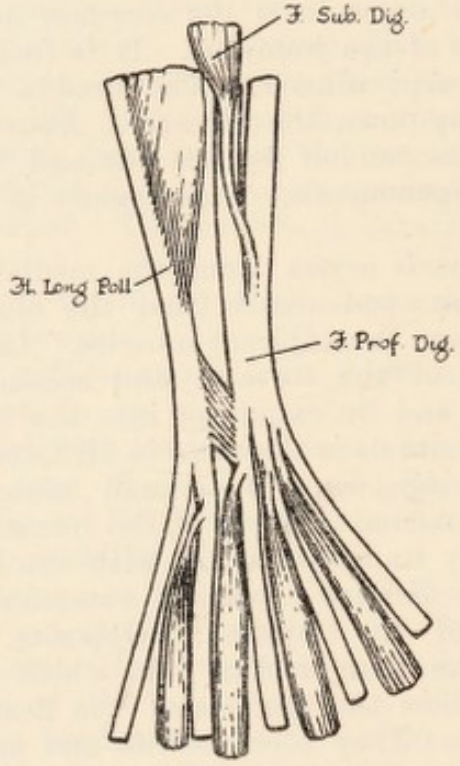
Flexor profundus digitorum compared with the flexor sublimis is a very large muscle indeed. It arises from (1) the medial surface of the ulna in its upper two-thirds, (2) from the medial condyle of the humerus, (3) and from the interosseous membrane and the medial surface of the ulna high up. Just above the carpal arch two tendons appear, and immediately below the carpal arch these divide into three, and passing through the tendons of the flexor sublimis they become inserted into the base of the terminal phalanx of the medial three digits. It is joined by a fibrous band to the flexor sublimis.

On the radial side the tendons of the profundus are fused with the tendons of the flexor pollicis longus. The degree of fusion between the profundus and the flexor longus pollicis

varies greatly in the different members of the Lemuroidea. In *Lemur* and *Galago* it is much the same as in *Tarsius*.

Flexor pollicis longus is a very powerful muscle. It takes origin by a large humeral head in close apposition with the flexor profundus and from the radius just below the tuberosity. The belly of the muscle is distinct from both the sublimis and the profundus. Immediately above the wrist the tendon of the flexor longus pollicis fuses with the tendon of the profundus, but soon becomes again separate, and then finally splitting into two, these are inserted into the base of the

Text-figure 49.



Relations of the digital flexors.

terminal phalanges of the pollex and the index. These two tendons replace the tendons of the profundus. This arrangement is repeated in *Lemur* and *Galago*.

In *Nycticebus* the flexor of the thumb is quite distinct from the profundus and greatly exceeds it in size.

Pronator quadratus is a fairly considerable muscle and extends from the ulna to the radius, occupying somewhat more than the distal fourth of these bones. The volar interosseous nerve passes under cover of the muscle. Mivart raised a query as to whether radio-ulnar fibres were to be found covering the whole extent of the interosseous membrane. This is certainly not the case. The muscle is confined to the distal area.

The Muscles of the Hand. (See text-fig. 48.)

Palmaris brevis.—This muscle is quite distinct. It arises from the transverse carpal ligament and is inserted into the fascia over the hypothenar eminence. It is present in *Lemur*, but Murie and Mivart were not able to make it out satisfactorily in *Galago*, *Loris*, or *Nycticebus*.

Lumbricales.—These muscles are relatively very large and they take origin from the radial side of the tendons of the flexor longus pollicis and from the flexor profundus. The first lumbrical arises from the radial side of the tendon of the flexor longus pollicis and the fourth from the ulnar side of the tendon of the fourth digit, being an exception to the rule. The tendons of these muscles pass round the radial sides of the digits to reach the dorsal extensor expansion opposite the metacarpo-phalangeal joint. These muscles are substantially the same in all Lemurs. *Perodicticus* has, however, only three.

Abductor brevis pollicis arises from the transverse carpal ligament and from the trapezium, and is inserted into the radial side of the first phalanx of the thumb. It is not so obvious in the Lemurs.

Adductor pollicis.—The transverse and oblique portions are more readily separable at their insertions than at their origins. The muscle arises from the palmar surface of the third metacarpal, and a tendinous intersection separates it from a similar muscle passing to the fifth digit. The lateral and less oblique fibres are inserted into the medial side of the base of the first phalanx of the thumb. The longer and more medial fibres end in a tendon which has a similar insertion. In the Lemurs the muscle appears to consist of one part only.

Flexor brevis pollicis arises from the transverse carpal ligament and from the trapezium. It divides into two portions, which are inserted into either side of the base of the first phalanx. Same in all Lemurs.

Opponens pollicis is a very minute muscle. It arises from the trapezium and the transverse ligament, and is inserted into the radial margin of the first metacarpal for about half its length. The same description applies to the Lemurs.

Abductor minimi digiti arises from the ridge on the unciform bone, and is inserted into the ulnar side of the base of the first phalanx of the little finger and into the dorsal extensor expansion. The flexor brevis minimi digiti is not separable from the abductor. This arrangement is the same in all Lemurs.

Opponens minimi digiti arises from the palmar surface of the third metacarpal, separated by a tendinous raphe from the adductor transversus pollicis. The muscle is inserted into the ulnar margin of the fifth metacarpal. This muscle is not mentioned by Burmeister. It differs from the description of the same muscle in *Lemur* as given by Murie and Mivart.

Lying in the same plane as the abductor minimi digiti and immediately medial to it, a muscle arises from the cuneiform and pisiform adjacent to the insertion of the flexor carpi ulnaris and under cover of the palmaris brevis, and is inserted into the base of the fifth metacarpal.

Palmar interossei (the interossei interni of Burmeister) *and the dorsal interossei* (the interossei externa of Burmeister).—These muscles represent real flexores breves digitorum, and they are eight in number, that is two for each digit except the pollex. The one on the ulnar side of the fifth digit represents the abductor minimi digiti, and the one on the radial side of the index the abductor indicis. These muscles arise from the palmar surface of the metacarpal bones, and opposite the first phalanx they tend to embrace the digit. Ventrally they are fused and remain fleshy as far as the terminal phalanges. They lie superficial to the fibrous flexor sheaths and are finally inserted about the base of the terminal phalanx.

The arrangement is much the same in all Lemurs.

THE MUSCULATURE OF THE LOWER EXTREMITY. (See text-fig. 45.)

The *Gluteus maximus* arises from the dorsal aspect of the ilium, from the dorso-lumbar fascia, and from the dorsal aspect of the sacrum. This part of the muscle is inserted into the third trochanter. The next part of the muscle arises from the transverse processes of the three coccygeal vertebræ and lies in apposition with the gluteus maximus dorsal to the great sciatic nerve. The inferior gluteal nerve passes between the two elements. This Femoro-coccygeus of Leche and Appleton was called by Burmeister pyriformis (*a*). It is inserted into the linea aspera in its upper two-thirds. It is supplied by a branch from the great sciatic nerve. The *tensor fascia femoris* is not present as a separate muscle. The Gluteus maximus muscle is substantially the same in all Lemurs. The tensor is absent in all Lemurs.

The *Gluteus medius* arises from the dorsal portion of the ilium and is inserted into the great trochanter of the femur. The *Gluteus minimus* arises from the lower part of the ilium just above the reflected head of the rectus femoris and is inserted into the great trochanter. The *Scansorius* is not present, and is found in no Lemur.

The *Piriformis* can hardly be described as a separate muscle, but is represented by the lower fibres of the gluteus minimus. In other Lemurs it is described as a large muscle.

The *Gemellus superior* arises from the ischial ramus just above the tuberosity.

The *Gemellus inferior* arises from the dorsal border of the ischial tuberosity.

The *Obturator internus* arises from a wide origin around the obturator membrane, from the pelvic surface of the pubis and ischium. It emerges from the pelvis by passing over the ischial

ramus, and joins with the gemelli to be inserted into the superior border of the great trochanter.

The *Quadratus femoris* arises from the lateral border of the ischial tuberosity, and passes to the femur where it has an extremely wide insertion. The insertion extends from the great trochanter along the posterior surface of the femur in its upper third. The distal portion of this muscle with a distinct branch from the great sciatic nerve represents the caudo-femoralis of Appleton and pyriformis (*b*) of Burmeister. This muscle is equally extensive in other Lemurs.

The *Obturator externus* arises from the obturator membrane and the bony margin of the foramen and passes to be inserted into a fossa medial to the upper margin of the great trochanter.

The *Iliacus* arises from the ventral aspect of the ilium and is inserted into the small trochanter of the femur and the bone immediately below it. Most of its fibres join with the psoas. In some Lemurs there is a tendency for the iliacus to split into two.

The *Psoas magnus* arises from the first to the fifth lumbar vertebra from the intervertebral discs and the adjacent side of the bodies; also from the fronts of the transverse processes. It is inserted into the small trochanter of the femur. It extends higher than in the other Lemurs.

The *Psoas minor* arises from the first and second lumbar vertebræ and descends in front of the psoas magnus to the iliac region, where it divides. The medial insertion is into the pubic region, while the lateral one is fused with the fascia covering the iliacus. The femoral nerve issues between the psoas magnus and the parvus. The muscle is larger in the other Lemurs.

The *Quadratus lumborum* lies partly under cover of the psoas and partly along its lateral border. It takes origin from the inner surface of the ilium and is inserted into all the transverse processes of the lumbar vertebræ as high as the first and finally is continued as a tendon in front of the last two ribs to reach the eleventh thoracic vertebra. Much the same in all Lemurs.

Femoral Region.

The *Pectineus* is continuous with the psoas and runs from the ramus of the pubis to the shaft of the femur just below the small trochanter. The same in all Lemurs. It is supplied by the anterior crural nerve.

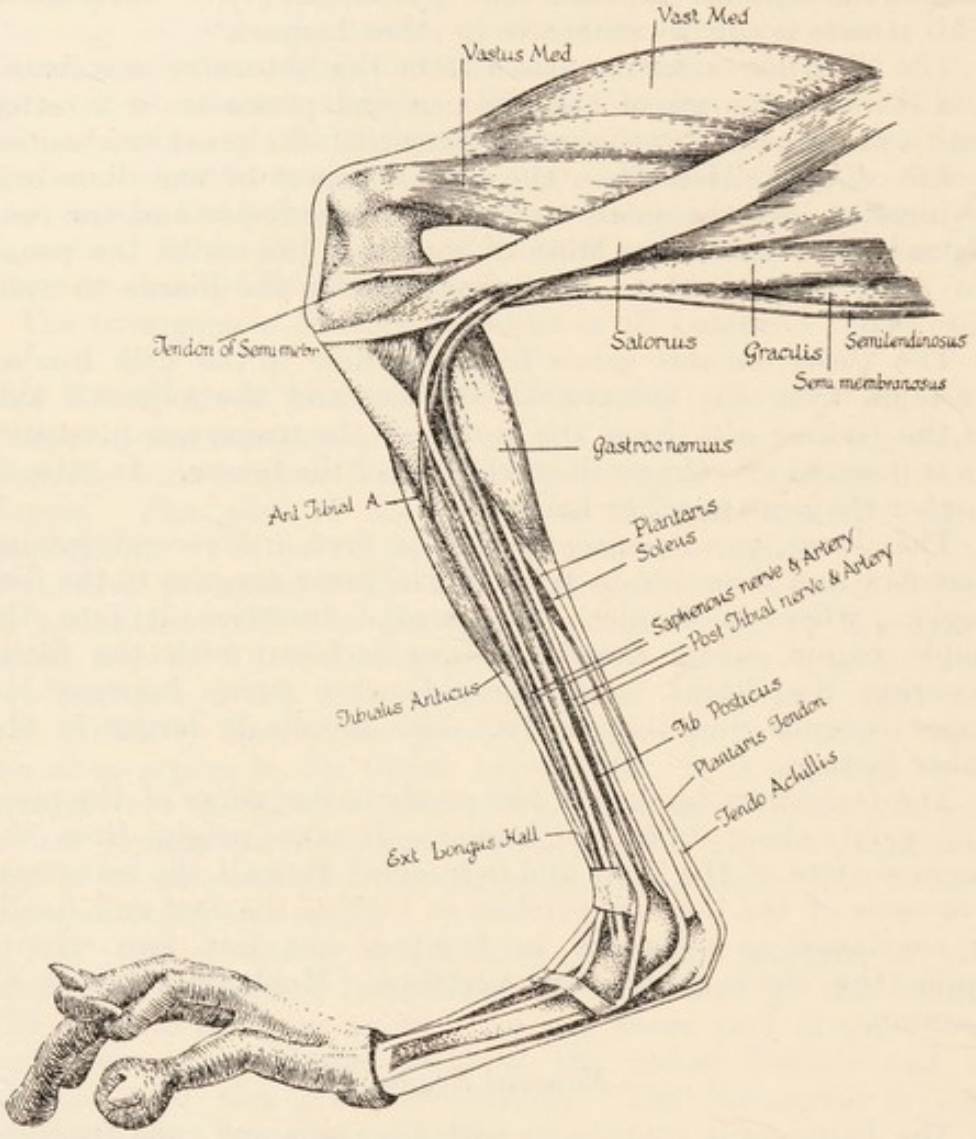
The *Rectus femoris* arises by two heads—an aponeurotic head which is dense and continuous with the fascia over the psoas, and a reflected head from the ilium just above the acetabulum. The two join together just above the level of the trochanters and is inserted into the patella. The same in all Lemurs.

The *Vasti* muscles in *Tarsius* reach vast proportions, and have undergone special differentiation.

The *Vastus lateralis* is a huge muscle occupying the lateral area of the thigh and takes origin from the femur beyond the great trochanter, and passes downwards to be inserted into the lateral margin of the patella. It is divisible into a dorsal and a ventral portion.

The *Vastus medialis* forms a great spindle-shaped mass along

Text-figure 50.



Musculature of Lower Limb.

the medial aspect of the thigh. It arises high up on the medial aspect of the femur, and divides into a small superficial portion which fuses with the intermedius and a deeper larger portion which gets inserted into the medial border of the patella.

The *Vastus intermedius* consists of a medial and a lateral portion. The lateral portion has an extensive origin from the femur, and above crawls round on to the mesial aspect of the femur

and fuses with the medial vastus. The medial portion in its origin is confined to the lower half of the shaft. It joins with the lateral portion, and together they are inserted partly into the deep surface of the patellar tendon and partly into the synovial membrane. This specialisation of the vastus is a peculiarity of *Tarsius*.

The *Sartorius* arises from the upper part of the ventral border of the ilium and is inserted into the mesial aspect of the tibia close to the origin of the tibialis anticus.

The *Gracilis* arises from the symphysis pubis. Its tendon fuses for a distance with the tendon of the semitendinosus. It is inserted into the medial aspect of the tibia just behind the tendon of the sartorius. It is very small in *Tarsius*, but well developed in the other Lemurs.

The *Adductor magnus* is very small indeed and arises only from the pubis. It is inserted into the posterior aspect of the femur halfway down its posterior border. Though so very small it lies behind the obturator nerve, and therefore represents the adductor magnus. It is well-developed in all Lemurs.

In front of the obturator nerve there is only one adductor, which we have called the *adductor longus*. It arises from the pubic bone and is inserted into the posterior aspect of the femur. This muscle, except in *Chiromys*, as well as the adductor brevis is represented in Lemurs.

The *Biceps femoris* arises by a thin tendon from the ischial tuberosity. After forming a fleshy belly at its middle, it again becomes tendinous and is inserted into the outer tuberosity of the tibia. It is present, but slightly different in form and in insertion, in the different Lemurs.

The *Semimembranosus* arises beneath the tendon of the biceps from the tuberosity of the ischium and is inserted into the posterior aspect of the tibia on the medial condyle. The same in all Lemurs.

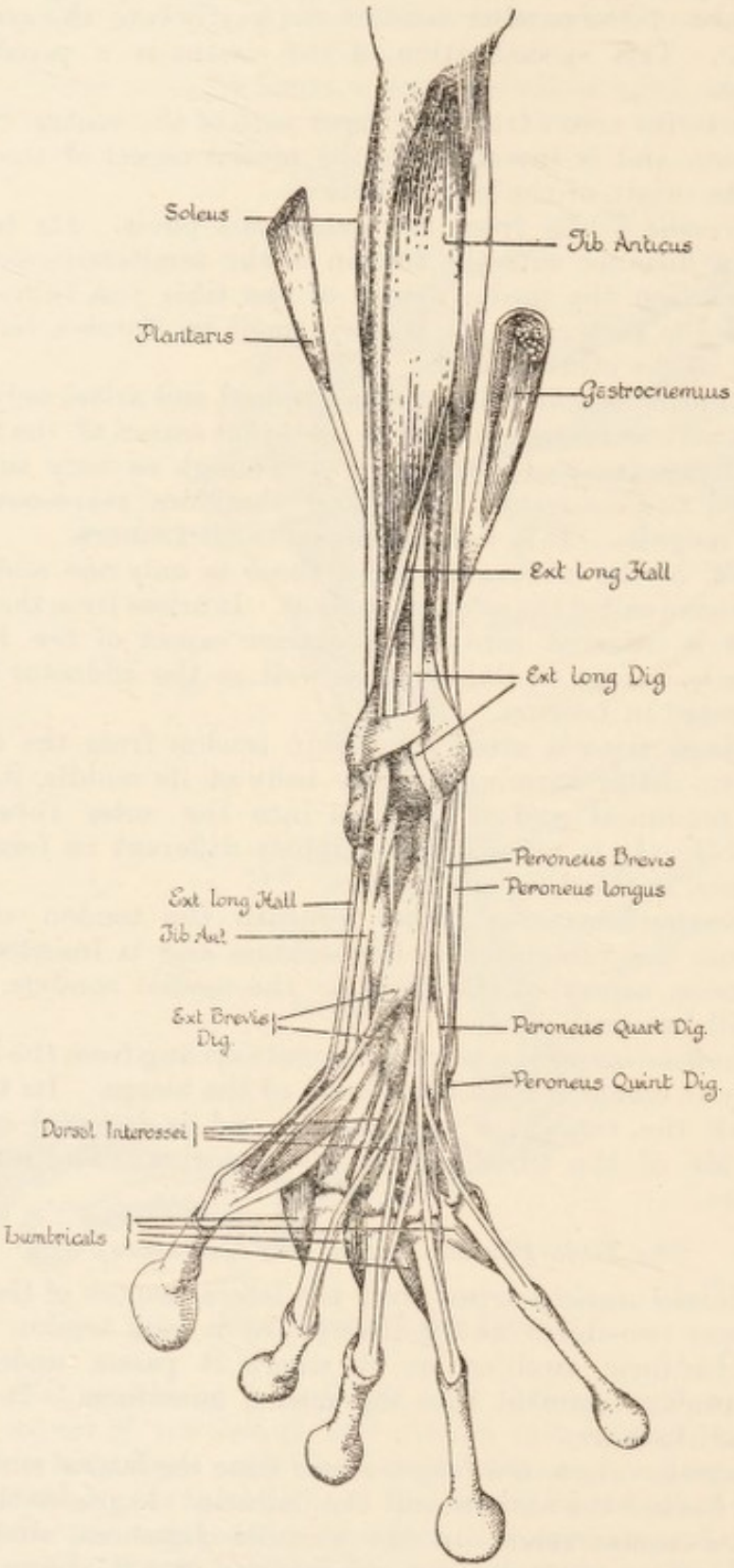
The *Semitendinosus* is a powerful muscle arising from the ischial tuberosity in common with the tendon of the biceps. Its tendon fuses with the tendon of the gracilis and is inserted on the medial side of the tibia behind the sartorius. The same in all Lemurs.

The Tibio-Fibular Region (the Extensors).

The *Tibialis anticus* arises from the lateral aspect of the tibia in its upper two-thirds and is inserted by a long tendon which bears a fusiform swelling on it where it passes under the dorsal annular ligament into the medial cuneiform. It is the same in all Lemurs.

The *Extensor digitorum longus* arises from the lateral surface of the tibia behind the anticus and the hallucis. It passes through a separate compartment in the annular ligament, and then divides into four tendons which are inserted into the bases of the terminal phalanges of the four outer toes. Two muscular

Text-figure 51.



Muscles of front of the Leg and dorsum of the Foot.

[104]

bellies are distinguishable above the ankle as well as two tendons, beyond which the tendons divide into four. It is subject to many differences in the Lemurs.

The *Extensor hallucis* arises from the lateral surface of the tibia under cover of the tibialis anticus. It soon becomes a slender tendon and crosses in front of the tibialis, and eventually becomes inserted into the base of the terminal phalanx of the hallux. The same in *Lemur*.

The *Peroneal group* of muscles consists of four distinct muscles.

The *Peroneus longus* arises from the posterior part of the upper extremity of the tibia and from the fibula. It passes under the cuboid, and developing a sesamoid bone is inserted into the proximal end of the metatarsal of the hallux.

The *Peroneus brevis* arises from the fibula and is inserted into the base of the fifth metatarsal.

The *Peroneus quarti digiti* arises from the fibula between the peroneus longus and the brevis, and passing behind the lateral malleolus is inserted into the dorsal expansion of the fourth digit along with the tendon of the extensor longus digitorum.

The *Peroneus quinti digiti* arises alongside the preceding muscle, and after a similar course is inserted into the dorsal extensor expansion of the little toe.

All these peroneal muscles pass behind the lateral malleolus and are furnished with stout retinacular ligaments. The peroneal muscles are similarly arranged in all Lemurs. There is no true peroneus tertius in the Lemuroidea.

The Tibio-Fibular Region.

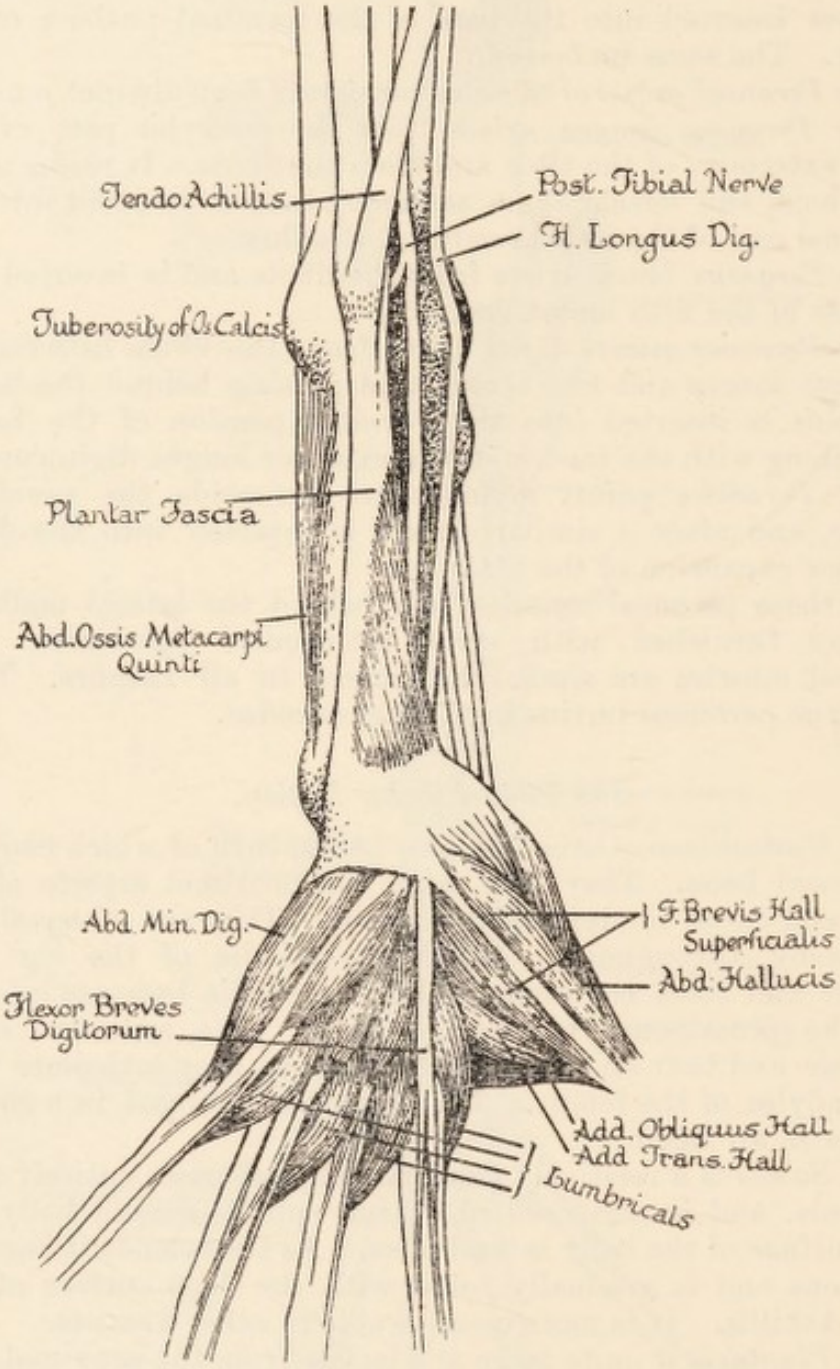
The *Gastrocnemius* arises by two heads, each of which contains a sesamoid bone. They arise from the proximal aspects of the inner and outer condyles of the femur. They are of equal size and fleshy throughout. About the middle of the leg they coalesce and form the tendo Achillis, and this becomes inserted into the prominence of the os calcis. The sesamoid bones are large and bear an articular face where they articulate with the condyles of the femur. The muscle is arranged in a similar manner in all Lemurs.

The *Soleus* is a relatively small muscle and arises entirely from the fibula, and is composed of a frail spindle-shaped belly, the deep surface of the belly is tendinous. As it descends it becomes tendinous and is gradually fused with the deep surface of the tendo Achillis. It is more considerable in other Lemurs.

The *Plantaris* is quite large and arises from the proximal part of the outer condyle of the femur and from the sesamoid bone articulating with the outer condyle. It passes after becoming tendinous in the middle of the leg on the medial side of the tendo Achillis and becomes inserted into the plantar fascia. The muscle is the same in *Lemur catta*, but is absent in *Loris* and *Nycticebus*.

The *Flexor longus digitorum* arises from the upper third of the posterior surface of the tibia. It becomes tendinous in the lower half of the leg, and passes under cover of the medial annular

Text-figure 52.



Superficial dissection of the Plantar surface of the Foot.

ligament and then lies superficial to the tendon of the hallucis, to which it is joined. It then divides into four tendons which are inserted into the terminal phalanges of the four outer toes. This muscle varies considerably in the different Lemurs.

The *Flexor longus hallucis* is relatively a very large muscle and arises from the fibula as far as the bone extends before it fuses with the tibia. It passes under cover of the medial annular ligament, and in the sole of the foot it passes under cover of the long flexor, to which it is tightly bound. Then appearing on the medial side of this tendon, it passes to the terminal phalanx of the great toe.

The *Tibialis posticus* is relatively a small muscle and arises between the tibia and fibula from the interosseous membrane. By a slender tendon it is inserted into the scaphoid, but reaches no other tarsal bone.

The *Popliteus* is large and takes origin from the outer condyle of the femur, and piercing the capsule of the knee-joint under cover of the fibular collateral ligament is inserted into the posterior aspect of the tibia immediately above the origin of the flexor longus digitorum. The same in all Lemurs.

Region of the Foot (*dorsal and plantar surfaces*).

The *Extensor brevis digitorum* arises from the medial surface of the os calcis and the cuboid. Out of the muscle are formed three tendons, of which the first is inserted into the base of the proximal phalanx of the hallux, the second and third are inserted into the dorsal extensor expansions of the second and third toes. It varies greatly in the different Lemurs.

The *Plantar fascia* is extremely powerful and extends from the os calcis to the five digits, where it fuses with the flexor digital sheaths. It receives the plantaris, and gives origin to the flexor brevis digitorum of the second toe.

The *Flexor brevis digitorum* consists of four muscles. The outer three arise from the tendon of the flexor longus digitorum just before it divides, and split to enclose the long tendons opposite the proximal phalanx, and then become inserted into the second phalanx of the three outer toes. The tendon to the index arises from the plantar fascia. A *flexor brevis superficialis* also arises from the plantar fascia and is inserted into the terminal phalanx of the great toe.

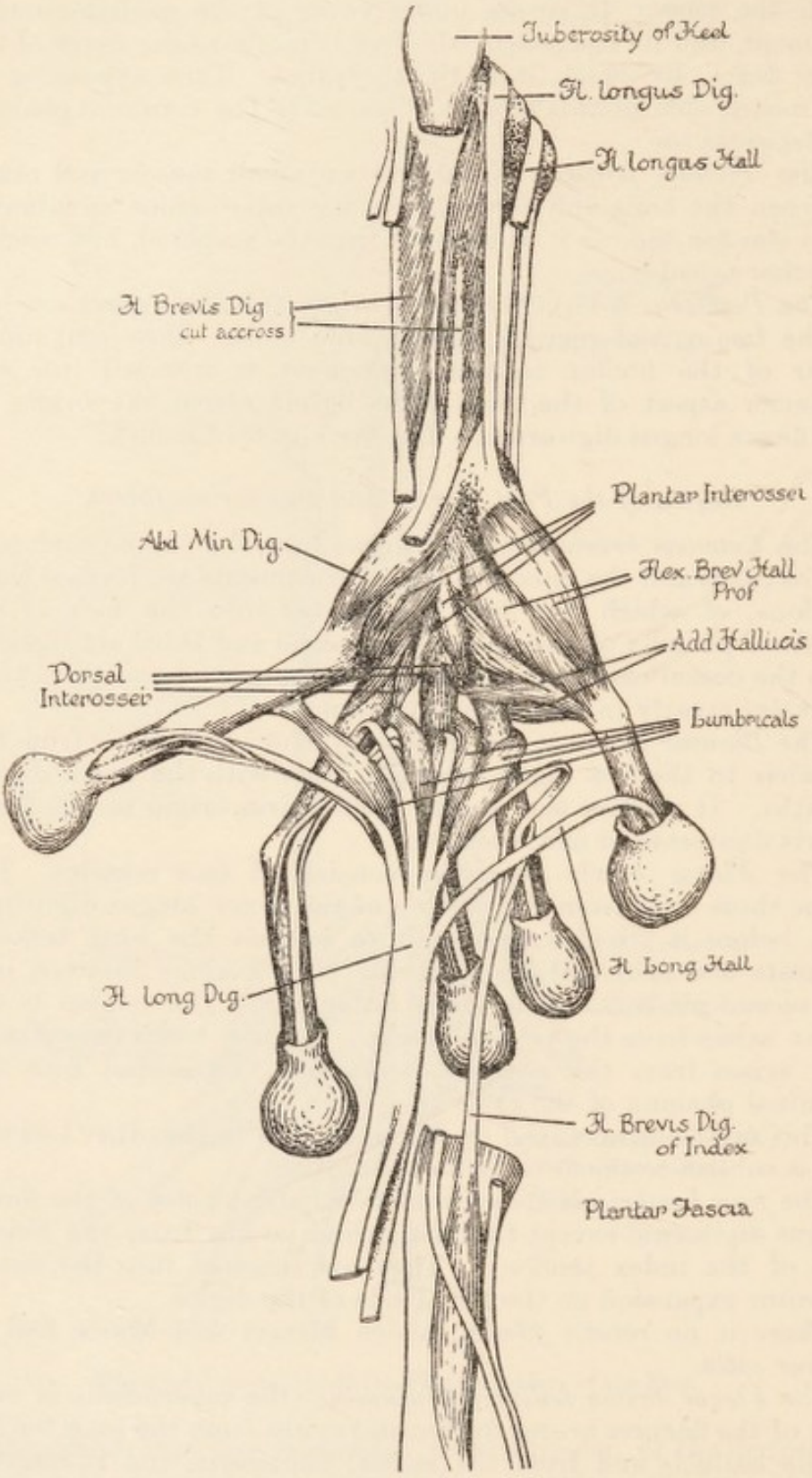
This muscle is arranged on the same plan in the other Lemurs, but is subject to much individual variation.

The *four lumbricals* arise from the adjacent sides of the flexor longus digitorum except the first, which arises from the fibular side of the index tendon. They are inserted into the dorsal extensor expansion on the tibial side of the digits.

There is no *rotator fibulæ*, which Mivart and Murie find in *Lemur catta*.

The *Flexor brevis hallucis profundus* (the superficialis is only part of the flexores breves digitorum) arises from the long tendon of the hallucis and from the medial cuneiform, and is inserted into the base of the proximal phalanx of the hallux by two heads.

Text-figure 53.



Deep dissection of the Plantar surface of the Foot.

The *Abductor hallucis* arises from the scaphoid and is inserted into the tibial side of the base of the proximal phalanx of the great toe.

We distinguish an *Adductor obliquus* and an *adductor transversus* of the hallux. The first is double-bellied and arises from the cuboid, the second and third cuneiforms, and the sheath of the peroneus longus, and together they are inserted into the outer side of the base of the proximal phalanx of the great toe. The *transversus* arises from the third metatarsal and is similarly inserted.

The *Abductor minimi digiti* arises from the outer surface of the os calcis and is inserted into the outer side of the first phalanx of the little toe. This muscle is the same in all Lemurs, but is very large in *Tarsius*.

We have notes of an *abductor ossis metacarpi quinti* arising from the outer side of the os calcis and being inserted into the fifth metatarsal. This might represent an opponens minimi digiti. Mivart and Murie record the presence of a few fibres in *Lemur catta* which might be so described. This muscle was not described by Burmeister.

The *Interossei* are so arranged that there are two to each digit except the first, and in addition more superficial slips going to the inner side of the index and to the inner side of the fourth. These muscles are substantially the same in all Lemurs. There is no trace of an accessorius in *Tarsius* or in any of the Lemurs.

Summary.

As a summary to this account of the anatomy of *Tarsius* we give a classification of the principal morphological characters arranged in three groups:—(1) Primitive Marsupial placental, (2) Lemurine, and (3) Anthropoid characters. We have found the work of Gregory on the Orders of Mammals of great assistance in preparing this list.

(1) Primitive characters:—

Arboreal habits and adaptations.

An insectivorous diet.

The *Tarsius fischeri* is said to be distinguished by the presence of scales on the ventral surface of the tail near the tip. These are not present in *Tarsius spectrum*.

The tail is long and the back is arched.

The external ears are simple but aberrant in form.

In the skull the arrangement of the foramina for the exit of the nerves is in some respects simple, and moreover the arrangement of the venous sinuses is primitive.

The nose is far in front of the brain-case, and Fischer, from his study of the chondrocranium, remarks that this feature recalls the reptilian condition.

The lachrymal foramen is situated on the face.
The presence of an ento-tympanic bulla.
The number of the vertebræ is the primitive one.
The appendicular skeleton preserves numerous primitive features such as :—

An entepicondylar foramen.
A third trochanter on the femur.
Pelvis with pubic symphysis.
Manus and pes plantigrade.
Normal carpus with os centrale.
Pollex and hallux divergent.

The teeth differ from the primitive formula in the reduction of the premolars to three. Otherwise they retain the primitive tritubercular pattern, the upper molars being simple tritubercular teeth and the lower molars tuberculo-sectorial. The incisors are specialised, but in a manner different from that which occurs in the Lemurs.
The brain is smooth and shows a small corpus callosum and a large ventral commissure.
The cerebellum retains in the clearest manner the simple morphological subdivision into three primary lobes and closely resembles the cerebellum of Marsupials. In the Lemuroidea the cerebellum is much modified.
The base of the brain-stem is primitive in the extent of the pontine fibres. The small size of the inferior olivary nucleus indicates that it has not departed from the primitive condition.
The organ of Jacobson resembles exactly this structure in the Marsupials.
The third eyelid is large and has a plate of cartilage and a well-developed Harderian gland.
The arrangement of the alimentary viscera and the dorsal mesentery is the simplest among mammals, and it is almost necessary to go back to the Amphibia and Reptiles for a parallel.
The vesiculæ seminales are simple dilated sacs.
The retention of flexores breves digitorum muscles in the manus.

(2) Lemurine characters :—

Arboreal habits and ability to sit up and take the food in the hands.
In the external characters, the distribution of the vibrissæ; the presence of carpal vibrissæ in the fœtal Tarsier; the prominence of the labia minora; long hands and feet with palmar and plantar pads; testes descending into a hairy scrotum.
Large orbits and entotympanic bulla. There is, however, no malar foramen.

The malleus, incus, and stapes with the os orbiculare closely resemble these bones in the Lemurs.

The lunate excluded from articulation with the magnum by the os centrale. The magnum is small and compressed by the unciform.

The astragalus agrees with the Lemurine form. The bone is broader below than above; the tibial malleolar facet is larger than the fibular malleolar facet; the sustentaculum tali is broadly continuous with the facet for the scaphoid.

The testes descend into a hairy scrotum.

The uterus is bicornuate, and the labia minora project prominently.

A detailed comparison with the Lemurine muscular system is given in the text with the individual muscles. Mivart and Murie in their summary agree that in *Tarsius*, in twenty-three muscle groups the arrangement is the same as in the Lemurs.

The venous drainage of the head and neck and the distribution of the blood-vessels of the limbs resembles that of the Lemurs.

The disposition of the cortical areas of the brain is in essential agreement with the Lemurine pattern.

The histology of the retina is unknown in the Lemurs, but ophthalmoscopic examination discloses in both Lemurs and *Tarsius* no pigmented macula as in the Anthropoids.

The specialisation of vision, the nocturnal habits, and a general retinal pattern of the nocturnal type are all Lemurine features.

The hyoid bone has a large lesser cornu.

The lungs and liver are of the Lemurine type.

(3) Anthropoid characters:—

The reduction of the face which bends down on the cranium.

The eyes parallel and directed forwards.

The animal is habitually erect.

The orbit is almost completely closed from the temporal fossa.

The ethmoid forms part of the medial wall of the orbit.

The relation of the internal carotid to middle ear.

The formation of the tympanic which becomes an expanded plate.

The nose is simple and has only three turbinal bones.

The proportion of the length to the breadth of the scapula is greater than in any other Prosimian except *Chiromys* (Mivart and Murie).

The ilio-pubic angle is smaller than in the Lemurs.

The os calcis bears a larger tuberosity than in *Lemur*.

The supra-orbital foramen is reduced to a notch.

The sublingua is much reduced.

The tracheal rings are patent posteriorly.

The heart extends from the second to the sixth rib.

The arch of the aorta gives off the three great vessels.

The angle made by a line drawn through the superior vena cava and the inferior vena cava with a line drawn from the superior vena cava to the apex of the heart is greater than in the Lemurs.

The caudal progression of many structures which occurs in other Lemurs is not present in *Tarsius*. This is shown in the level of the diaphragm, the position of bifurcation of the aorta, the level of the heart, and the lower limit of the pleura and lungs.

The musculature shows some appreciation beyond the Lemurine level in the higher differentiation of the facial muscles, in the digastric, and the somewhat lower insertion of the rectus abdominis.

The male genitalia have undergone no specialisation. There is a slight indication of a frenulum ; the septum pectiniforme has remained fibrous tissue ; the musculature and the relation of the prostate are as in man. The main difference from the Lemurs is the fact that the vas and the excretory duct of the vesicula form a common ejaculatory duct.

In the female the urethra opens independently of the clitoris.

It is interesting to note that *Tarsius* habitually progresses in the upright position, and that such organs as the diaphragm, the bifurcation of the aorta, etc. are relatively not so far caudal as in the other Lemurs (Ruge), yet there is no modification of the structures associated with the tail region.

We have not dealt with any of the embryological features of *Tarsius*.

There is no need to analyse the many divergent views put forth about the zoological affinities and the significance of *Tarsius*. With all the evidence of its anatomy marshalled, there can be no doubt that *Tarsius* is a Lemur of the Lemurs and is annectant to the early Eocene primitive placentals, and that standing at the base of the Primate stem it reaches forth to the Simian forms and is annectant to the Anthropoidea.

In conclusion, I wish to express my very best thanks to Mr. T. J. Poulton, who drew most of the pictures for me, and to Mr. F. W. Randoll and Miss Ellen Barnes, who helped me in the labelling of the drawings, in the revision of the text, and in the preparation of the many hundreds of serial sections.

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