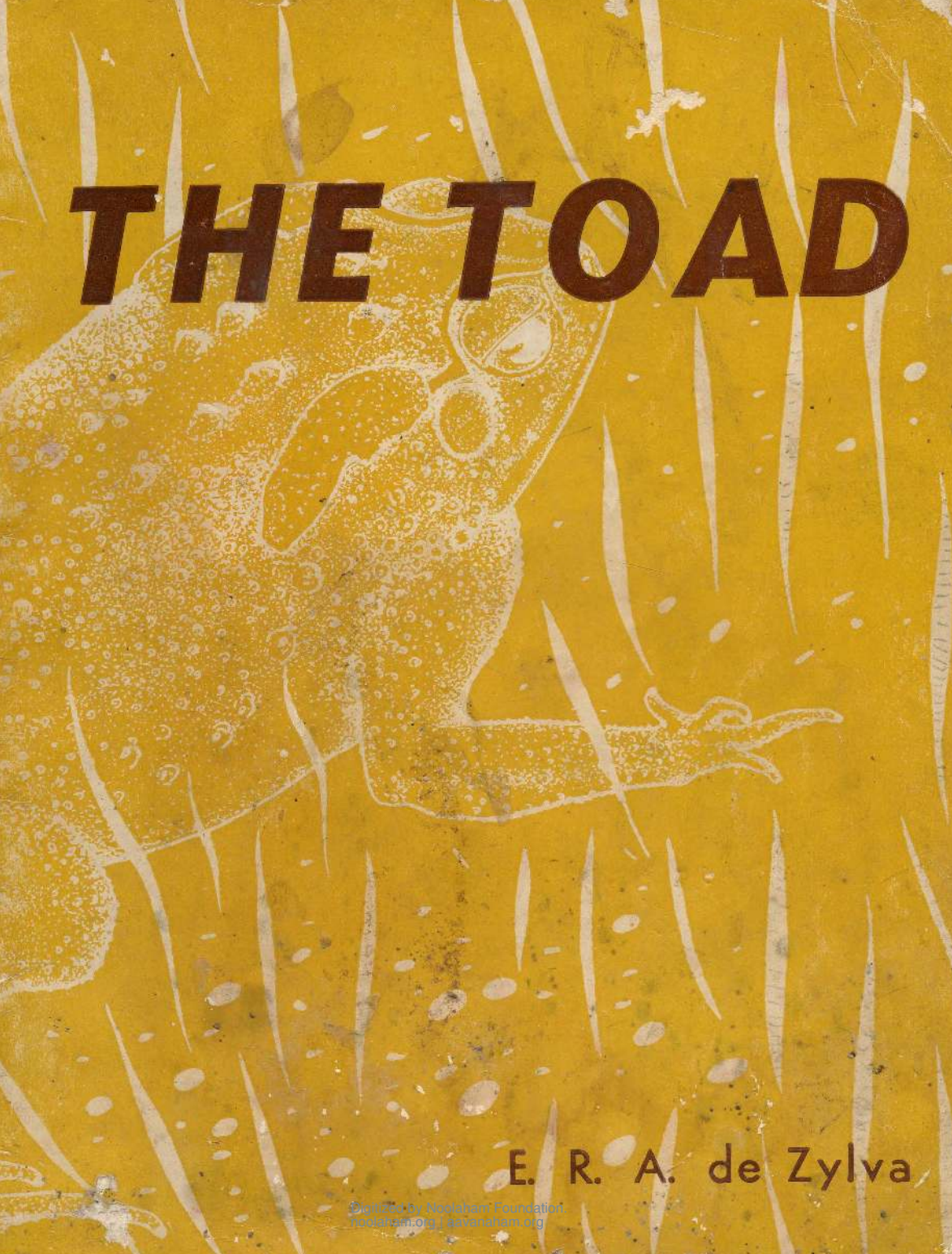
THE TOAD



E. R. A. de Zylva

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S. BALASINGAM
10TH MAY 1963.

THE TOAD

Bufo melanostictus Schneider

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THE ASSOCIATED NEWSPAPERS OF CEYLON LTD.
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FOREWORD

The inclusion of Zoology as a subject in the curriculum of our schools has been comparatively recent and, therefore, the teaching of the subject is still in the early stages of development. One of the major handicaps that our students have suffered from is that they have had to dissect local animals with such theoretical guidance as they could gather from textbooks written for English students and containing descriptions of, in some instances, very different animals. Students who have attempted to dissect the rat with the help of a textbook description of the rabbit or cut open *Pheretima* with the description of *Lumbricus* to guide them, will have had experience of this.

This handicap is now being gradually reduced with the considerable assistance of teachers of Zoology in India, where the subject has been taught in the schools for a much longer time than in Ceylon, and the efforts of some of our own teachers to provide adequate descriptions of local animal types. Mr de Zylva makes another welcome contribution in this direction. He has chosen the most popular of all our animal types and I believe that this little book will set new standards for the dissection of the toad.

P. KIRTISINGHE, M.Sc. (Lond.)
Reader in Zoology in the University of Ceylon

Colombo, November 1958

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PREFACE

In preparing this handbook, I have borne in mind the need of a suitable text for the student of Zoology in the General Certificate of Education (Higher Level) and the First Examination for Medical Degrees. It has been the practice to use English textbooks which deal with the anatomy of the Frog, while in the laboratory the student has had to dissect the Toad. The study of English types of animals by our students is being gradually replaced by the study of corresponding types from the local fauna. I have tried to advance this trend by presenting this description of the anatomy of the Toad.

I have to acknowledge with thanks the encouragement and assistance I have received from Mr P. Kirtisinghe, Reader in Zoology in the University of Ceylon, who has kindly read over the manuscript and offered helpful criticism.

This handbook is dedicated to the beginner in Zoology in the hope that it will guide him through the initial stages of his contact with this most absorbing subject, and create in him a real desire for a more extensive acquaintance with the animal kingdom.

E. R. A. DE ZYLVA

Colombo, October 1958

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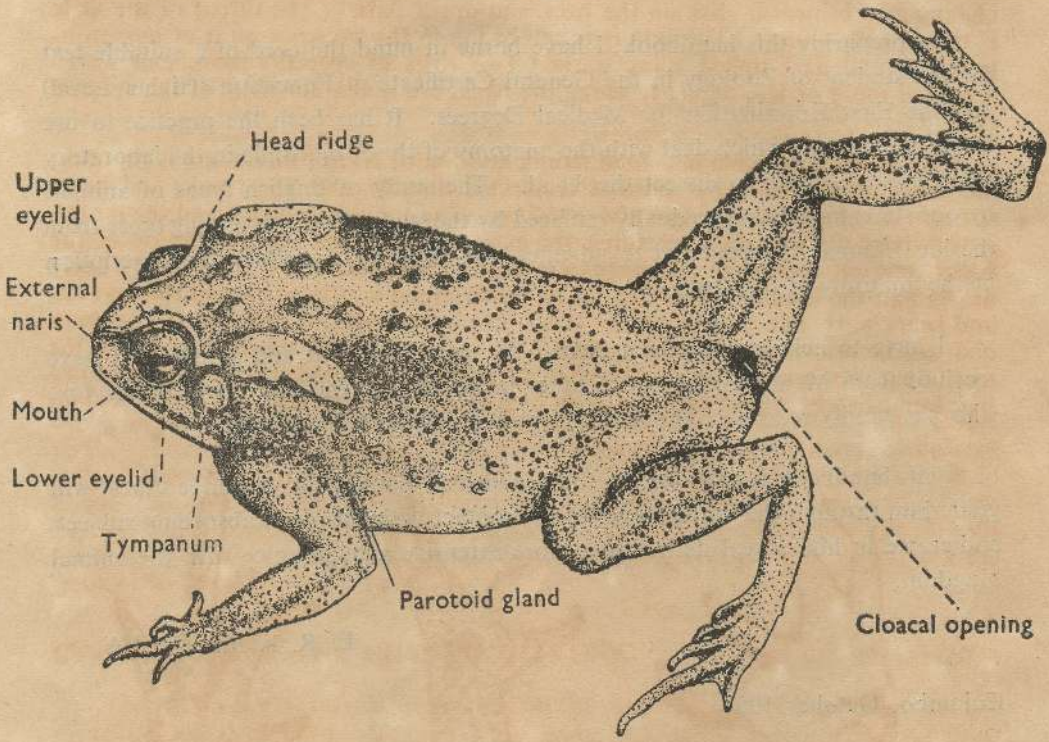

Fig. 1 THE TOAD : EXTERNAL FEATURES
(right hind limb extended)

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EXTERNAL CHARACTERS

The toad, *Bufo melanostictus* Schneider, is the commonest occurring species of amphibian in Ceylon, being found in considerable numbers practically throughout the whole island. The female, which is larger than the male, reaches a body length of about four inches. The colour of the animal changes according to the nature of its surroundings, but the most usual is yellowish-olive on the belly and lower parts changing to brownish-olive on the back and upper parts. The throat of the male is tinged with orange. The skin is rough owing to the presence on it of numerous tubercles and dark-tipped spiny warts. Two rows of specially prominent warts, arranged more or less regularly along the back, are a characteristic of the species. (Fig. 1)

The body is divisible into head, trunk and limbs. As in fishes, there is no neck; the short, thick, triangular head is connected directly with the trunk, and bears strongly developed bony ridges above the eyes. The snout is rounded and the mouth is very large. Two small apertures, the external nares, lie near to the tip of the snout, one on each side. The eyes are large, the diameter of their orbits being nearly half the length of the head. The upper eyelid is very thick and immovable, and bears warts like the rest of the skin. The lower eyelid is thin and transparent, and can be drawn up over the eyeball from below; for this reason it is called the nictitating membrane. The dark, horizontal pupil is surrounded by a golden-brown iris. Immediately behind each eye is an oval area of smooth skin of a darker colour

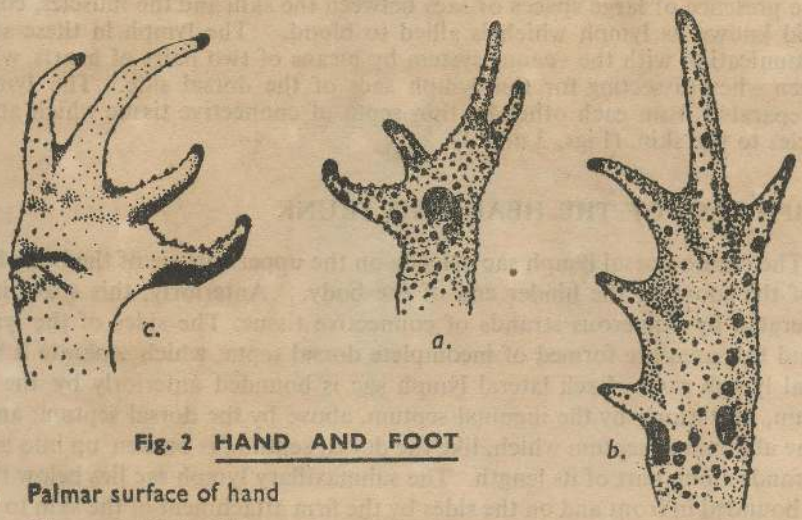

Fig. 2 HAND AND FOOT

a. Palmar surface of hand

b. Planter surface of foot

c. Upper surface of hand of male showing nuptial pads

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than that surrounding it; this is the ear drum or tympanic membrane. Two fairly large, kidney-shaped glands, the parotoid glands, are present on the trunk behind the ear drums. These glands, as well as some of the glands in the skin, secrete a viscid substance which is unpalatable and slightly poisonous. This secretion contains a substance called bufonin, whose poisonous nature serves as a defensive weapon against most predatory animals. At the posterior end of the trunk, high up on the dorsal side, is a median opening, the cloacal aperture.

The fore limbs are shorter than the hind limbs. Each fore limb is made up of upper arm, forearm and hand. The hand has only four fingers or digits; the first is slightly longer than the second, and the third is the longest of all. The upper surfaces of the first and second digits of the male bear pigmented, roughened areas, the nuptial pads (Fig. 2c), which help it to hold on to the female during the mating season. There are two tubercles on the palm, of which the outer is the larger. (Fig. 2a) The hind limb is made up of thigh, shank and foot. The foot has five toes of which the fourth is the longest. These toes are joined together by a web which extends to a little less than half their length. A little pre-axial toe is present. The plantar surface of the foot bears two large tubercles. (Fig. 2b)

LYMPH SACS

The skin is more or less loosely attached to the muscles beneath. This is due to the presence of large spaces or sacs between the skin and the muscles, containing a fluid known as lymph which is allied to blood. The lymph in these sacs is in communication with the venous system by means of two pairs of hearts, which can be seen when dissecting for the lymph sacs of the dorsal side. The lymph sacs are separated from each other by thin septa of connective tissue which attach the muscles to the skin. (Figs. 3 and 4)

LYMPH SACS OF THE HEAD AND TRUNK

The cranio-dorsal lymph sac extends on the upper surface of the body from the tip of the snout to the hinder end of the body. Anteriorly, this space is almost obliterated by numerous strands of connective tissue. The sides of the lymph sac behind this area are formed of incomplete dorsal septa, which separate it from the lateral lymph sacs. Each lateral lymph sac is bounded anteriorly by the axillary septum, posteriorly by the inguinal septum, above by the dorsal septum, and below by the abdominal septum which, like the dorsal septum, is broken up into a number of strands along part of its length. The submaxillary lymph sac lies below the lower jaw, bounded in front and on the sides by the firm attachment of the skin to the edge of the lower jaw, and behind by the submaxillary septum which separates it from the pectoral lymph sac. This is separated from the ventral lymph sac behind and from the lateral lymph sacs and the lymph sacs of the arms on the sides by the pectoral

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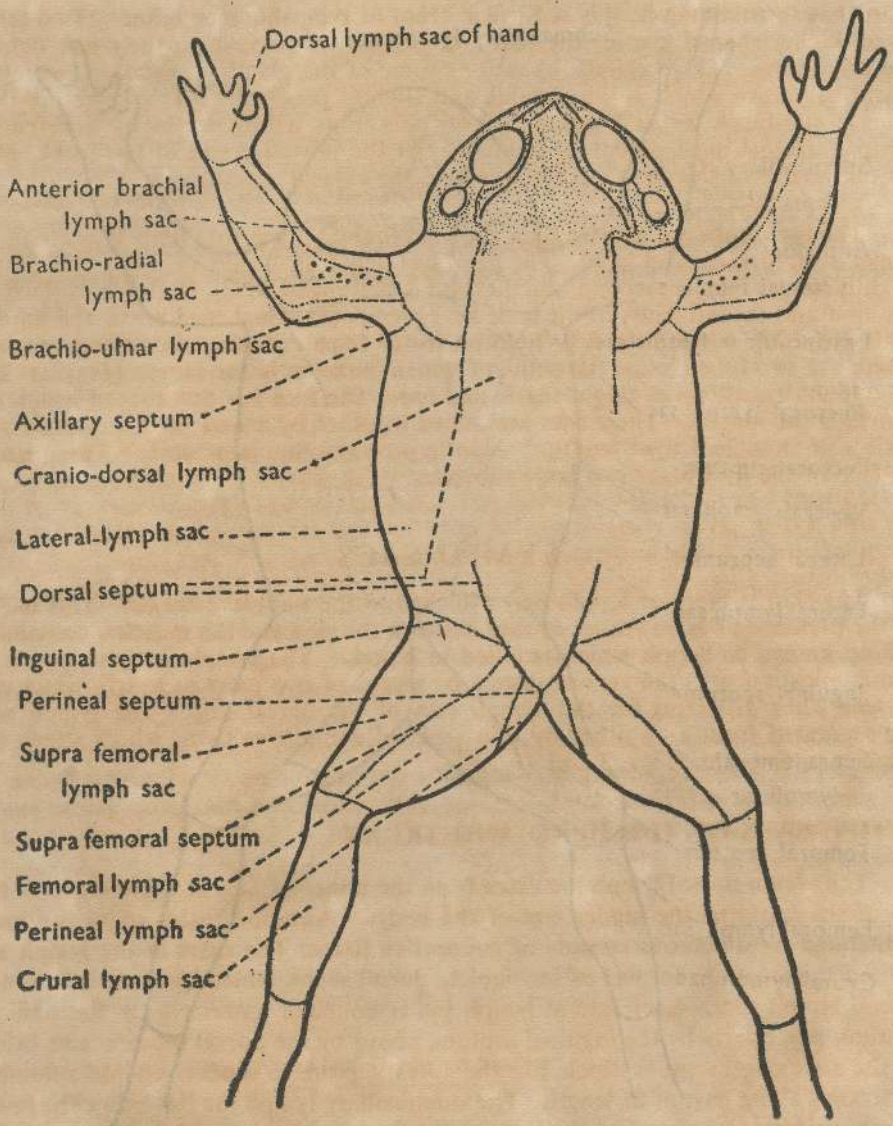

Fig. 3 DORSAL LYMPH SACS

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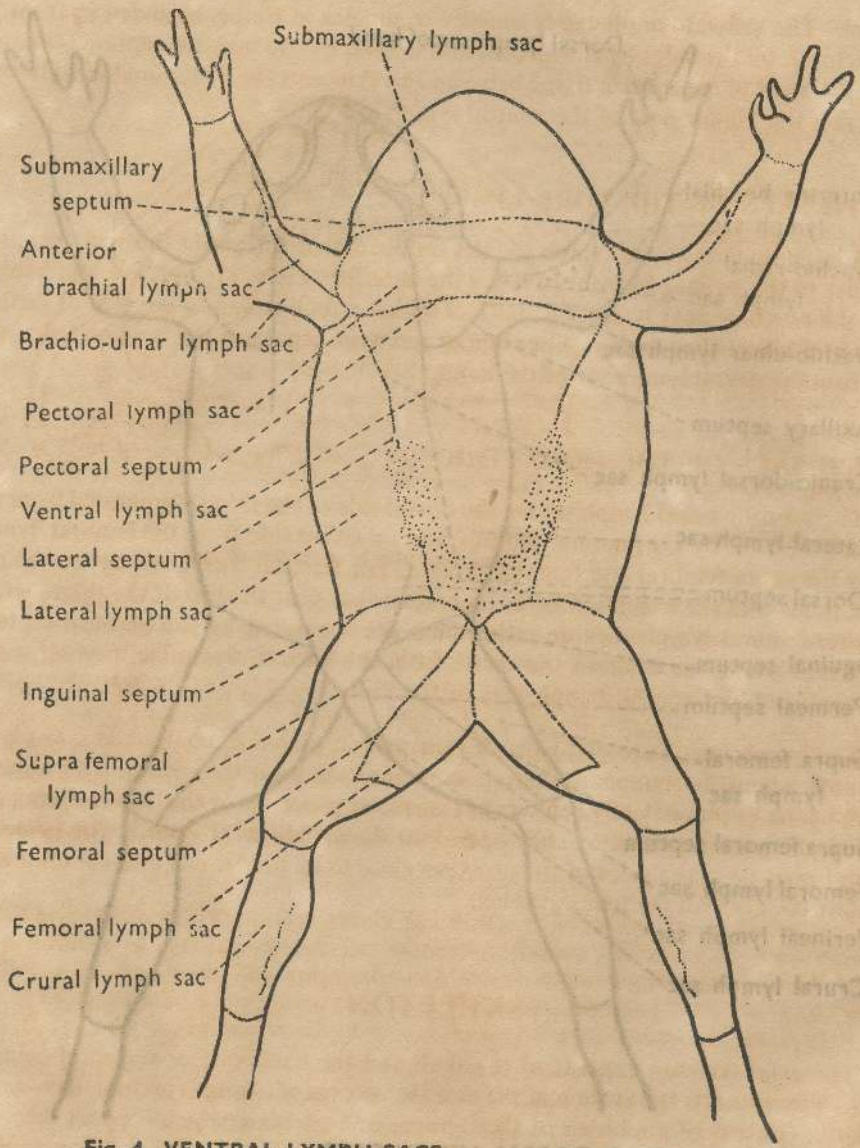

Fig. 4 VENTRAL LYMPH SACS

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septum. The ventral lymph sac is roughly triangular in shape, bounded in front by the pectoral, on the sides by the lateral, and behind by the inguinal septa. There are several strands of connective tissue between the skin and the abdominal muscle wall traversing the hinder part of the ventral lymph sac.

LYMPH SACS OF THE FORE LIMB

A large brachio-radial lymph sac lies on the dorsal surface of the arm, from the shoulder to the wrist. In front of it lies the anterior brachial lymph sac, and behind it lies the brachio-ulnar lymph sac, both of which extend round to the ventral surface of the arm where they meet. A septum at the wrist separates the lymph sacs of the arm from the dorsal lymph sac of the hand.

LYMPH SACS OF THE HIND LIMB

The supra-femoral lymph sac on the dorsal side of the thigh is separated from the lateral lymph sac by the inguinal septum, and on either side from the femoral lymph sac by the supra-femoral and femoral septa. The femoral lymph sac covers the rest of the thigh with the exception of its innermost face near the top of the thigh, where the inter-femoral lymph sacs on either limb are separated by the perineal septum. The crural lymph sac encloses the shank from the knee to the ankle, beyond which are the dorsal and ventral lymph sacs of the foot.

The lymph hearts are two pairs of transparent, globular, contractile sacs placed at points where the lymphatic vessels communicate with the veins. The anterior lymph hearts lie immediately behind the transverse processes of the third vertebra and beneath the pectoral girdle. They open into the subscapular veins. The posterior lymph hearts lie at the sides of the urostyle, close to its hinder end and communicate by short vessels with the femoral veins.

SKELETON

The axial skeleton consists of the skull and the backbone or vertebral column. The former protects the brain and the chief sense organs—nose, eyes and ears—while the latter consists of a number of small bones or vertebrae, which support the body and house the main nerve cord or spinal cord. The appendicular skeleton consists of the bones of the fore and hind limbs and the girdles by which they are attached to the body.

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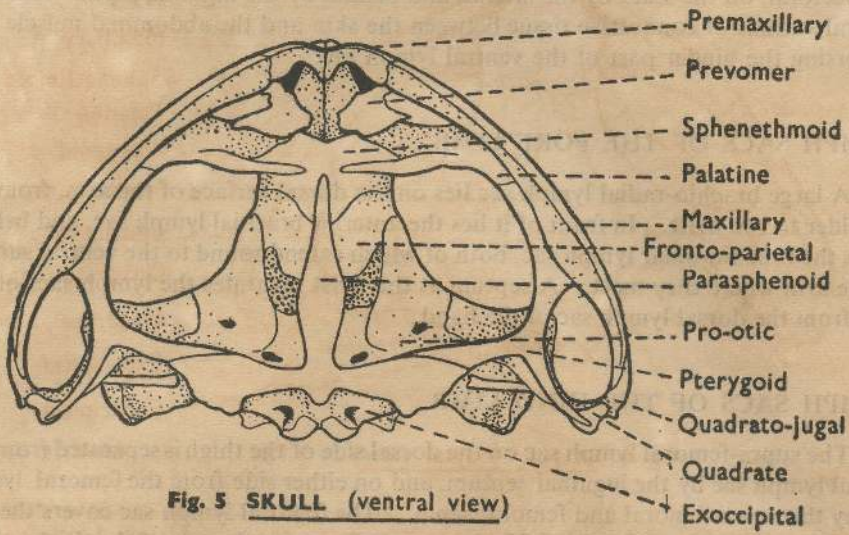

Fig. 5 SKULL (ventral view)

The larval toad, or tadpole, has an entirely cartilaginous skull. Thus the skull of the toad consists of a foundation of cartilage, and the bones of the skull may be classified as cartilage bones, or those that arise by replacement with bone of original cartilaginous tissue, and membrane bones, so called on account of the membrane of connective tissue which originally occupies the positions in which they later appear, and are formed directly in the course of development without being preformed in cartilage.

The primitive cartilaginous cranium, or chondrocranium, becomes covered over by a number of cartilage bones and membrane bones. The cartilage bones are a girdling—or ring-bone, the sphenethmoid, which encircles the anterior ethmoidal region of the cranium, the paired pro-otics which lie in front of the auditory capsules, and the paired exoccipitals which surround the foramen magnum. (Figs. 5, 6)

On the dorsal side of the cranium (Fig. 6), the membrane bones formed are a pair of nasals lying above the nasal capsules, a pair of fronto-parietals overlying the cranium, and a pair of squamosals lying above and over the sides of the auditory capsules. The nasal bones project anteriorly over the premaxillary bones of the upper jaw, extend laterally outwards to meet the upper jaw thus forming the anterior border of the orbit, unite with each other in the midline, and extend backwards above

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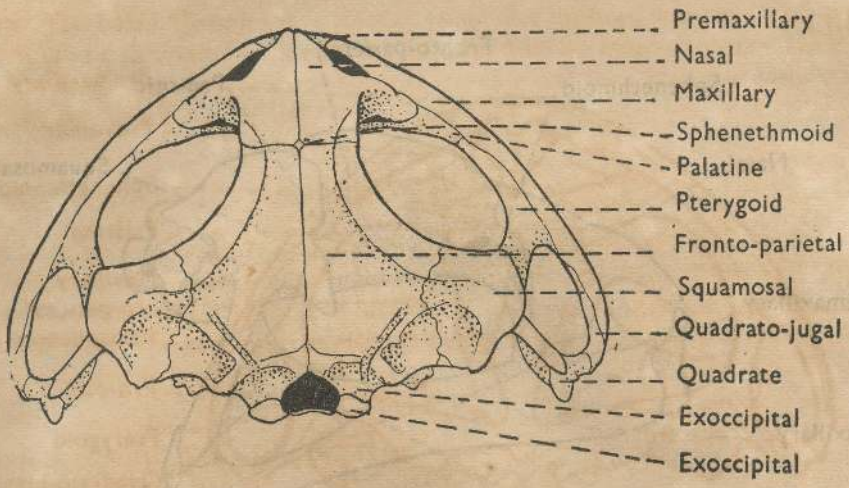

Fig. 6 SKULL (dorsal view)

the anterior border of the sphenethmoid to meet the fronto-parietals, leaving only a minute area of the sphenethmoid visible on the dorsal side of the adult skull. The fronto-parietals extend from the posterior edge of the nasals to form the roof of this portion of the skull and the inner margins of the orbits. They extend backwards to meet the exoccipitals, and laterally to meet the squamosals. An anterior prolongation of the head of the hammer-shaped squamosal forms part of the posterior border of the orbit, while the posterior prolongation of the head forms a support for the tympanic membrane ; the handle-like projection of the squamosal runs down to the angle of the jaw, lying against the pterygoid for some distance and terminating on the quadrate.

On the ventral side of the cranium, the membrane bones formed are a pair of prevomers* lying below the nasal capsules, extending from the upper jaw to the anterior edge of the sphenethmoid and forming the inner edge of the internal nares, and the parasphenoid, shaped like an inverted T, its anterior arm overlapping the sphenethmoid, the middle of its base meeting the exoccipitals posteriorly, and the two arms extending laterally behind the pro-otics to join the inwardly directed arms of the pterygoid bones.

*Note : The term 'prevomer' is used in preference to the term 'vomer' as these bones in the toad are not homologous with the mammalian vomer.

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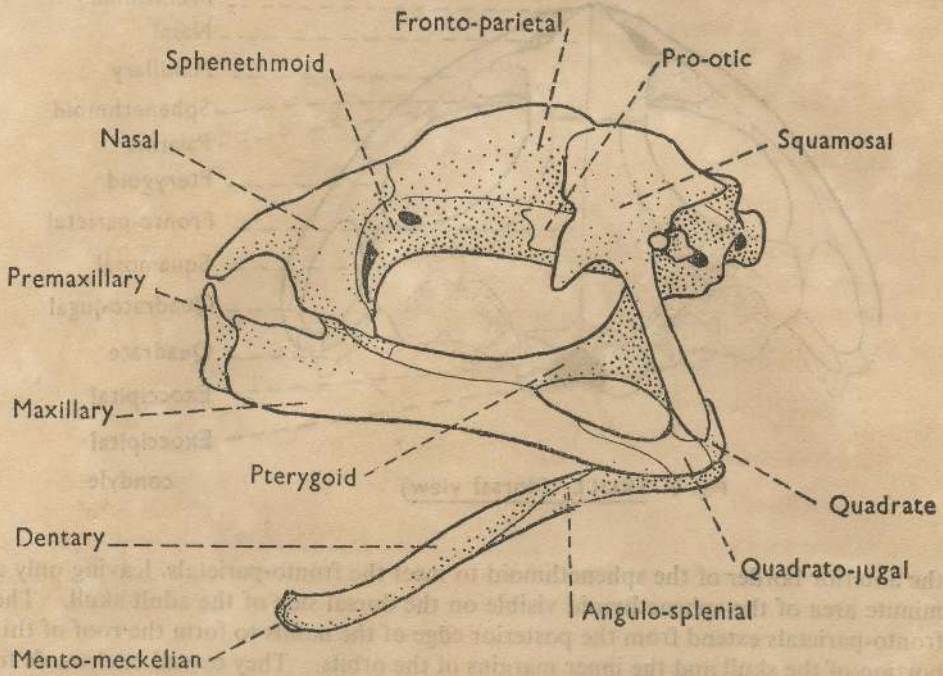

Fig. 7 SKULL AND LOWER JAW (lateral view)

The primitive upper and lower jaws, formed of the palato-pterygo-quadrate bar and Meckel's cartilage respectively, become either replaced or strengthened by a number of bones. The quadrate cartilage is the only remaining vestige of the larval upper jaw. The upper jaw on each side is made up of membrane bones, premaxillary, maxillary and quadrato-jugal, and is attached to the skull by two other membrane bones, the palatine and pterygoid. The palatine runs inwards from the maxillary to the anterior end of the sphenethmoid. The pterygoid has three arms, the anterior limb running forwards along the upper jaw to meet the palatine, the posterior limb running back to the quadrate at the angle of the jaw, and the inner limb running under the auditory capsule to meet the outer end of the parasphenoid on each side. The mento-meckelian cartilage of the lower jaw is replaced by a pair of mento-meckelian cartilage bones in front, followed by a dentary and an angulosplenial on each side, which are membrane bones covering the rest of the Meckel's cartilage (Fig. 7). The

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an gulosplenial occupies most of the inner surface, and the jaw is strengthened on the outer surface distally by the dentary, which runs forwards to meet the mento-meckelian bone.

HYOID APPARATUS

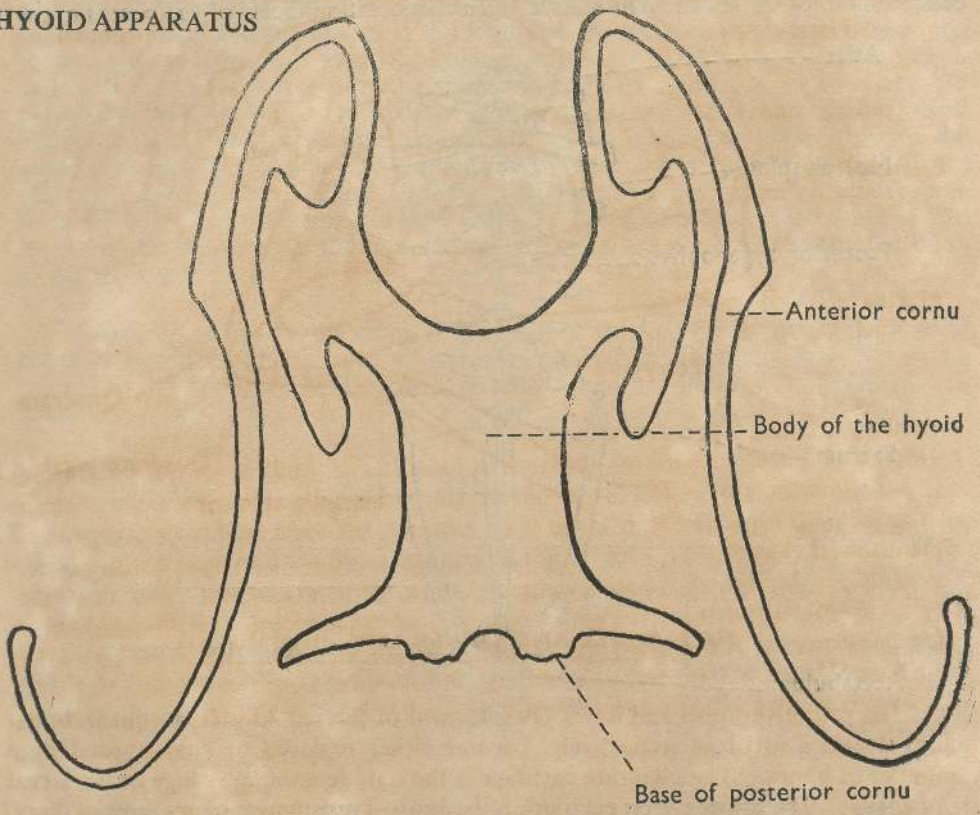

Fig. 8 HYOID APPARATUS

All that remains of the gill arches that supported the gills of the tadpole is a thin plate of cartilage lying in the floor of the toad's mouth cavity ; this is the hyoid apparatus. From the anterior angles of the body of the hyoid, a pair of slender cartilages, the anterior cornua, curve backwards and then forwards and upwards to meet the auditory capsule. A pair of stouter and shorter bony projections, the posterior cornua, diverge from the posterior angles of the body of the hyoid to lie on either side of the larynx or voice box.

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VERTEBRAL COLUMN

The vertebral column consists of nine vertebrae and one long tapering bone, the urostyle. The essential parts of a vertebra are the centrum, or body, the neural arch surmounted by the neural spine encircling the neural canal, and the transverse processes on either side of the neural arch. The articulating facets of the centrum are

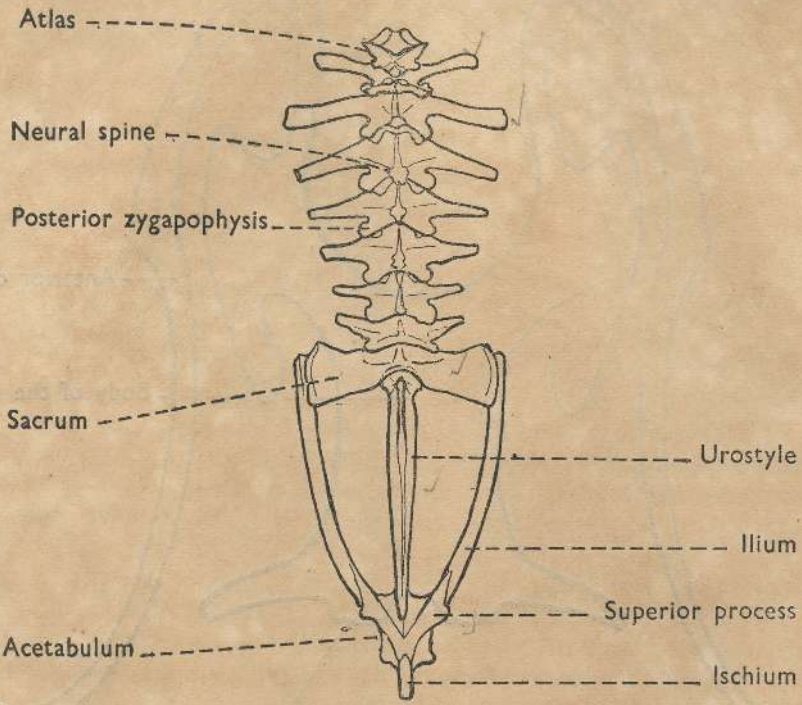

Fig. 9 VERTEBRAL COLUMN (dorsal view) **WITH PELVIC GIRDLE**

not flat, one usually being concave and one convex, the convexity of one centrum fitting into the concavity of the centrum behind it, for the vertebrae are of the procoelous type with the concavity on the anterior face of the centrum. On the anterior and posterior faces of a neural arch are paired processes, the articular surfaces known as the anterior and the posterior zygapophyses, the former facing upwards and inwards and the latter downwards and outwards. These extra articulations strengthen the vertebral column and limit its lateral movement.

The first vertebra, or atlas, which articulates with the exoccipital condyles of the skull, has no transverse processes and no anterior zygapophyses. On the lower half

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of its anterior face, the atlas bears a pair of concave facets which fit over the exoccipital condyles (Fig. 6). Each vertebra from the second to the eighth can be considered as typical. The centrum is procoelous and forms the floor of the neural canal, the neural arch forms the sides and roof of the neural canal, and a small blunt neural spine projects upwards and backwards from the top of the neural arch; the pair of transverse processes project horizontally outwards from either side of the neural arch, and a pair each of anterior and posterior zygapophyses are present. The ninth

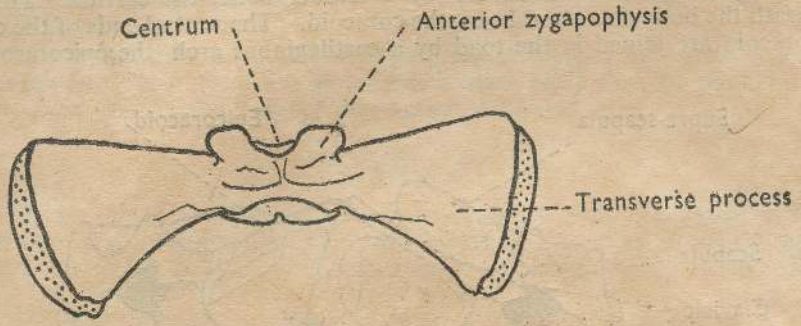

Fig. 10 SACRAL VERTEBRA (dorsal view)

vertebra, or sacral vertebra, has specially stout, backwardly directed transverse processes, their ends enlarged and dorso ventrally flattened and their lateral margins bearing cartilaginous borders to which the iliac processes of the pelvic girdle are attached (Fig 10). The sacral vertebra has no posterior zygapophyses, and its centrum bears two knob like convexities on the posterior face which fit into two corresponding cavities on the anterior face of the urostyle. The urostyle (Fig 9) is a long bony rod, tapering posteriorly, and surmounted by a prominent vertical ridge under which the neural canal continues for a short distance.

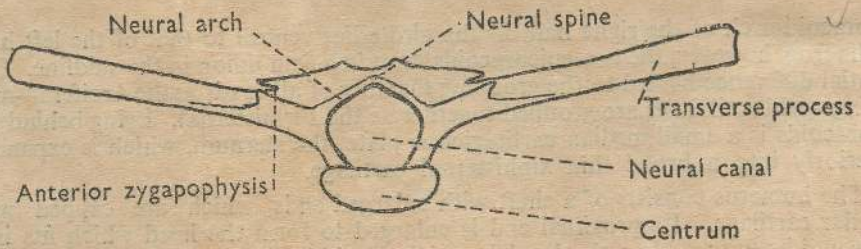

Fig. 11 SACRAL VERTEBRA (anterior view)

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PECTORAL GIRDLE AND FORE LIMB (Figs. 12 and 13)

The pectoral girdle can be divided into two halves, each of which consists of three bones which provide an articular surface for the humerus in the glenoid cavity where they unite. They are the scapula, coracoid and clavicle. The scapula lies above the body and on its side, and has a partly cartilaginous distal plate, the supra-scapula. Anteriorly, beneath the body, is a slender horizontal bar of cartilage, the precoracoid, which is covered over on its anterior border by a slender bone, the clavicle. Posteriorly, beneath the body, is a stout bone, the coracoid. The ventral ends of the clavicle and coracoid are joined in the toad by a cartilaginous arch, the epicoracoid; the

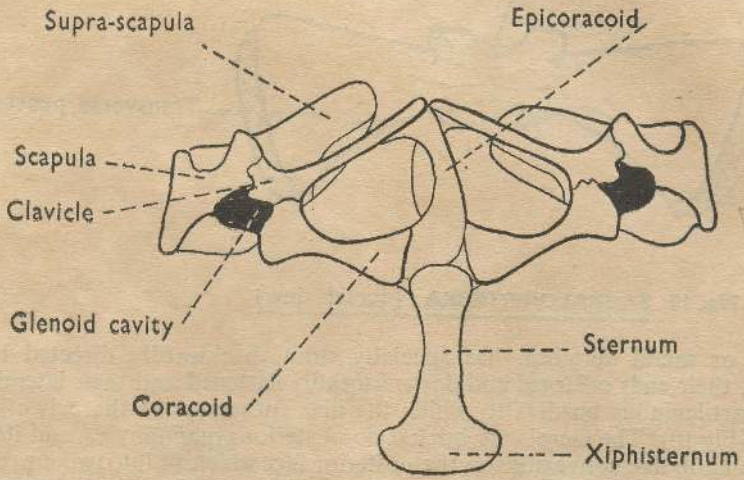

Fig. 12 PECTORAL GIRDLE

epicoracoid arch of the right half of the girdle lies ventral to that of the left half. (In the frog, however, the two epicoracoids meet in a firm union in the midline. This essential difference has led to the grouping together of all toads as the Arcifera—arch bearing—while all frogs are grouped together as the Firmisterna). Lying behind the epicoracoids is a small median cartilaginous plate, the sternum, which is expanded posteriorly into a broad thin xiphisternal cartilage.

The humerus consists of a shaft with enlarged ends which are capped with articular cartilage. Its proximal end is enlarged to form the head which fits into the glenoid cavity. Near the head is a deltoid ridge running along the proximal half of the anterior surface, which serves as a base for the insertion of the deltoid muscle. At the distal end is an almost spherical articular surface for the bone of the

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forearm, with a marked ridge of bone on either side of it. On the inner side, this ridge is expanded inwards to form the median crest, or crista medialis, which serves to secure the muscle which flexes the lower arm. The forearm bone, or radio-ulna, bears two distinct grooves which demarcate an anterior or radial portion lying across the ulnar portion and coming to lie on the inner side at the wrist joint. Its proximal end is hollowed to fit over the spherical articular surface of the humerus at the elbow

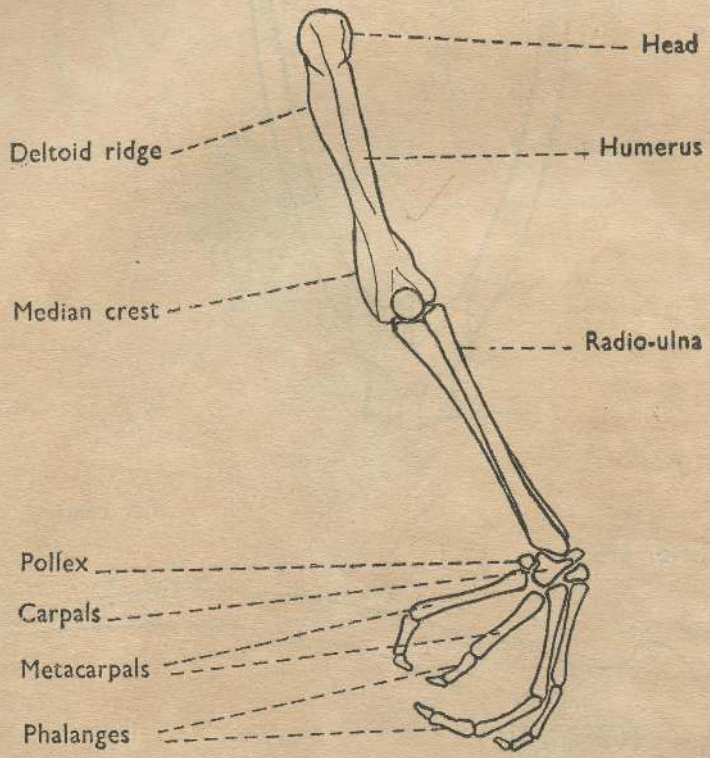

Fig. 13 FORE LIMB

joint, behind which the olecranon process of the ulnar portion of the bone projects backwards to fit behind the end of the humerus when the forearm is extended. The wrist joint is made up of a proximal row of three and a distal row of three carpal bones, or carpalia. The pollex, or thumb, is reduced to one small bone. The metacarpal bones of the other four fingers are present; the second and third bear two phalanges each, and the fourth and fifth three.

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PELVIC GIRDLE AND HIND LIMB (Figs. 14 and 15)

The pelvic girdle forms a much more rigid union with the body than does the pectoral girdle, being ossified and attached to the transverse processes of the sacrum. Corresponding with the scapula, precoracoid and coracoid of the pectoral girdle are

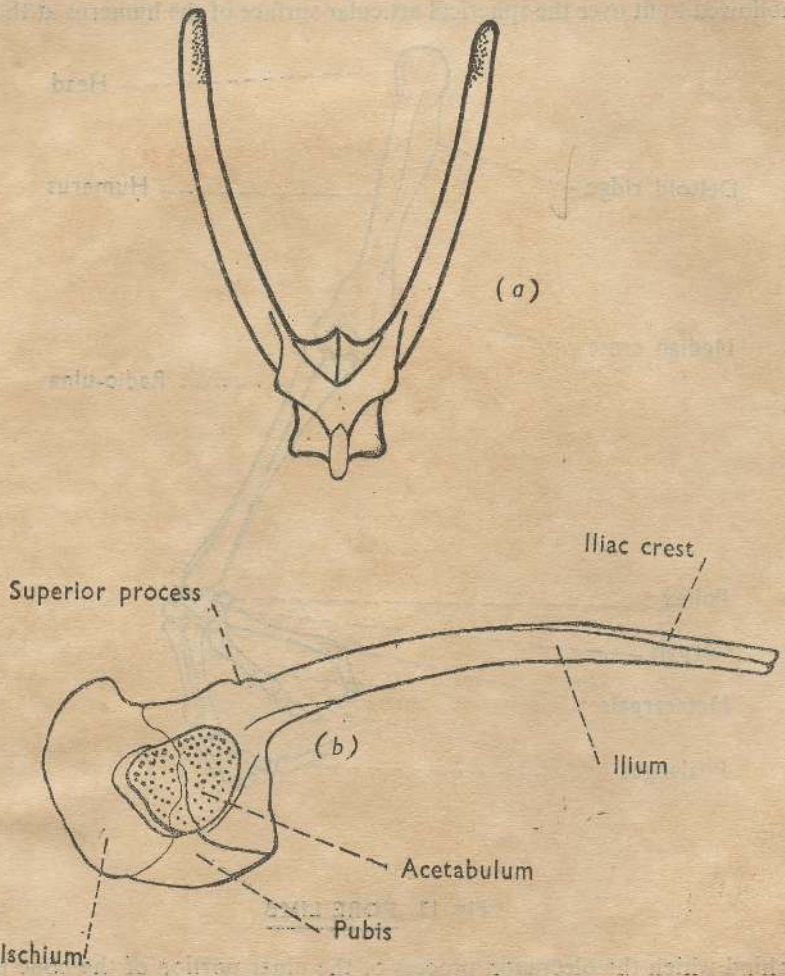

Fig. 14 PELVIC GIRDLE

(*a.* dorsal view; *b.* lateral view)

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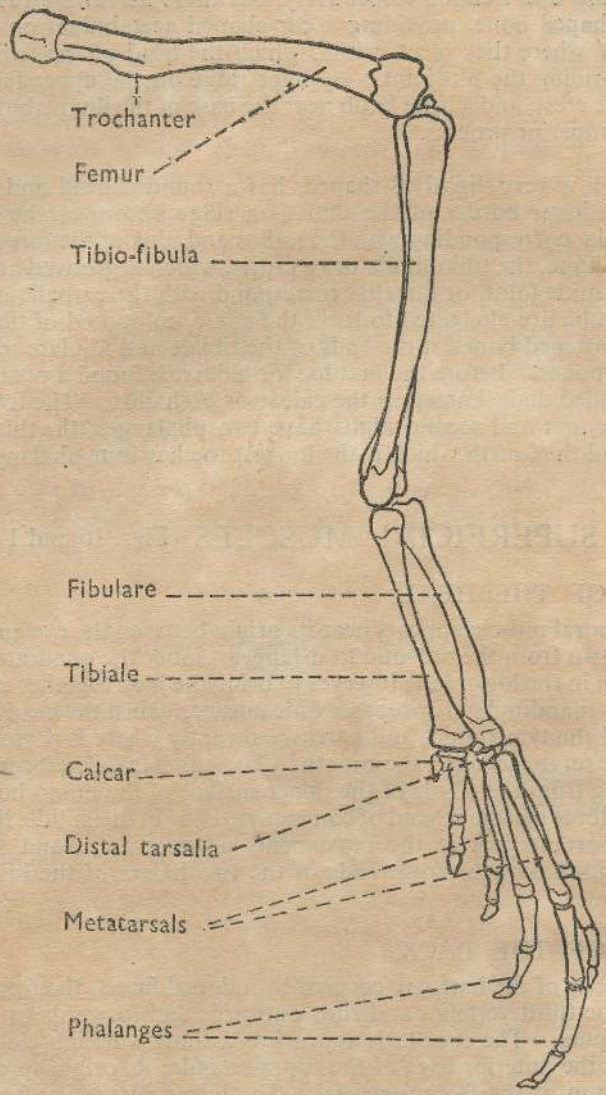

Fig. 15 **HIND LIMB** (right)

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the ilium, pubis and ischium respectively, but these halves are fused in the midline into one V-shaped bone, providing a cup-shaped acetabulum on either side at the base of the V where they meet, within which the head of the femur or thigh bone articulates forming the hip joint. A slight ridge on the upper face of the ilium is called the iliac crest, and a little knob near the base of the ilium above the acetabulum is called the superior process.

The femur is very slightly S-shaped, has a rounded head and a flattened distal end. On the inner border of the shaft is a ridge known as the trochanter. The tibia and fibula, corresponding with the radius and ulna of the fore limb, are fused to form a single bone, the tibio-fibula or os cruris, which is grooved at either end. The bones of the ankle joint, or tarsalia, correspond with the carpalia of the wrist. The proximal tarsalia are elongated to form the ankle, composed of tibiale and fibulare. Two small, flattened bones at the ends of the tibiale and fibulare represent the distal row of tarsal bones. Before the first toe, or hallux, is found a preaxial bone belonging to a modified digit, known as the calcar or prehallux, The five metatarsals are present. The first and second digits have two phalanges, the third and fifth three phalanges, and the fourth which is the longest toe has four phalanges.

SUPERFICIAL MUSCLES (Figs. 16 and 17)

MUSCLES OF THE HEAD

The temporal muscle appears near its origin between the eye and the tympanum, and passes down from the pro-otic to disappear under the quadrato-jugal on its way to its insertion in the lower jaw; it serves to bring the jaws together closing the mouth. The depressor mandibularis arises as a wide muscle against the head of the squamosal, passes behind the tympanum, and narrows abruptly where it passes round the angle of the jaw; it serves to open the mouth. The submaxillaris forms the floor of the mouth, arising from the whole of the upper surface of the inner border of the lower jaw, and the fibres meet in a band of connective tissue in the middle line. This muscle plays an important part in the movements of respiration and swallowing. The submentalis lies below the front ends of the two halves of the lower jaw, which it serves to connect.

MUSCLES OF THE BACK

The muscles of the back are covered by a dorsal fascia, the front end of which is attached to the third vertebra and runs outwards and forwards to the under side of the supra-scapula. The cucullaris appears as a short wide muscle running from the exoccipital to the anterior edge of the supra-scapula; its origin spreads across to the ridge on the top of the fronto-parietal. The infraspinatus is of roughly triangular form, its broad base arising from the upper surface of the supra-scapula and converging with the latissimus dorsi as it passes outwards and forwards to form the tendon by which it is inserted into the deltoid crest of the humerus. The latissimus dorsi is a narrow muscle lying along the posterior border of the infraspinatus, which arises

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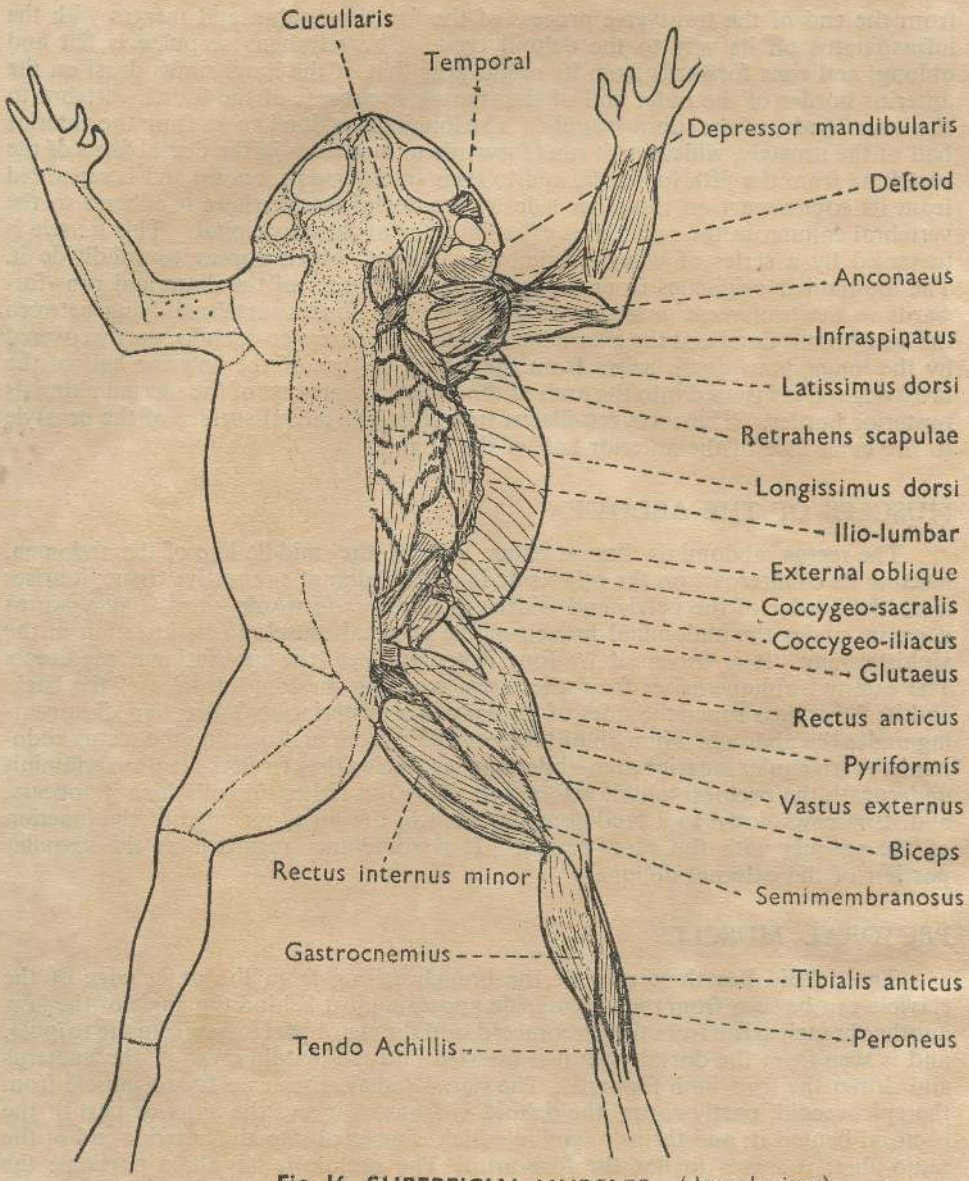

Fig. 16 **SUPERFICIAL MUSCLES** (dorsal view)

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from the end of the transverse process of the fourth vertebra and merges with the infraspinatus on its way to the deltoid crest. The retrahens scapulae is flat and oblong, and runs forwards from its origin near that of the longissimus dorsi on the anterior border of the outer end of the transverse process of the fourth vertebra to the inner border of the supra-scapula. The longissimus dorsi arises from the anterior half of the urostyle, widens as it runs forwards to insertions in the dorsal faces of the vertebrae from the fifth forwards, and to their transverse processes, and is separated from its counterpart on the other side by the dorsal fascia where it adheres to the vertebral column in the midline; it extends as far as the exoccipital. This muscle is traversed by a series of wavy, tendinous partitions which appear to subdivide it. The ilio-lumbar originates from the antero-lateral border of the ilium and runs forwards to the transverse processes of the seventh to fourth vertebrae, lying between the longissimus dorsi and the external oblique. The coccygeo-sacralis, partly covered by the longissimus dorsi, arises from the lateral surface of the anterior half of the urostyle, and is inserted into the arch of the transverse process of the sacrum along its posterior border. The coccygeo-iliacus runs from the lateral surface of the urostyle to the inner face of the anterior half of the ilium.

MUSCLES OF THE ABDOMEN

The rectus abdominis lies on either side of the middle line of the abdomen, meeting its counterpart on the other side in a linea alba of connective tissue; it arises from the border of the pelvis and widens as it passes forwards, narrowing again as it passes under the abdominal branch of the pectoral muscle to its insertion in the xiphisternum. It is traversed by four irregular lines, the inscriptiones tendineae. The external oblique arises from the fascia covering the long muscles of the back, and its fibres pass round the sides of the body in a posteriorward direction, disappearing under the abdominal branch of the pectoral in front and meeting the rectus abdominis. A triangular anterior omo-abdominalis muscle arises from the rectus abdominis underneath the pectoral muscle referred to above, on either side of which it appears, and it narrows down to a tendinous insertion in the posterior edge of the junction of the scapula with the supra-capula. It is sometimes regarded as the scapular portion of the external oblique.

PECTORAL MUSCLES

The deltoid has three origins: the branch arising from the outer edge of the clavicle can be seen from the ventral side appearing just behind the angle of the jaw, another branch arises from the precoracoid, and the major part arises from the scapula, and is seen from the dorsal side; it is inserted into the deltoid crest of the humerus and draws the fore limb forwards. The sterno-radial arises as a broad muscle from the epicoracoid, partly covers the deltoid in front of it and the anterior part of the pectoral behind it, and forms a tendon which is inserted into the anterior end of the radio-ulna; it serves to flex the fore arm. The pectoralis has three portions: the epicoracoid part arises from the posterior end of the epicoracoid, and is partly covered over by the sterno-radial, the sternal part arises from the sternum and xiphisternum,

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and the abdominal part arises from the rectus abdominis, and all three parts run forwards and outwards to their insertion in the deltoid crest of the humerus, gradually narrowing as they pass outwards. It serves to pull the fore limb downwards and inwards.

MUSCLES OF THE FORE LIMB

The anconaeus arises from the posterior border of the scapula, the upper border of the glenoid cavity and the anterior half of the humerus, and the fibres unite to form a strong muscle passing into a tendon which is attached to the elbow joint and inserted into the proximal end of the radio-ulna. The other muscles of the arm and forearm can be separated into extensor and flexor.

MUSCLES OF THE HIP

The glutaeus arises from the outer and upper surface of the middle and posterior thirds of the iliac, and runs backwards narrowing sharply to pass between the origins of the vastus externus and rectus anticus muscles of the thigh to its insertion into the trochanter of the femur. The pyriformis is a narrow muscle arising from the apex of the coccyx and disappearing under the muscles of the thigh to be inserted into the inner side of the femur.

MUSCLES OF THE THIGH

The triceps femoris lies on the anterior border of the thigh and extends on to both dorsal and ventral surfaces; it is a strong muscle, and has three parts at its origin, the vastus externus arising from the upper and hinder end of the ilium on the dorsal side, the rectus anticus arising from the ventral surface of the ilium in its middle region, also seen on the dorsal side, and the vastus internus arising from the acetabulum. The triceps is inserted by a tendon which runs down over the knee joint to the tibio-fibula. The semimembranosus is a broad muscle on the dorsal surface of the thigh, lying on the inner side of the biceps and the pyriformis; it arises from the border of the ischium and is inserted into the dorsal ligament at the back of the knee joint, and through this to the tibio-fibula. The adductor longus is partially visible between the vastus internus and sartorius on the ventral side; it arises from the pubic symphysis, is long and flat, and is inserted below the middle of the femur with the adductor magnus which it joins . The sartorius is a long, flat muscle which lies along the middle of the ventral surface of the thigh; it arises from the pubic symphysis and terminates in a tendon which runs behind the knee joint to its insertion in the proximal third of the tibio-fibula. The adductor magnus lies behind the sartorius under which it disappears distally; it arises from the lower part of the ischium and the pubic symphysis and is inserted into the distal half of the inner surface of the femur. The gracilis major, or rectus internus major, arises by a tendon from the pubic symphysis and ends in a tendon which is inserted into the upper surface of the head of the tibio-fibula; it is a broad, flat muscle lying behind the adductor magnus, and disappearing distally under the rectus internus minor. The latter lies on the inner surface of the thigh, and is a narrow muscle arising in a band from the pubic symphysis, being joined by a number of strands of fibres which run to it from the skin on its course and passing into a thin tendon which blends with that of the rectus internus major.

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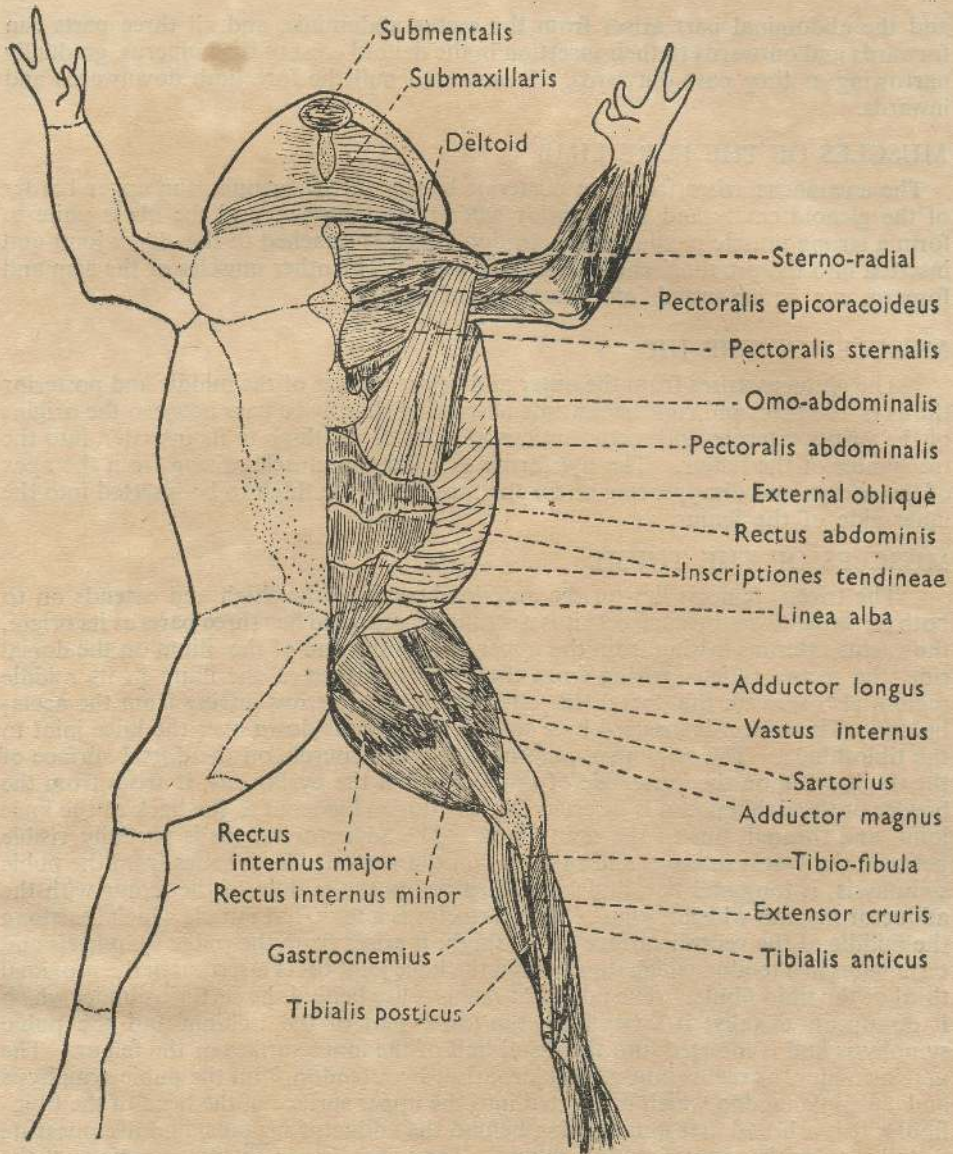

Fig. 17 SUPERFICIAL MUSCLES (ventral view)

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The gastrocnemius or calf muscle arises by a broad tendinous expansion covering the back of the knee joint and attached to the end of the femur, the head of the tibio-fibula and the tendon of the triceps muscle. It diminishes in size as it passes backwards to form the tendo Achillis which is inserted into the heel. The peroneus is a long narrow muscle arising from the distal end of the femur by a tendon which passes over the knee joint and swells to form a muscle on the outer side of the tibio-fibula to which it is attached, and it is inserted in the fibulare of the ankle joint. The tibialis anticus lies on the outside of the peroneus and is attached by a tendon of origin to the femur; it runs along the outside edge of the shank and divides into two parts, one of which is inserted in the tibiale and one in the fibulare. The extensor cruris lies between the tibialis anticus and the tibio-fibula on the ventral side; it arises by a tendon from the end of the femur and is inserted in the outer surface of the tibio-fibula, reaching almost as far as the posterior third of that bone. The tibialis posticus lies on the ventral side between the tibio-fibula and the gastrocnemius, being almost entirely covered over by the latter; it arises by numerous fibres from the inner and upper face of the tibio-fibula and passes from the end of that bone as a tendon which is inserted into the tibiale.

ALIMENTARY SYSTEM

The toad has no teeth either on the jaws or on the roof of the mouth. The tongue is attached to the floor of the buccal cavity at its anterior end (Fig. 18), and the posterior end, which is free, can be flicked out very fast and accurately to capture insects which are the toad's staple diet. The toad does not chew its food; there are therefore no salivary glands. The internal nares open into the front end of the buccal cavity. On the right side of the floor of the buccal cavity of the male is a slit which leads into the vocal sac; this is a hollow sac laying under the floor of the mouth cavity in its lower wall, and it functions as a resonating chamber.

The pharynx is not clearly marked off from the buccal cavity, but the two laterally placed openings of the Eustachian tubes lead into it. On its floor is the glottis, a longitudinal slit standing on a small mound. The glottis leads into the laryngeal chamber. The oesophagus is short and passes imperceptibly into the stomach, which is wider anteriorly and narrows posteriorly to the pyloric constriction which marks the position of a sphincter muscle separating the stomach from the duodenum. The latter is short and is bent back parallel to the stomach; it receives the bile duct from the liver. The pancreas surrounds the bile duct and has no separate duct of its own

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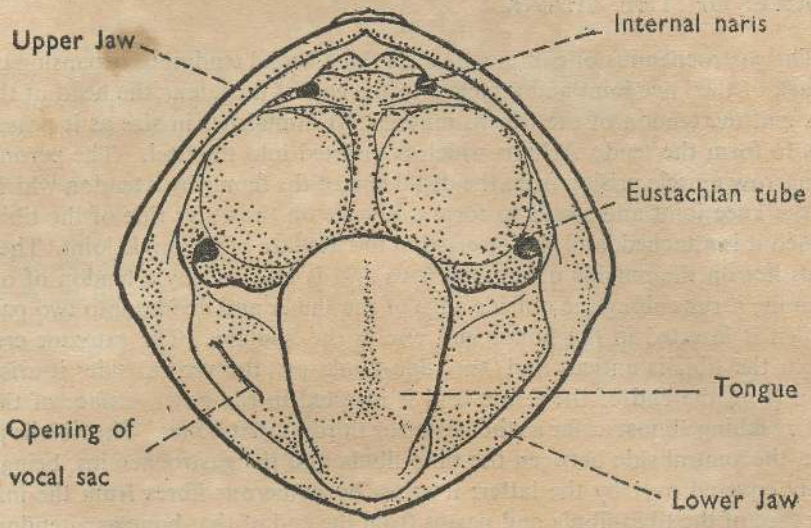

Fig. 18 BUCCAL CAVITY

and it lies between the stomach and the duodenum in the mesentery. The liver is large and consists of two lobes, the left larger and partially subdivided. The gall bladder is a small spherical sac lying between the right and left lobes of the liver. (Fig. 19)

The duodenum passes into a long narrow ileum which is arranged in a series of regular folds, and passes into a short, straight, wide rectum, or large intestine, the final portion of which receives the openings of the urinary and genital ducts on its dorsal side and that of the bladder on its ventral side. This portion is called the cloaca.

The alimentary canal is suspended in the body cavity by an encircling fold of the thin membrane, or peritoneum, which lines the body cavity and forms the mesenteries. The mesenteries hold the intestine and other organs in place and carry the blood vessels which pass to and from them. The intestine is several times the length of the toad's body. (Fig. 19)

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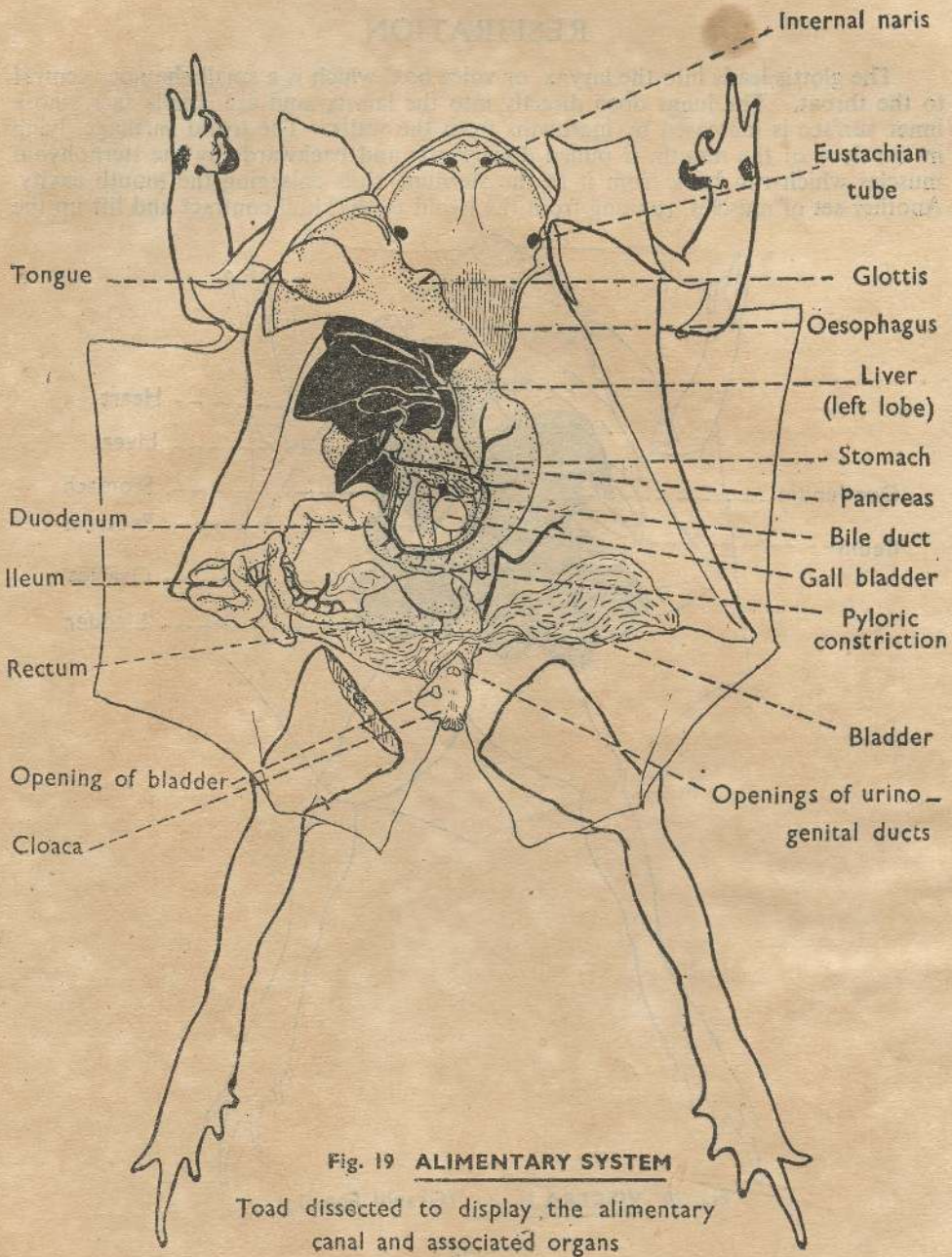

Fig. 19 ALIMENTARY SYSTEM

Toad dissected to display the alimentary canal and associated organs

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The glottis leads into the larynx, or voice box, which is a small chamber ventral to the throat. The lungs open directly into the larynx, and are simple sacs whose inner surface is increased by ingrowths from the walls. The hyoid cartilage, lying in the floor of the mouth, is pulled downwards and backwards by the sternohyoid muscles which run back from it to the sternum, thus enlarging the mouth cavity. Another set of muscles, running from the hyoid to the skull contract and lift up the

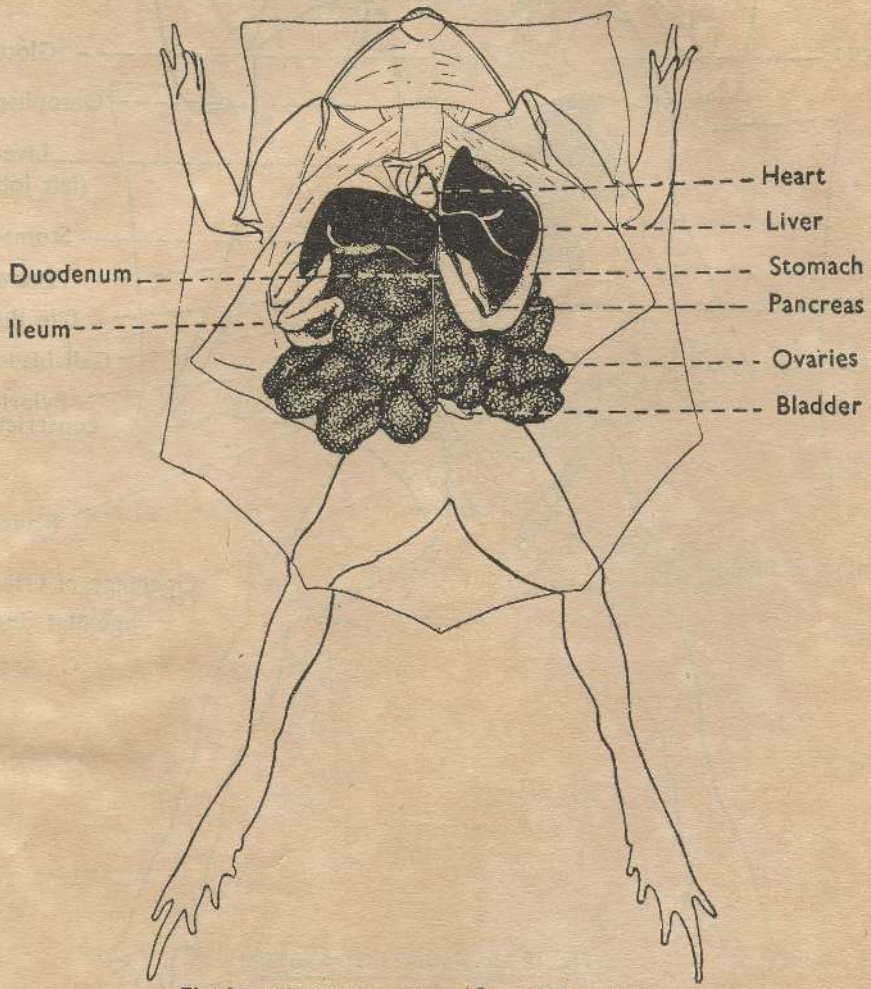

Fig. 20 **VISCERA** *in situ* (Gravid Female)

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hyoid plate, thus reducing the volume of air in the mouth cavity. These two movements act in respiration. The nares are opened and air is drawn into the mouth cavity by several quickly repeated lowerings and raisings of the floor of the mouth, until the mouth cavity is filled with air. The nares are then closed, the glottis is opened and the floor of the mouth is raised, thus forcing the air from the mouth cavity into the lungs. The air is forced out again by the elastic recoil of the lungs and the pressure of the other internal organs on them as soon as the nares are opened. The mode of respiration may therefore be described as a buccal force pump type of respiration.

This is not the only means of respiration, as there is also some interchange of gases between the air and the blood which takes place through the skin, to which there is an abundant supply of deoxygenated blood.

HEART

The heart is enclosed in a thin sac, the pericardium, which contains a fluid which surrounds and lubricates it. This hollow, conical, muscular organ is made up of several chambers :—(1) the ventricle, a large conical pumping organ with a thick

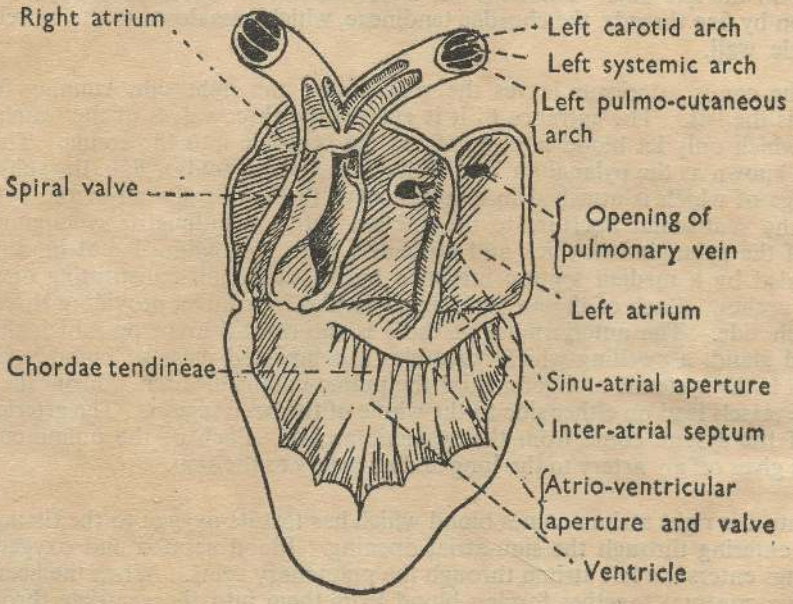

Fig. 21 DIAGRAM OF HEART (frontal section)

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muscular wall, from which arises on the right side of the ventral surface (2) the truncus arteriosus, made up of conus arteriosus and bulbus arteriosus, (3) the left and right auricles, or atria, which are thin walled, the right larger than the left from which it is separated by the longitudinal sulcus, and both opening into the ventricle above which they are placed, (4) the thin-walled sinus venosus lying on the dorsal side of the heart, triangular in shape and opening into the right auricle by the sinu-atrial aperture.

The right and left anterior venae cavae lead into the sinus venosus in front, and the posterior vena cava leads in from behind. The sinu-atrial aperture is guarded by bars, the other openings between the chambers by valves or folds in the lining of the heart.

The two pulmonary veins from the lungs unite and pass into the left atrium from its dorsal surface. The inter-atrial septum or sulcus lies obliquely, further to the left dorsally than ventrally. The walls of the atria have muscular ridges, the columnae carneae, but these are not so pronounced as they are in the ventricle. The interior of the ventricle is spongy and the central cavity is small. The opening between the atria and the ventricle is guarded by three valves, one dorsal, one ventral, and one lateral on the left side. These are the atrio-ventricular valves, and they are held in position by fine threads, the chordae tendineae, which pass down to the muscle of the ventricle wall.

The conus arteriosus leaves the ventricle on the right side, running forwards towards the left. The entrance to it is guarded by three valves of the watch pocket type, which only let blood pass out from the ventricle into the conus. The conus is also known as the pylangium, and within it is a spiral fold or flap, the spiral valve, the edge of which is attached in a spiral curve to the dorsal wall of the pylangium from the ventricular aperture to its junction with the bulbus or synangium. The wall of the pylangium is thick and muscular. The synangium is not muscular and is divided by a median septum into two halves, each half constituting one of the aortic arches. Each of these halves again divides into three, providing three arches on each side. The anteriormost of these is the carotid arch, on which there is a carotid gland, a swelling which resembles a compacted mass of blood vessels, the second is the systemic arch, and third the pulmo-cutaneous arch. From the carotid arches vessels lead on either side to the whole of the head region. The arteries to the rest of the system come from the systemic arches. Each of the pulmo-cutaneous arches gives off an artery to the lung and an artery to the skin.

Into the right atrium comes blood which has lost its oxygen to the tissues of the body, entering through the sinu-atrial opening. Blood aerated and oxygenated in the lungs enters the left atrium through the pulmonary veins. When the heart beats, the atria contract together forcing blood from them into the ventricle through the atrio-ventricular aperture; the ventricle becomes filled with deoxygenated blood from the right atruim and oxygenated blood from the left atrium, and the spongy nature of the ventricle retards the mixing of these two qualities of blood. When the ventricle contracts, the deoxygenated blood from the right side of the ventricle is the first to

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leave it through the truncus which leads off from the right side of the ventricle. Afterwards comes the somewhat mixed blood, and finally the oxygenated blood from the left side. The pulmo-cutaneous arch is the shortest and offers the least resistance to the blood flowing through the truncus, which first fills the pulmo-cutaneous arch, and this deoxygenated blood is carried to the lungs and skin. When the pulmo-cutaneous arches become dilated with blood and the pressure in them increases, the blood begins to force itself along the synangium into the systemic and carotid arches, and as it does so it forces over the spiral valve and prevents further flow into the pulmo-cutaneous arches. On account of the resistance which the carotid gland offers, the blood next flows into the systemic arches, and when these are filled the resistance which they offer is sufficient to force the final flow of blood from the truncus into the carotid arches. Thus it follows that the most deoxygenated blood flows from the heart into the lungs and skin, and the last and most oxygenated blood into the head and brain, while the mixed blood which is less perfectly oxygenated flows to all the other parts.

According to Foxon, the valves in the heart of the frog do not direct the flow of blood as explained above. No other explanation of the part played by the valves present in the heart has however been given. (See New Biology, Vol XII, p. 113, Mode of action of the heart in the Frog, by G. E. H. Foxon.)

ARTERIES (Fig. 22)

Shortly after its origin, the carotid arch on each side gives off an external carotid or lingual to the tongue. Just beyond this branch there is a small swelling, the carotid gland or labyrinth, from which the internal carotid continues to the brain

Close to the origin of the systemic arch, a small vessel branches to the larynx, the laryngeal. As the systemic arch passes round the oesophagus it gives off the occipito-vertebral, which supplies part of the head and the vertebral column; next it gives off the subclavian to the arm. Before it unites with the systemic arch of the other side to form the dorsal aorta, the left systemic arch gives off an oesophageal. At the junction of the systemic arches, a single median coeliaco-mesenteric artery passes to the stomach, intestines, liver and spleen. The dorsal aorta passes backwards giving off paired renal arteries to the kidneys on each side. The first pair of renal arteries also supplies the gonads. The dorsal aorta then bifurcates to form the left and right iliacs, supplying the muscles of the posterior region and the legs.

The pulmo-cutaneous arch branches, the pulmonary artery going to the lungs and the cutaneous to the skin.

The arteries branch often, finally breaking up into minute capillaries which are finally distributed throughout every tissue. The arteries are thick walled and muscular, to cope with the pressure exerted on them by the heart, and hence appear lighter in colour.

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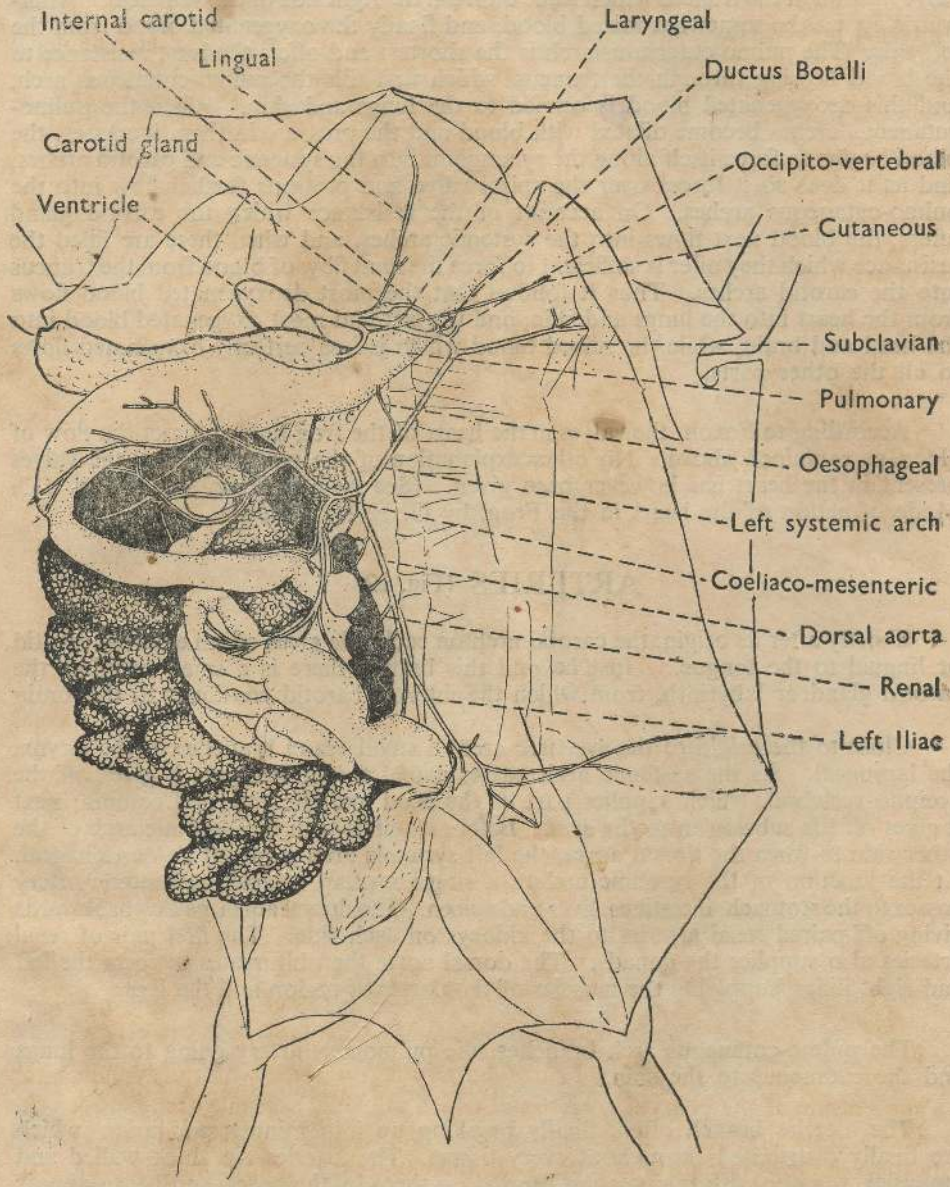

Fig. 22 ARTERIES

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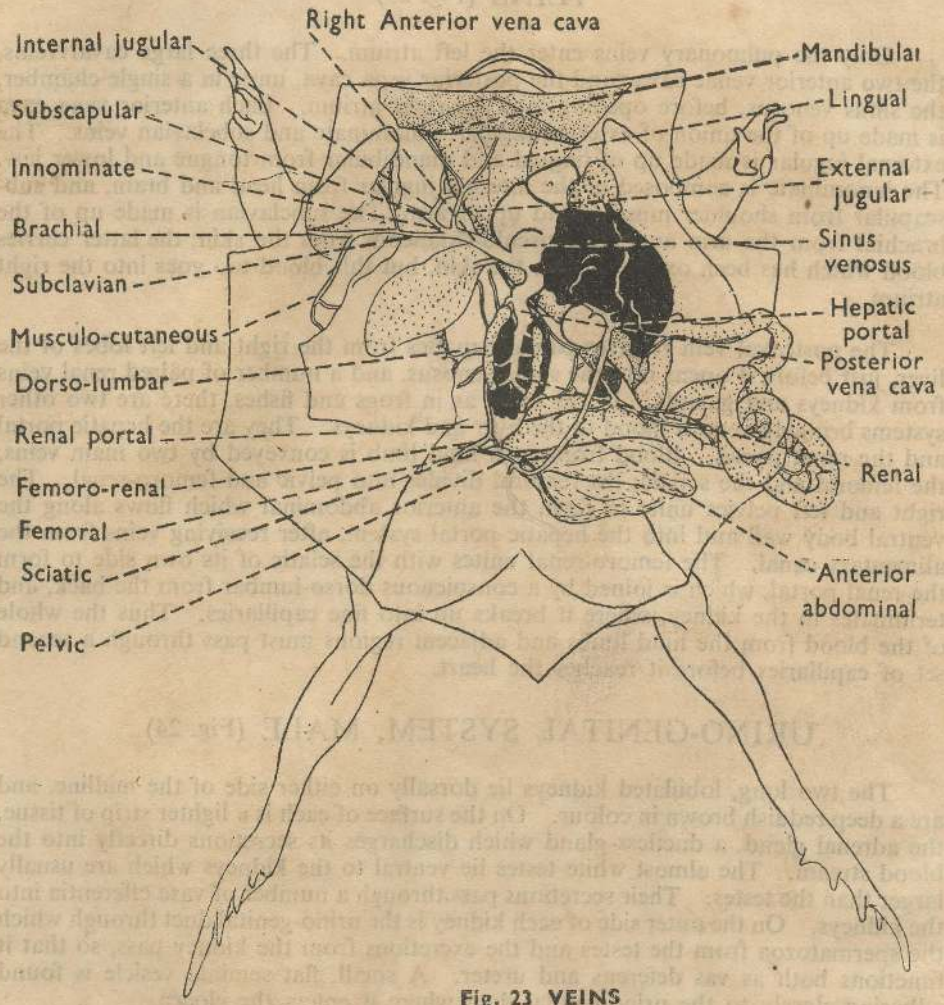

Fig. 23 VEINS

Not infrequently, the internal carotid artery is connected with the systemic arch on the outside of the pharynx by a vessel which joins the systemic arch between the positions of its laryngeal and occipito-vertebral branches. This is the ductus Botalli, a portion of the dorsal aorta as it occurs in the blood system of the tadpole which has persisted through metamorphosis. (See Fig. 21)

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VEINS (Fig. 23)

Only the pulmonary veins enter the left atrium. The three large caval veins, the two anterior venae cavae and the posterior vena cava, unite in a single chamber, the sinus venosus, before opening into the right atrium. Each anterior vena cava is made up of the union of external jugular, innominate and subclavian veins. The external jugular is made up of lingual and mandibular from tongue and lower jaw. The innominate is composed of the internal jugular from head and brain, and subscapular from shoulder muscles and upper arm. The subclavian is made up of the brachial from the arm and the musculo-cutaneous from the skin; the latter carries blood which has been oxygenated in the skin, but this blood too goes into the right atrium.

The postcaval vein receives paired hepatics from the right and left lobes of the liver, just before it opens into the sinus venosus, and a number of paired renal veins from kidneys and gonads. In the toad, as in frogs and fishes, there are two other systems bringing venous blood to the liver and kidneys. They are the hepatic portal and the renal portal. Blood from each hind limb is conveyed by two main veins, the femoral and the sciatic; the femoral divides into pelvic and femoro-renal. The right and left pelvics unite to form the anterior abdominal which flows along the ventral body wall and into the hepatic portal system, after receiving veins from the alimentary canal. The femoro-renal unites with the sciatic of its own side to form the renal portal, which is joined by a conspicuous dorso-lumbar from the back, and terminates in the kidney, where it breaks up into fine capillaries. Thus the whole of the blood from the hind limbs and adjacent regions must pass through a second set of capillaries before it reaches the heart.

URINO-GENITAL SYSTEM, MALE (Fig. 24)

The two long, lobulated kidneys lie dorsally on either side of the midline, and are a deep reddish brown in colour. On the surface of each is a lighter strip of tissue, the adrenal gland, a ductless gland which discharges its secretions directly into the blood stream. The almost white testes lie ventral to the kidneys which are usually larger than the testes. Their secretions pass through a number of vasa efferentia into the kidneys. On the outer side of each kidney is the urino-genital duct through which the spermatozoa from the testes and the excretions from the kidney pass, so that it functions both as vas deferens and ureter. A small, flat seminal vesicle is found adhering closely to the urino-genital duct where it enters the cloaca.

Commonly, in the toad, the anterior part of the testis remains undeveloped. This portion of the testis, termed Bidder's organ, resembles a rudimentary ovary and it has been shown experimentally that it can be made to develop into a functional ovary.

A group of finger-like, yellowish structures, situated at the anterior end of each testis are fat bodies; they function as a reserve supply of nutriment for the testis.

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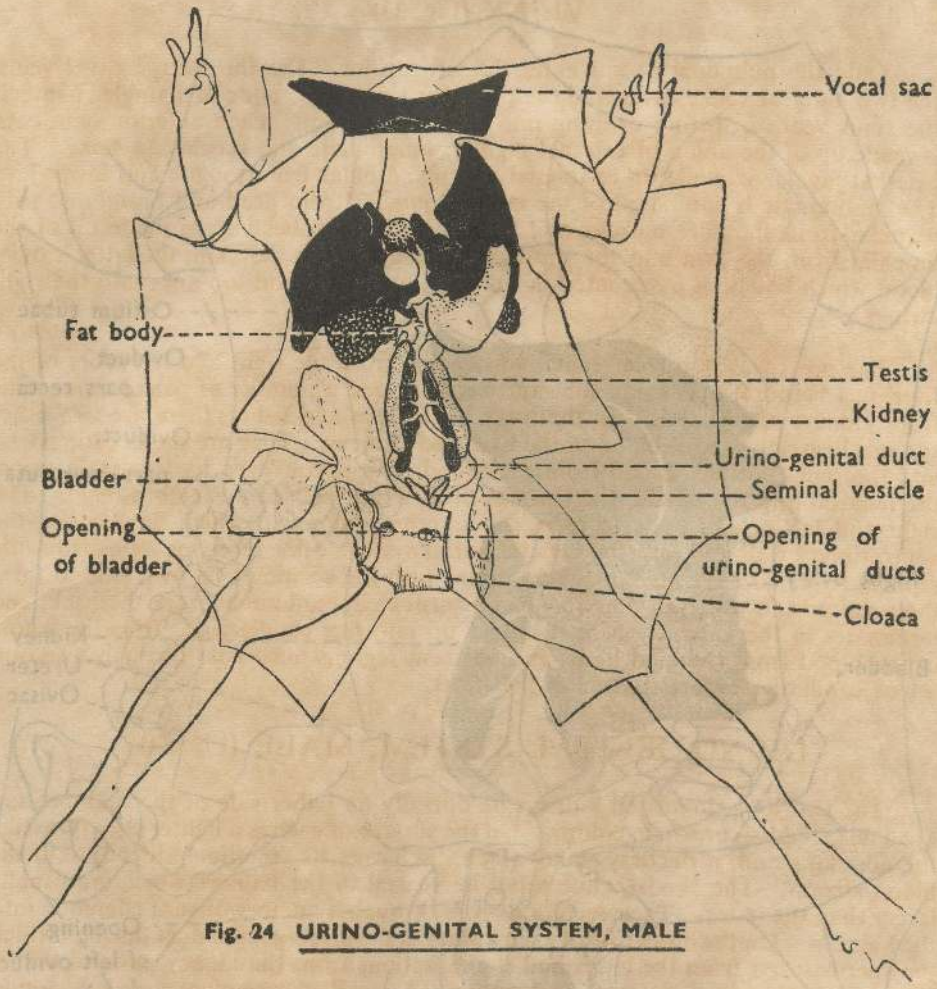

Fig. 24 URINO-GENITAL SYSTEM, MALE

URINO-GENITAL SYSTEM, FEMALE (Fig. 25)

The sac-like ovaries are found ventral and lateral to the kidneys. Small originally, they occupy most of the body cavity when the ova are developing (Fig. 20). They are enclosed in a layer of peritoneum. Each ovary is divided by thin-walled septa into about fifteen compartments, and on the inner walls of these compartments the ova develop. These subdivisions correspond with the lobes seen on the surfaces of the ovaries. The dark pigmented ova are visible through the wall of the ovary.

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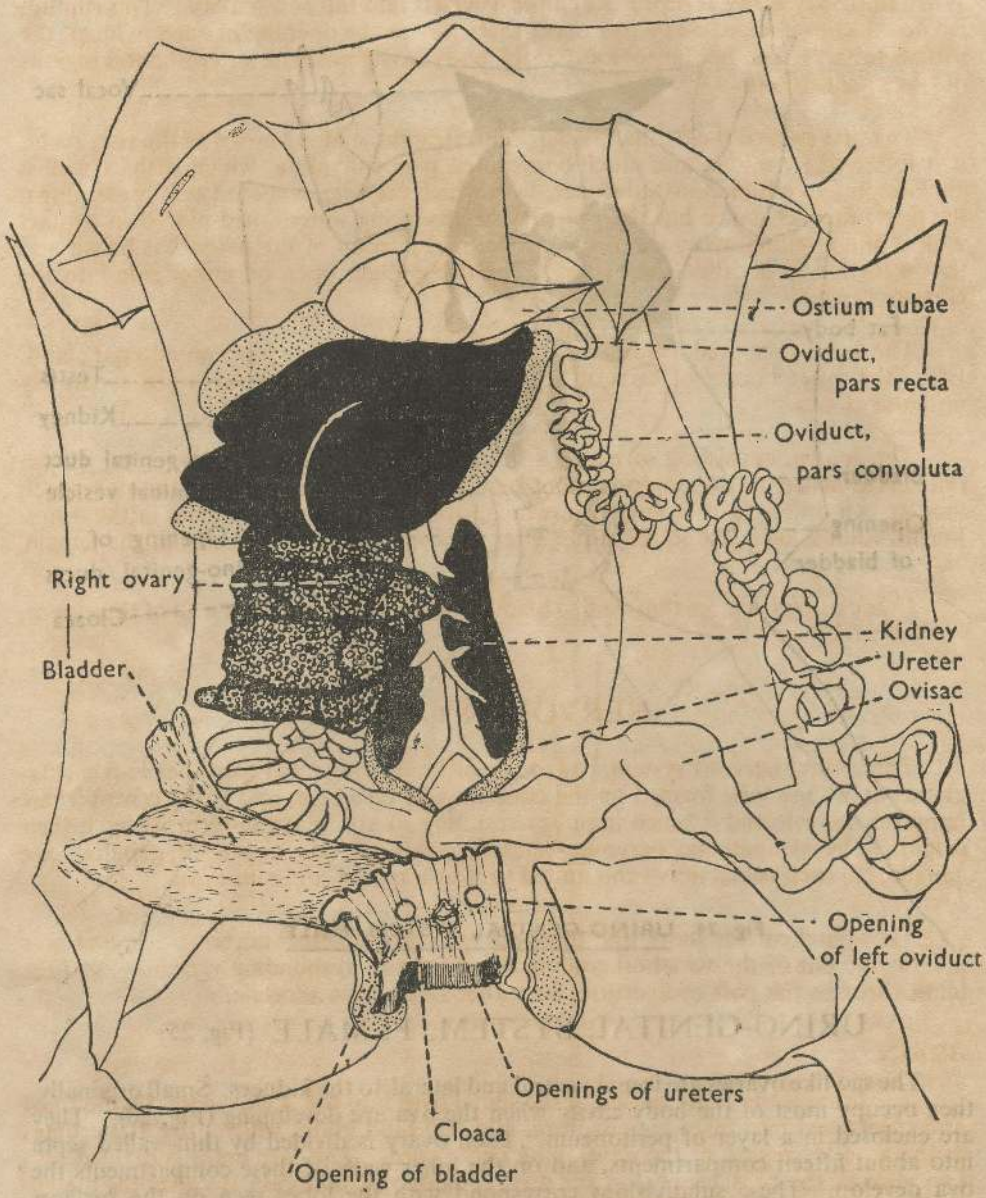

Fig. 25 URINO-GENITAL SYSTEM, FEMALE

(left ovary removed)

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When the ovary is ripe it ruptures and the ova pass into the body cavity. This rupture is known as ovulation. The ova make their way to the opening of each oviduct, the ostium tubae, which lies far forward in the body cavity near the antero-lateral regions of the pericardium.

The first part of the oviduct is short and straight, and is known as the pars recta; it is followed by a long and much convoluted pars convoluta, which is thick walled and secretes an albuminous substance, with which each egg is coated as it passes down the duct; this substance has the property of absorbing water when placed in contact with it and swelling up enormously. The final portion of the oviduct is broad and thin walled, and is called the ovisac. The two ovisacs open on either side into the cloaca.

The kidneys are reddish brown, and, as in the male, they have an adrenal gland. From the outer border of each an ureter arises, the pair of which open separately into the cloaca.

The spawn, consisting of up to a thousand eggs, on emerging from the cloaca remains attached in two long gelatinous strings, one from each oviduct. In this respect, toad-spawn differs from frog-spawn, which forms a large adhesive mass in the water. Fertilization takes place in the water after the eggs have left the body of the female.

In both sexes, a large thin-walled bladder opens into the ventral wall of the cloaca.

NERVOUS SYSTEM

The central nervous system, consisting of brain and spinal cord, lies in a cartilaginous and bony tube formed by the cranium and vertebrae, and is the centre where impulses are felt and whence impulses resulting in voluntary movement have their origin. The sympathetic nervous system consists of two chains of ganglia, one ganglion to each spinal nerve and united to it by a ramus communicans.

The spinal cord is short, and there are ten pairs of spinal nerves. The first nine pairs come out of the vertebral column behind the corresponding vertebrae, and the tenth through the pair of apertures on either side of the urostyle.

BRAIN

The brain is the continuation of the spinal cord into the skull, where it is modified and specialized into three regions, fore, mid and hind brain, which arise as swellings in the anterior region of the developing nerve cord. The fore brain is divided into two regions, the prosencephalon and diencephalon, the midbrain is called the mesencephalon, and the hind brain the metencephalon.

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DORSAL SURFACE OF THE BRAIN

In the anteriormost region, or prosencephalon, are the two fused olfactory lobes, united in the midline, and to them the olfactory nerves run from the nose. Behind them, the two cerebral lobes or cerebral hemispheres, also part of the prosencephalon, lie close together but not fused. Next is a short region, the diencephalon or thalamencephalon, covered over by a thick plexus of blood vessels, the choroid plexus. A short pineal stalk attaches the pineal body to the posterior region of the thalamencephalon behind the choroid plexus, and this stalk lies over the surface of the plexus extending anteriorwards. In the most primitive of the amphibia, now extinct, the fossil bones of the skull show that there was a large round opening at this point, and it is believed that in them the pineal eye was an extra eye, and its stalk an optic nerve emerging through this foramen.

In the next region or mesencephalon, are found two ovoid swellings, the optic lobes, which touch each other in the midline and are hollow within.

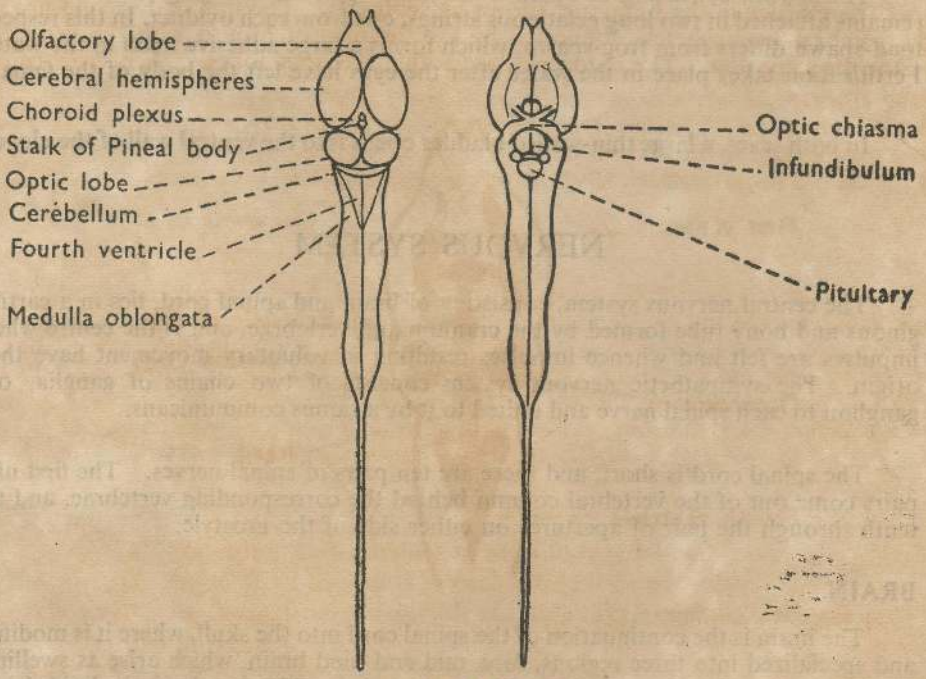

Fig. 26 BRAIN

(*a.* dorsal view; *b.* ventral view)

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On the roof of the hind brain, or metencephalon, is a very small transverse ridge, the cerebellum; the area behind this, the medulla oblongata, has a large cavity which is covered by a triangular choroid plexus. This region passes imperceptibly into the spinal cord.

VENTRAL SURFACE OF THE BRAIN (Fig. 26b)

In the prosencephalon, the olfactory tracts are seen to arise in the pars inferior and to pass forwards to form the olfactory nerves. The floor of the diencephalon is marked by a pair of bulges meeting in the midline, behind which the optic nerves arise. Here some fibres of each side cross over to the nerve of the other side forming the optic chiasma. Above and behind the optic chiasma is a diverticulum of the diencephalon called the infundibulum, which extends backwards to where it meets the pituitary body; the pituitary body is one of the endocrine or ductless glands. Behind the diencephalon on either side, the optic tracts pass inwards from the optic lobes. The thickened floor of the metencephalon is known as the crura cerebri.

CAVITIES OF THE BRAIN

The cavities in the brain are known as ventricles. The first and second are in the cerebral hemispheres, connected by the foramen of Monro with the ventricle of the diencephalon. The optocoeles are within the optic lobes. A narrow canal

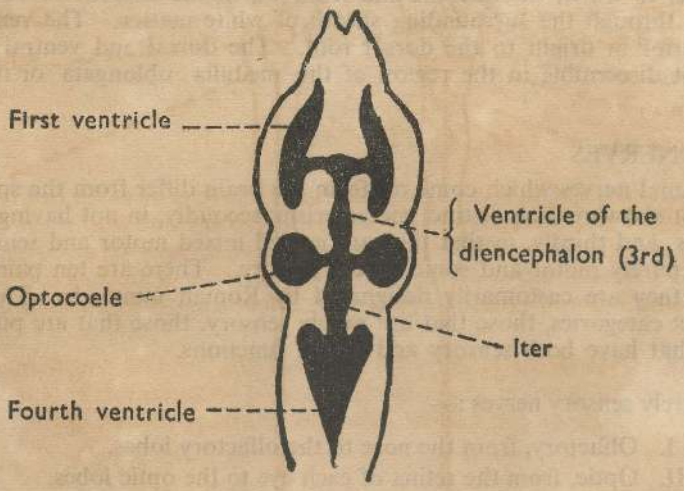

Fig. 27 DIAGRAM TO SHOW CAVITIES OF THE BRAIN

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connects the diencephalon with the metencephalon, and is known as the iter, or more fully the iter a tertio ad quartum ventriculum, which means 'the passage from the third to the fourth ventricle'.

SPINAL CORD

The central nervous system is, in the earliest stages of its development, a simple tube of nerve cells; though it undergoes great changes in form in its development, this primitive tubular character is shown in the neurocoele or central canal in the spinal cord, which expands within the brain to form the ventricles. The spinal cord gives off ten pairs of spinal nerves.

Each nerve arises by two roots, a dorsal and a ventral root. These roots unite and immediately split up into three branches. A small dorsal branch goes to the dorsal body wall, a large ventral branch goes to the body as a spinal nerve, and a small visceral branch or ramus communicans goes to the corresponding ganglion in the sympathetic nerve chain. The tapering posterior end of the spinal cord forms the filum terminale in the urostyle.

The spinal cord is grooved on both dorsal and ventral surfaces, the ventral groove being much deeper. A section across the nerve cord reveals a darker butterfly shaped grey matter surrounding the neurocoele, forming a pair of dorsal horns and a pair of ventral horns to which the afferent and from which the efferent nerve roots pass, respectively, through the surrounding sheath of white matter. The ventral root is slightly anterior in origin to the dorsal root. The dorsal and ventral grooves or sulci are not discernible in the region of the medulla oblongata or in the filum terminale.

CRANIAL NERVES

The cranial nerves which come off from the brain differ from the spinal nerves, firstly, in not showing such distinct metamerism, secondly, in not having dorsal and ventral roots, and thirdly, in that they are not all mixed motor and sensory nerves, some being purely motor and some purely sensory. There are ten pairs of cranial nerves and they are customarily designated by Roman numerals. They fall into three distinct categories, those that are purely sensory, those that are purely motor, and those that have both sensory and motor functions.

A. Purely sensory nerves :—

I. Olfactory, from the nose to the olfactory lobes.
II. Optic, from the retina of each eye to the optic lobes.
VIII. Auditory, from the auditory capsule to the medulla oblongata.

B. Purely motor nerves :—(to the muscles of the eyeball only).

III. Oculomotor, from the floor of the mid-brain to four of the muscles which move the eyeball, the superior rectus, the inferior rectus, the internal rectus and the inferior oblique.

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IV. Trochlear or pathetic, from close behind the optic lobes on the dorsal surface to the superior oblique muscles of the eyeball. (The action of these muscles serves to turn the eyeballs upwards and slightly inwards, hence the name 'pathetic'.)

VI. Abducens, from near the midline of the floor of the hind brain to the posterior rectus and levator bulbi muscles of the eye.

C. Mixed motor and sensory nerves, ganglionated at the root :—

V. Trigeminal, arising behind the fourth cranial nerve in the hind brain, and having three branches :—

(*a*) ophthalmic, from the skin of the snout, sensory ;

(*b*) maxillary, to the upper lip and lower eyelid, motor and sensory;

(*c*) mandibular, to the muscles of the lower jaw, motor.

At the base of the trigeminal is a large ganglion, the Gasserian ganglion.

VII. Facial, arising close to the auditory nerve immediately behind the trigeminal, and associated with the Gasserian ganglion, it leaves the skull with the trigeminal, but immediately divides into two branches :—

(*a*) Palatine, which runs across the floor of the orbit and lies above the mucus membrane of the roof of the mouth, supplying it, sensory ;

(*b*) Hyomandibular, which runs outwards and back to curve round the auditory capsule, passing down behind the Eustachian tube to the angle of the mouth where it branches to the tympanic membrane and divides again into two at the angle of the jaw, forming

(i) the Mandibular, in the floor of the mouth along the inner edge of the lower jaw to the chin ;

(ii) the Hyoid, the longer of the two which runs along the anterior cornu of the hyoid supplying the muscles of the hyoid.

IX. Glossopharyngeal, arises behind the seventh and eighth cranial nerves near the tenth with which it is united by a ganglion near its origin ; it has two branches :—

(*a*) an anterior branch which joins the facial nerve ;

(*b*) a posterior branch which runs to the tongue and the ventral wall of the pharynx.

X. Vagus or pneumogastric, which breaks up into several branches among which the principal ones are the laryngeal to the larynx, the cardiac to the heart, the pulmonary to the lungs, and the gastric

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to the stomach and intestine. The word 'vagus' means 'wanderer', in reference to its wide distribution throughout the system, from head to intestine.

The ninth and tenth nerves supply the digestive and respiratory tracts, carrying motor fibres to the muscles of the throat, face and tongue.

The eighth or auditory nerve is composed of two branches, one associated with the function of hearing and the other with that of balancing, thus enabling the toad both to hear and to determine its position in relation to gravity.

SPINAL NERVES (Fig. 28)

There are ten pairs of spinal nerves corresponding with the ten vertebrae, the first nine passing out on either side of the vertebral column through spaces between the zygapophyses just behind each of the first nine vertebrae, and the tenth passing out through a foramen on either side of the urostyle. The roots of the last four pairs of nerves do not issue out of the neural canal immediately after they branch from the spinal cord, but run backwards for some distance from their origin before they reach their points of exit from the neural canal. Thus they form inside the neural canal a bundle known as the cauda equina.

1. The hypoglossal passes out between the atlas and the second vertebra to the muscles of the shoulder, hyoid and tongue.

2. A large brachial nerve passes out from behind the second vertebra, receives branches from the first and third spinal nerves forming the brachial plexus, and supplies the muscles of the arm, coracoid and clavicle.

3. The third spinal nerve passes out from behind the third vertebra, sends a branch to the brachial plexus, and supplies the oblique and rectus muscles of the abdomen and the skin in that region.

4, 5 and 6. The fourth, fifth and sixth spinal nerves are alike, running backwards from behind the fourth, fifth and sixth vertebrae, respectively, to supply the muscles of the belly and the skin.

7, 8 and 9. The seventh, eighth and ninth spinal nerves, together with a branch from the tenth, constitute the sciatic plexus. Before the seventh spinal nerve joins the eighth, it gives off the ilio-hypogastric which supplies the muscles and skin of the abdomen, and just near its junction with the eighth it gives off the crural nerve which supplies the muscles and skin of the thigh. The largest nerve in the body, the sciatic nerve, arises from the sciatic plexus and supplies the muscles and skin of the hind limb. Branches from the sciatic plexus also supply the posterior part of the alimentary canal, the urino-genital system and the bladder.

10. The coccygeal nerve leaves the neural canal by a foramen on the side of the urostyle ; it is a small nerve, which sends a branch to the sciatic plexus and supplies the region of the coccyx.

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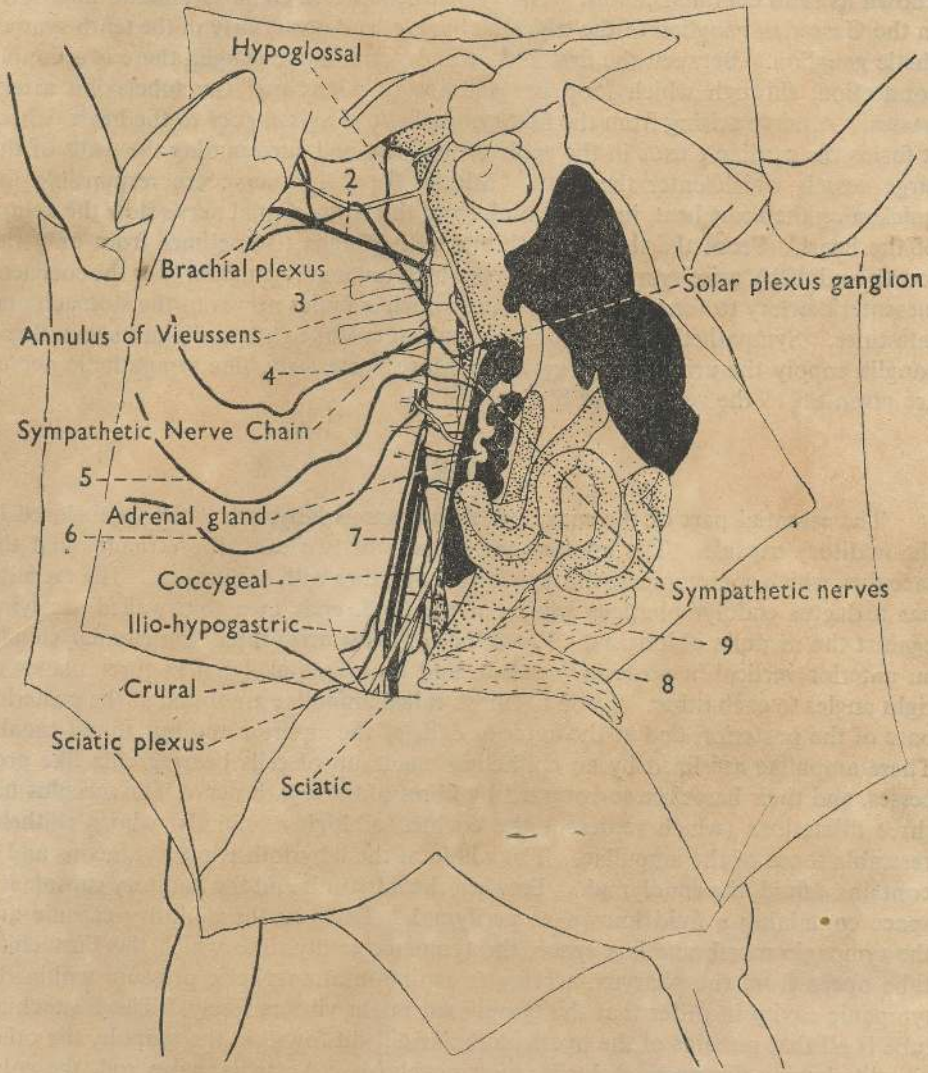

Fig. 28 SPINAL AND SYMPATHETIC NERVES

SYMPATHETIC NERVOUS SYSTEM (Fig. 28)

Lying on either side of the vertebral column is a chain of sympathetic nerve ganglia, connected with the ventral roots of the corresponding spinal nerves by nerves

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known as rami communicantes. The sympathetic nerve chain terminates anteriorly in the Gasserian ganglion of the trigeminal nerve, and posteriorly in the tenth sympathetic ganglion. Between the first and second sympathetic ganglia there is a double connection, through which loop or 'annulus of Vieussens' the subclavian artery passes. A nerve arising from the first sympathetic ganglion goes to the heart, where it forms the cardiac plexus in the walls of the atria and surrounding the walls of the large vessels which enter the heart. Stimuli from this nerve are responsible for quickening the heart beat, just as stimuli from the tenth cranial nerve slow the action of the heart. From the third, fourth and fifth ganglia, (sometimes from only the fourth and fifth), arise sympathetic nerves which unite in a ganglion over the coeliaco-mesenteric artery to form the solar plexus, which supplies nerves to the stomach and intestines. Sympathetic nerves from the sixth, seventh, eighth and ninth sympathetic ganglia supply the urino-genital system. More posteriorly, fine sympathetic nerves are given off to the rectum and bladder.

EAR

The essential part of the ear is the membranous labyrinth which is enclosed in the auditory capsule. The internal ear consists of two sacs, the utriculus and the sacculus, which communicate through a wide aperture with each other. The sacculus has a ductus endolymphaticus which, in the toad, ends in a thin walled sac lying against the medulla oblongata. From the utriculus arise three semicircular canals, an anterior vertical, a posterior vertical, and a horizontal, lying in three planes at right angles to each other. Little swellings called ampullae are found at the posterior base of the posterior, and at the anterior ends of the anterior and horizontal canals. These ampullae are lined by an epithelium made up of cells bearing cilia like processes, and their bases are surrounded by fibres of the eighth nerve. The sacculus has three dilatations (which represent the cochlea of higher animals) whose epithelia resemble those of the ampullae. The whole of the labyrinth is membraneous and it contains a fluid, the endolymph. Between the labyrinth and the auditory capsule is a space containing a fluid known as perilymph. Between the auditory capsule and the tympanic membrane is a space, the tympanic cavity, into which the Eustachian tube opens from the pharynx, serving to maintain atmospheric pressure within the tympanic cavity in order that the tympanum might vibrate freely. The Eustachian tube is all that remains of the hyomandibular gill slit found in the tadpole, the other gill slits having disappeared during metamorphosis. A cartilaginous rod, the columella auris, extends across the tympanic cavity from the tympanic membrane to the cartilage that encloses the inner ear.

The true organ of hearing is the sacculus. Sound vibrations set the tympanic membrane in motion, and this movement is transferred by the columella to a cartilagi-

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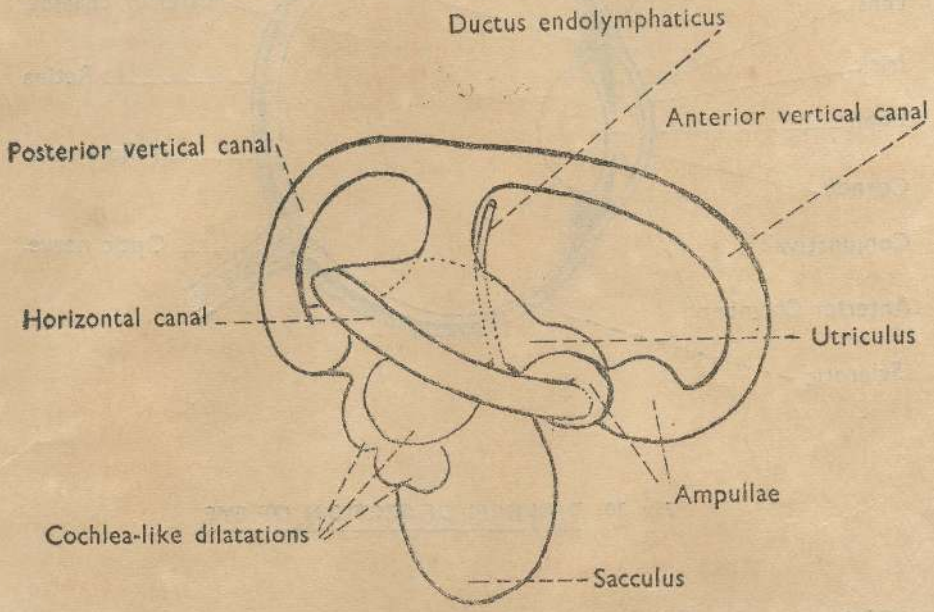
Fig. 29 DIAGRAM OF INTERNAL EAR



nous plug in the fenestra ovalis, the aperture leading from the middle ear to the inner ear. The vibrations are conveyed from there through the perilymph and the walls of the labyrinth to the endolymph, where they stimulate the ends of the auditory nerve in the dilatations of the sacculus.

All motion can be resolved into three planes, and creates a tendency for endolymph to flow through one or other of the semicircular canals, and this flow causes impulses to be registered by the sensitive cilia in the ampullae of the canals, enabling the toad to appreciate its position in relation to gravity.

EYE (Fig. 30)

The outer coat or sense capsule of the eye corresponds to the auditory or nasal capsules of the ear or nose, but it fits closely to the eye instead of forming a hollow capsule fused to the skull as in the other sense organs. Over the greater part of the eye it consists of dense connective tissue with some cartilage, and is known as the sclerotic, but over the front of the eye it is transparent and here is known as the cornea. The skin over the cornea adheres to it as a delicate, transparent covering, the conjunctiva, and is kept moist by the secretion of the Harderian glands below the eye.

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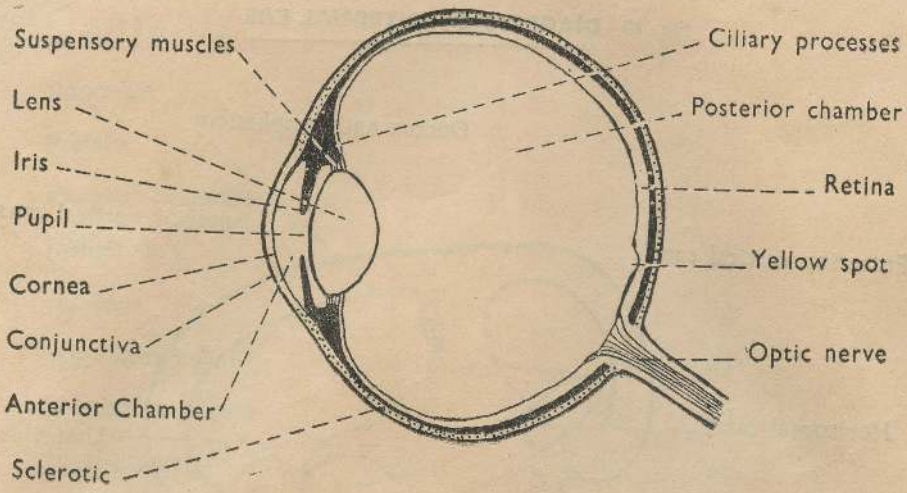

Fig. 30 DIAGRAM OF SECTION OF EYE

Within the sclerotic is the choroid coat, consisting of looser and highly vascular connective tissue containing numerous dark pigment cells. In front, the choroid separates from the sclerotic and extends inwards as a partition known as the iris, lying across the hollow of the eyeball which it thus divides into anterior and posterior chambers... The anterior chamber is small and is filled with a clear fluid, the aqueous humour, while the posterior chamber is larger and is filled with a jelly-like vitreous humour. In the centre of the iris is an opening, the pupil. The iris contains muscular tissue by means of which the size of the opening can be altered.

Immediately behind the iris lies the lens, a firm, transparent, sub-spherical body, which focuses the light entering by the iris and cornea on the sensitive surface at the back of the eye. It is suspended from the ciliary processes of the choroid by suspensory muscles, which function at will to provide for different distances of vision. The lens separates the permanent vitreous humour from the aqueous humour which is constantly being replaced.

The retina is a delicate sensitive surface containing two primary layers; the outer pigment layer of cells lining the choroid, and the inner retina proper, which is of complex structure, and is connected with the optic nerve by which impulses received

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in the retina are conveyed to the brain. The network of nerves lines the inside of the eye and the pigment layer prevents light impulses reaching the receptive surface of the retina except through the pupil. In the front half of the eye, the retina loses its complex structure and becomes very thin, but it lines the posterior chamber to the edge of the lens. The yellow spot directly behind the pupil is most used, and gives the clearest detail of vision. At the blind spot the retina is thin and the optic nerve leaves the eyeball through a gap in the choroid and sclerotic.

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