THE DETAILED ANATOMY OF TRITURUS TOROSUS.

by Gertrude M. Smith.

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THE DETAILED ANATOMY OF TRITURUS TOROSUS.

Introduction.

This investigation was undertaken, on the advice of Dr. Fraser, because of its interest from an evolutionary stand point. As the investigation has shown, this form is much more nearly in the direct line of descent of higher vertebrates than is the frog, which, in comparison, is very highly specialized.

Since the life history and habits have been fully dealt with by Ritter(Proc.Cal.Acad.Sc.1897), Storer(Syn. of Amph. of Cal.1925), Cope(Bat.North Am.), and others, it is unnecessary to give a detailed account here. For the discussion of the external features also, Ritter and Storer are sufficiently complete.

None of these authors, however, have discussed in detail the internal anatomy. This alone is dealt with in the present thesis.

Since in each of the systems examined so many structure were different from those described in other Urodeles, conclusions as to their homology could be drawn only after comparison with descriptions and figures given in various works in comparative amatomy of vertebrates and more particularly in those works dealing with the Anura and Mammals.

The systems will be discussed in the following order:

Skeleton,

Muscular,

Digestive,

Vascular, or Circulatory,

Respiratory,

Nervous,

Sense Organs,

Urino-Genital,

Glands.

Material.

Most of the material used for dissection was obtained from Beaver Lake in Stanley Park and Lonely Lake near Departure Bay, Vancouver Island. The specimens, which were preserved in the usual formalin preparation were in very good condition for dissection.

Specimens were also found by the writer in an old mill pond in Lynn Valley and a pond near Sixteenth Avenue and Arbutus Street.

THE SKELETON

Although the skeleton of this form for the most part resembles that of other Urodeles it is very interesting from an evolutionary standpoint.

The Skull (Plate I, figs. I&2)

The skull of T.torosus is particularly interesting because of the presence of a supra-temporal bar which suggests a direct line of descent from Urodeles to Reptiles. This bar is present in Hatteria, the only living genus of the Rhyncocephalia, and some fossil forms. The bar is apparently found only in the two forms, Triturus and Triton (Kingsley, 1925, p.125)

The skull is more primitive than that of the Anura because of a reduced number of bones. It does however resemble the anuran skull in shape and general appearance.

On the ventral side the following bones are observed. The premaxillae are fused and in the median line is the small fontanelle. Postero-laterally are the maxillae. Teeth are present on both the maxillae and premaxillae. On the roof of the mouth the vomer and palatine of each side are fused, forming the vomero-palatine. On the median line between the two vomers is a large foramen, the inter-vomerine foramen. The palatine teeth are in two long, anteriorly converging rows. The parasphenoid makes up the remainder of the floor of the cranium.

The lateral border of the cranium, as well as the inner wall of the orbit, is made up of one bone, the orbito-

sphenoid or sphenethmoid. The pterygoid is a fairly well developed bone with a forward projection, part of which is still cartilaginous in some individuals. The quadrate is laterally and ventrally placed to the squamosal. The quadrate bears the condyles for articulation with the mandible. No skeletal structure occurs between the maxilla and the quadrate There is, however, a well developed ligament extending across the interval between the maxilla and the quadrate and also one between the maxilla and pterygoid.

In the auditory capsule the periotic is ossified. On the outer, vnetral side of the capsule is the fenestra ovale in which is the stapes. There is no columella. The ossified exoccipital is fused with the periotic. On the exoccipitals are the condyles which articulate with the first vertebrae

On the dorsal surface the premaxilla extends back a short distance medially. There is a cavity on the median line which is bounded for the most part by the premaxillae but the anterior portion of the frontals form its posterior margin. Laterally, as before is the maxilla. Between the maxilla and premaxilla on the dorsal surface is the nasal, a comparatively large bone. A prefrontal is also present, forming the anterior border of the orbit. Over the dorsal surface of the brain are the paired frontals.

Posterior to these are the paired parietals. In each of the parietals is a deep broad fossa passing from near the median line antero-ventrally. This forms the groove in which lies the anterior temporal muscle. Onthe posterior margin of the groove is a well developed ridge which serves as the attachment for the posterior portion of the temporal muscle. The periotic, exoccipitals and supra-occipitals are fused. On the surface of the periotic are the impressions of the semicircular canals. The squamosal has an anterior projection which passes forward to meet with a posterior process from the frontal, thus forming a supra-temporal bar. This is the bar to which reference has already been made.

The lower jaw is made up of two Meckel's cartilages surrounded by membrane bones, dentale, splenial, angular and a fused coronary and suprangular. There is one cartilage bone, the articular, which articulates with the quadrate. The dentale is supplied with teeth.

The branchial skeleton is represented by the hyoid arch and two branchial arches. There is a central portion the copula, or basibranchial cartilage, from the anterior end of which are two lateral cartilaginous projections or cornua. To these two cornua the ceratohyal is attached at its anterior end. This is the representation of the hyoid arch. Anteriorly it consists of a large flat oval cartilage, posteriorly it is ossified. The posterior end of this

bone is attached to the squamosal. To the posterior end of the copula are attached the paired representatives of the first and second branchial arches. The first ceratobranchial is completely ossified, the second only partially so. They come together in a cartilage posteriorly. From this cartilage an ossified first epibranchial passes back parallel with the ceratohyal and ventral to it.

In the larynx two small arytenoid cartilages support the anterior part of the tracheal chamber. On the lateral sides of the vestibule are two other small cartilages.

The Vertebral Skeleton.

The four regions in the vertebral column may be distinguished, though for the most part the vertebrae are similar. There is but one vertebra, the atlas, in the cervical region. This articulates with the occipital condyles of the skull by means of two similar condyles. This is followed by the thoraco-lumbar or trunk region made up of twelve or thirteen vertebrae all bearing ribs. The sacral region consists of but one vertebra. This has the transverse process especially developed for the support of the pelvic girdle. The caudal region is made up of numerous vertebrae. In the anterior portion the vertebrae have well developed haemal arches as well as the lateral zygaphyses for the articulation. There are no ribs in the tail region. The vertebrae of the tail gradually decrease in size and complexity until at the posterior end they are mainly centra.

The vertebrae are opisthocoelus.

The ribs arise as in Necturus, form two heads, a dorsal (tubercular) and ventral(capitular) portion. The two unite and pass for some distance around the bod. cavity.

The Pectoral Girdle (Plate III, figs.6&7)

The coracoids are large and cartilaginous, the left overlapping the right, on the ventral surface. There is also a small cartilaginous procoracoid, and on the dorsal surface is the scapula. Surrounding the glenoid cavity is an ossified portion extending into the coracoid, procoracoid and scapula. There is a small foramen in the ossified part of the coracoid. There is a small ridge on the dorsal surface of the scapula which serves as an attachment for the cucllaris muscle.

The humerus is quite regular but the radius and ulna are present as two separate but similar bones. There are seven carpals, five of which are partially ossified, four metacarpals and eight phalanges. The distribution of the phalanges is as follows: one on the second digit, two on the third, three on the fourth, two on the fifth.

The Pelvic Girdle (Plate III, fig.8)

The pelvic girdle consists of a cartilaginous plate the ischio-pubic plate, of which the posterior part is ossified. From the anterior end is a bifurcating projection, the epipubis or ypsiloid cartilage. Running dorsally from the postero-lateral portion of the

plate, to be joined up with the sacral vertebra are two ossified ilia. The ilia pass posteriorly as well as dorsally; because of this the origin of the muscles of the hind limb is greatly modified.

The femur is ossified and the tibia and fibula are two separate bones both strongly developed. On the posterior margin of the fibula is a long flat ridge which serves to give breadth to the limb. There are sometimes eight and sometimes nine tarsals, in the former case numbers four and five are fused. Five of the tarsals are partially ossified. There are five metatarpals and eleven phalanges the latter being distributed as follows; one in the first digit, two in the second, three in the third, three in the fourth, two in the fifth.

In the ischio-pubic plate are two foramina through which the obturator nerve passes. Hence the foramen may be termed the obturator foramen and regarded as the homologue of the obturator in higher forms.

THE MUSCULAR SYSTEM.

In the main the nomenclature here used is as applied to homologous muscles in the higher forms.

Muscles of the hyoid region.

Geniohyoideus - a long thin muscle extending from the sternum to the tip of the mandible. The origin is in the mandible and the insertion in the fascia of the sterno-hyoid.

Brancho-hyoideus(cerato-hyoideus) - is a heavy muscle originating in the anterior portion of the cerato-hyal and running postero-laterad to be inserted in the posterior part of the ceratohyal and the posterior part of the first epibranchial.

Sternohyoideus - arises from the sternum and is inserted in the dorsal surface of the hyoid arch. It is also derived in part from the anterior portion of the rectus abdominis.

Mylohyoideus - (Intermaxillaris anterior-Bronn)
Submaxillaris -Ecker)

It is a transverse muscle originating on the medial border of the mandible and inserted in the fascia of the median ventral line and the hyoid.

Stylohyoid - (Intermaxillaris posterior-Bronn)
Hinder prtion of submaxillaris - Ecker)

It is a narrow, well developed muscle arising on the posterior margin of the mandible and inserted in a fascia over the coracoid, about the medial line.

Muscles of the Pectoral Region.

Procoraco-humeralis - lies on the ventral surface of the procoracoid cartilage. It originates on the anterior portion of the procoracoid and is inserted on the humerus. It corresponds to the deltoid in man.

Supracoracoideus - lies on the ventral surface of the coracoid. It originates on the coracoid and is inserted on the humerus posterior to the insertion of the previously described muscle.

Pectoralis - It is situated on the ventral surface posterior to the supracoracoideus and in the anterior portion running parallel with it. It is a fan-shaped muscle. The anterior portion arises from a fascia similar to the linea alba on the median line and from the cartilaginous sternum. The posterior portion originates in a fascia overlying the rectus abdominis and the superficial aponeurosis of the external oblique. The two run together to be inserted on the lateral process of the humerus. In this form the pectoral muscle shows beginning of differentiation into anterior and posterior portions.

Coracho-brachialis brevis - is a flat muscle dorsal to the pectoral on the posterior and ventral surface of the coracoid. It arises from the posterior margin of the coracoid and passes laterally to be inserted in the proximal end of the humerus.

Corac o-brachialis longus - is a long thin muscle arising from the lateral posterior border of the coracoid Its origin is covered on the ventral surface by the coraco-brachialis brevis. It passes laterally to be inserted on the humerus about two-thirds of the way from the shoulder.

Coraco-radialis propius - is a thin flat muscle lying on the ventral surface of the coracoid directly on the bone, dorsal to the supra coracoideus and having the same origin on the coracoid as that muscle. It is a fan-shaped muscle, the fibres of which come together to form a long tendon. One branch of the tendon runs out to be inserted in the humerus, the other spreads to form a fan-shaped tendon which is inserted on the radius and ulna around the inner margin of the elbow joint. (See figure)

Biceps - (Humero- antibrachialis inferior-Bronn) This is a strong, well developed muscle which arises from the distal end of the lateral process, passes alog the humerus to be inserted in the proximal end of the radius.

These two muscles correspond to the biceps brach ii in the rabbit(Bensley) and to the biceps in man.

Muscles of the Dorsal Surface.

Dorsalis scapulae - (Infraspinatus-Ecker) It is a well developed muscle on the dorsal surface of the scapula just anterior to the latissimus dorsi and

covered by it in the medial posterior region. Anteriorly it is covered by the cucullaris. It arises from the medial cartilaginous surface of the scapula, passes ventrad to be inserted in the lateral process of the humerus just posterior to the processaco-humeralis.

Latissimus dorsi- (Dorso-humeralis-Bronn) It is a flat triangular muscle just posterior to the dorso-scapularis and covering the postero-medial portion of that muscle with its anterior border. It covers also the serratus magnus. It arises from the fascia on the dorso-medial line of the body from the third to the sixth vertebrae. The posterior portion arises from the myotome of the fifth and sixth vertebrae. It passes ventrally as a converging muscle to be inserted in the proximal end of the extensor side of the humerus near the lateral process. The insertion is just caudad to and partially covered by the insertion of the dorsalis scapulae.

Cucullaris -(Capiti-dorso-scapularis-Bronn)
Trapezius)

This is also a converging muscle anterior to the dorsalis scapulae. It arises from the fascia on the dorso-medial line of the first two or three vertebrae and also from the exoccipitals. The two branches come together and are inserted on the dorsal border of the bony coracoid and on the ridge near the anterior border of the bony scapula. Bronn compares this muscle with the cucullaris

and sternoeleido-mastoid in man.

Subcoracoscapularis - It arises from the upper edge of the bony procoracoid on the inner surface of the bone and from the inner surface of the scapula. It passes laterally to be inserted on the inner surface of the deltoid crest of the humerus. It is a short, stout muscle in the axillary fossa.

Anconeus or Triceps - It has three definite origins.
Scapularis medialis - arises from the posterior border of the scapula, around the glenoid cavity and from the proximal end of the humerus.
Humeralis lateralis - Arises from the proximal end of the humerus on the outer or lateral surface
Humeralis medialis - arises along the anterior border of the humerus throughout its entire length.
All three come together to form a tendon which passes over the elbow joint and is inserted on the ulna.

Serratus magnus - (Thoraci-scapularis-Bronn)
It is a fairly well developed muscle on the dorso - lateral surface of the trunk covered by the latissimus dorsi. It has two branches, an upper and a lower portion.
The lower portion arises from the second rib and passes anteriorly to be inserted in the inner anterior border of the scapula near the insertion of the cucullaris.
The upper portion arises from the second and third ribs and passes anteriorly to be inserted on the posterior border of the cartilaginous part of the scapula.

Muscles of the Forearm.

Flexor carpi radialis - (Humero-radialis volaris Bronn)

It arises from the medial surface of the humerus just above the lateral epicondyle. It runs along the radius to be inserted in the distal end of that bone and the carpus radiale.

Flexor digiti communis - (Humero-phalangi volaris Bronn)

It arises from the medial epicondyle of the humerus, runs along the radius to a fascia in the palm of the hand which is divided into four branches, one going to each digit.

Flexor carpi ulnaris -(Humero-ulnaris volaris Bronn)

It arises from the medial epicondyle of the humerus, in common with the preceding, and is inserted in the distal portion of the ulna and the ulnar carpal.

Extensor carpi radialis -(Humero-radialis dorsalis Bronn)

It arises from the lateral side of the humerus near the lateral epicondyle. It is inserted on the outer surface of the distal end of the radius and the radial carpal.

Extensor digiti communis -(Humero- digiti 2-5-Bronn

It also arises from the lateral epicondyle, passes along the dorsal surface of arm and passes into a fascia which is divided into four branches, one going to each digit.

Extensor carpi ulnaris -(Humero-ulnaris dorsalis- Bronn)

It also arises from the lateral epicondyle on the outer side of the arm and is inserted on the distal end of the ulna and the ulnar carpal.

Muscles of the Back and Neck. (Plate IV, fig.9)

Digastric - (Cephalo-dorso-maxillaris-Bronn
Depressor maxillae - Ecker)

This is a strong,well developed muscle on the lateral side of the jaw. It has two origins,one a thin muscle arising from the dorsal fascia,the other,a stouter muscle,arises from the lateral margin of the squamosal.The two come together to be inserted on the posterior angle of the lower jaw.

Masseter -(Petro-tympano-maxillaris-Bronn)

It is a similar muscle to the foregoing and situated anterior to it.It arises from the anterior border of the quadrate bone and the lateral border of the supra-temporal bar. It passes downward and slightly forward to be inserted on the lateral surface of the lower jaw,anterior to the insertion of the digastric.

Pterygoid - (Pterygo-maxillaris-Bronn)

It is a small muscle arising from the pterygoid and passing down,covered by the temporal,to be inserted on the lower jaw.

Temporal - (Fronto-parietal maxillaris-Bronn)

This arises from the middle line from a fascia on the dorsal surface of the atlas. It runs antero-ventrad in a groove in the parietal,passing under the supra-temporal arcade,ventrally to be inserted by a long tendon on the postero-medial surface of the lower jaw. There is also a posterior part of this muscle which arises from the neural spines of the second,

third and fourth vertebrae. It passes antero-ventrally just posterior to the anterior portion of the temporal and is inserted on the posterior margin of the groove of the parietal and on the dorsal margin of the squamosal.

The temporalis is made up of fibres from the longissimus dorsi and constitutes the dorsal insertion of that muscle. There is a ventral portion of the longissimus dorsi whose insertion is on the occipital region.

Levator scapulae - (Basi-scapularis-Bronn)

This is a long thin muscle arising from the occipital bones passing backward to be inserted on the anterior upper margin of the cartilaginous scapula.

The Muscles of the Eye.

The muscles of the eye are very similar to those of the frog. On the dorsal surface may be seen the superior oblique from the anterior margin and the superior rectus from the postero-medial margin of the orbit. On the ventral surface may be seen the inferior oblique arising near the origin of the superior and the three recti muscles from the postero-medial angle of the orbit.

The Trunk Muscles.

The trunk muscles show some advance towards differentiation. The dorsal or epaxial muscles remain in the form of myomeres. The ventral or hypaxial portions show a beginning of development into layers. There is present an external and an internal oblique, a transverse, a rectus abdominis. The external and internal oblique and transverse are separated from the dorsal myomeres by the lateral line. On the lateral

borders of the rectus abdominis are myomeric thickenings.

Muscles of the Pelvic Girdle and Hind Limb.

Pyramidalis - It consists of two small rectangular muscles on the ventral surface of the abdomen. It has its origin on the anterior border of the cartilaginous portion of the ischio-pubic bone. It passes anteriorly on either side of the main branch of the epipubis and parallel with it. It is inserted along the posterior margin of the arms of the ypsiloid cartilage. According to Bronn this muscle is homologous with the pyramidalis in man.

Rectus abdominis - (Pubo-thoracicus-Bronn)

It consists of two long narrow muscles on the ventral surface of the body on either side of the "linea alba" and traversed by seven"inscriptiones tendinae" The muscle arises from the entire anterior margin of the ischio-pubic plate and passes anteriorly, covered in its anterior portion by the pectorals. It branches anteriorly, sending some branches to be inserted in the cartilaginous sternum. The rest of the muscle continues forward as the sternohyoideus to be inserted on the hyoid. The lateral portion of these muscles is particularly well developed ,forming a thick muscular band, thus showing the transition from the fishes to the higher forms.

External oblique- (Costo-abdominalis- Bronn)

This muscle arises from the point of the ribs all along the back. The muscle fibres arise in diverging points coming together to form a large flat muscle on the lateral surface of the body. The fibres run postero-ventrally, some of them being joined up with the lateral border of the rectus abdominis,

others going on as a thin film to the linea alba. Some of the fibres also are inserted on the ilium, others on the anterior margin of the ypsiloid cartilage and around the border of the acetabulum.

Internal oblique -(Abdominis obliquus internus-Bronn)
It is a flat muscle similar to the preceding and lying just beneath it. Its origin is the anterior border of the ilium and the vertebrae from the sacral region to the fourth rib. It passes anteriorly and ventrally. The fibres are inserted in the rectus abdominis and on the sternum.

Transversalis - This is a thin muscle similar to the two former and lying beneath the latter. Its fibres run transversely around the body from the vertebrae from the neck to the sacrum and are inserted on the mid-ventral line as in - scriptiones tendinae.

Gracilis - (Pubo-ischio tibialis)
It is a thin flat muscle originating in the middle line of the ventral surface of the ischio-pubic plate. The fibres run outward, converging, to be inserted on the medial anterior surface of the tibia.

Caudali-pubo-ischio-tibialis -
This is a thin narrow muscle arising from the ventral surface of the fourth and fifth caudal vertebrae, in common with the ischio and femoro-caudal. It passes forward parallel with these two muscles to be inserted in the posterior border of the gracilis.

Semimembranosus -(Ischio-flexorius-Bronn)
It is a long thin muscle originating on the posterior margin

of the ischium. It passes down and out, joining the preceding muscle near its origin on the gracilis, to be inserted on the plantar surface of the flexor digitorum. It resembles the semitendinosus of Menopoma as desribed by Mivart. (Proc. Zool. Soc. 1869)

Sartorius - (Pubo-tibialis-Bronn)

This is a long slender muscle which arises from a fascia along the outer anterior margin of the ischio-pubic plate. It runs outward anteriorly to the gracilis and is inserted on the tibia on the medial surface just in front of the insertion of the gracilis. This origin resembles that of Menobranchus as described by Mivart (Proc. Zool. Soc. 1869), in that it appears as a continuation of the external oblique muscles.

Ischio-caudal - (Mivart)

It arises in common with the semimembranosus from the ventral border of the fourth and fifth tail vertebrae running parallel with it to be inserted on the posterior margin of the ischium. It is the most medial of the three muscles passing along in this region.

Femoro-caudal - (Mivart)

This is a similar muscle to the preceding and arises in common with it and semimembranosus from the fourth and fifth caudal vertebrae. It passes anteriorly parallel with them to be inserted on the inner medial surface of the femur just below the great trochanter. This insertion is covered by that of the adductor.

Pectineus - (Pubo-ischio-femoralis internus-Bronn
Iliacus -Mivart)

It is a fairly well developed muscle originating on the

anterior borber of the ischio-pubic plate.It runs out to be inserted along the lower half of the femur to the tibial condyle. The position of this muscle corresponds to that of the iliacus in certain forms but from its origin and insertion it seems to correspond to the pectineus.

Adductor - (Pubo-ischio-femoralis externus-Bronn) It is a large triangular muscle on the ventral surface of the ischio-pubic plate,covered by the gracilis. It originates on the medial line of that plate runs laterally to be inserted on the medial surface of the femur near the insertion of the pectineus and femoro-caudal.

Gluteus maximus - This is a long narrow muscle originating in the distal or ventral end of the ilium near the acetabulum. It passes along the femur to be inserted in a fascia which passes over the condyle to the proximal end of the tibia. Please see page 20 for G. Medius and Minimus.

Rectus femoris - It is similar to the previous muscle and lies close to it. Its origin is just anterior to that of the gluteus maximus. It passes laterally to the the gluteus maximus to be inserted in a fascia passing over the knee joint, in common with the gluteus maximus, when the two muscles are inserted as a single tendon on the proximal end of the tibia.

The two preceding muscles are regarded by Bronn as different heads of the same muscle which he calls the Ilio-extensorius.

Biceps - This is a fairly well developed muscle arising from the femur about the middle of the shaft and passing out

to be inserted on the fibula.

Ilio-peroneal - It is a long slender muscle arising from the ilium in close connection with the gluteus maximus. It passes out to be inserted in the proximal end of the fibula on the posterior side.

These two muscles are regarded by Bronn as two heads of the same muscle which he terms the Ilio-femoro-fibularis.

Tibialis anticus - It arises on the distal end of the femur and proximal end of the tibia and is inserted on the tibia and tarsus.

Flexor communis digitorum -It arises from the distal end of the femur, passes down the plantar surface of the tarsus and is inserted on the five digits.

Flexor hallucis - It is a small muscle covered by the former. It arises from the inner upper border of the fibula and passes obliquely to be inserted in the hallux.

These two muscles are well developed in Triturus, covering the plantar surface of the foot with a thick pad.

Peroneus - It arises on the lateral epicondyle of the femur and is inserted along the anterior portion of the fibula.

Extensor brevis digitorum - It is a shott muscle covered by the extensor longus digitorum. It arises from the inner distal border of the fibula, passes down to be inserted on the five digits.

Extensor longus digitorum - It is a tendinous muscle arising from the distal end of the femur passing down to be inserted in each of the five digits.

Extensor hallucis - It is a small muscle arising in

common with the extensor brevis digitorum and passing obliquely across the pes to be insertedon the hallux.

Peroneus-tibial - (Fibulae-tibialis)

It is a small,short muscle running between the tibia and fibula in their distal portion. It originates on the fibula and passes across to be inserted more distally on the tibia.

Flexor-metatarsi et digiti -(Bronn)

It is a fibrous muscle covered by the flexor longus digitorum. It arises from the distal border of the fibula and passes out to be inserted in each of the five digits.

Tarso-metatarsals - (Bronn)

It arises from the ventral surface of the tarsal bones and passes out to be inserted in each of the five digits.

(To be read after the description of the Gluteus maximus)

Gluteus medius - It is a small muscle arising on the posterior border of the ilium and passes across to lie on the upper surface of the femur on the peroneal side.

Gluteus minimus - It is a smaller muscle than the former arising from the posterior border of the ilium passing across beside it to be inserted near the insertion of the latter but proximal to it on the femur.

According to Bronn this is the Ilio-femoralis and is homologous with the Iliacus in man.

The Caudal Muscles.

The muscles of the tail retain the myomeric construction characteristic of the fishes. The lateral bands or inscriptiones tendinae are distinct in the anterior half of the tail Posterior to that the muscles show little division into

myomeres but appear merely as two flat muscles one on either side of the tail. On the ventral surface of the tail there is a depression on the anterior third. Posterior to this there is a ridge. The same is true of the dorsal surface. For the anterior five myomeres of the tail the lateral longitudinal lines are distinct. Posterior to that they gradually disappear.

THE DIGESTIVE SYSTEM.

There are no very striking differences in the digestive system of Triturus.

The mouth is a wide opening bounded by two lips, an upper and a lower. On the roof of the mouth are the two openings of the posterior nares. In the median line anterior to them is a fontanelle, a large opening which has already been mentioned as occurring between the vomers.

The palatine teeth are in two long rows, converging anteriorly, one on either side of the median line.

The tongue is a small oval body attached in its middle portion to the floor of the mouth.

The oesophagus opens as a horizontal slit. It extends caudad as a straight tube for the distance of about ten millimeters when it broadens out to form the stomach, a body about twice its length. The small intestine is similar to that of the frog with less coiling. There is a distinct widening to form the large intestine. It opens posteriorly into the cloaca.

The liver is a large body on the ventral surface of the body cavity. Although it shows indications of division into separate lobes the body is still complete. The size and nature of the lobing of this organ varies greatly in different individuals. The gall bladder is a small sac-like body.

The pancreas is scattered more or less definitely along the blood vessels of the anterior portion of the small intestine and about the loop of the stomach.

THE CIRCULATORY SYSTEM.

The Heart

The pericardial cavity is situated well forward , just beneath the pectoral girdle. The heart is made up of one ventricle, two auricles, conus arteriosus and sinus venosus. The ventricle is thicked walled and muscular, the auricles are thin walled and non-muscular. The heart is turned as in the embryo of higher vertebrates so that the left auricle lies almost directly dorsal to the right. The auricles are divided by a complete septum. The two auriculo-ventricular openings, separated by the septum, come together in such a way as to form one opening into the ventricular cavity.

Opening from the cephalic end of the ventricle is the conus arteriosus. It is situated on the ventral surface of the auricles. A short distance out it becomes the bulbus arteriosus from which the arterial arches arise.

The sinus venosus is posterior and slightly dorsal to the ventricle. It opens into the right auricle.

The Arterial System.

The arterial system is for many reasons the most in - teresting. With the disappearance of the gills, the gill arches have also gone and there are evidences of transition.

The bulbus arteriosus divides to form two branches each of which is made up of three arches. These three arches correspond to the third, fourth and sixth arches in primitive forms. In some of the specimens examined a small branch representing the fifth arch was found but at best it was

poorly developed.

The most anterior of the three vessels is known as the carotid arch. It passes laterally to the carotid gland where it divides to form two branches, the external and internal carotids. The former runs mediad again for a short distance, as far as the thyroid gland where it turns and passes anteriorly, sending off various small branches. Shortly after it leaves the arch it gives off a small branch to the cerato-hyoid muscle, others to the muscles of the lower jaw and one to the tongue, the lingual artery.

The internal carotid passes laterally for a short distance from the carotid gland toward the angle of the lower jaw. Here it divides sending one branch mediad across the prootic bone to enter the cranium just posterior to the foramen for the pneumogastric nerve. This vessel supplies the brain (see later). The second branch of the internal carotid passes anteriorly and slightly mediad to supply the mucous membrane of the mouth and the under surface of the eye-ball.

About half way between the carotid gland and the division of the internal carotid a small vessel goes across to join with the systemic arch. This is a remnant of the connection sometimes known as the ductus Botalli (No.I).

The second vessel to leave the bulbus arteriosus is the systemic arch which passes dorsad and slightly posteriorly to meet the corresponding vessel from the opposite side near the median line.

In the region where the connection is made with the

internal carotid a branch leaves the systemic, passing laterally and anteriorly towards the angle of the jaw. Here it branches, sending one branch along the margin of the lower jaw, which in turn sends off small branches to the skin of the lower jaw. There are also three or four vessels passing dorsally from the main branch at the angle of the jaw to supply the skin along the side of the head. This vessel may be called the anterior cutaneous artery.

Slightly behind the origin of the cutaneous but before the two arches come together, two small vessels arise from the dorsal portion of each arch. They pass anteriorly for a short distance together. One of the branches then turns dorsad and passes through the body wall at the base of the skull in the region of the first vertebra. This is the occipito-vertebral. It again divides, one branch passing caudad through the transverse processes of the vertebrae, and sending occasional branches to the spinal cord. This is the vertebral. The other branch, the occipital, passes to the dorsal surface of the skull. The second branch runs anteriorly on the ventral surface of the skull till it reaches the posterior nares. Here it divides, sending one branch along the anterior margin of the orbit, the second running mediad around the margin of the posterior nares and then passing forward, sending off numerous small branches, to supply the region of the external nares. This vessel corresponds in origin and position to that figured by Kingsley as the ocular artery but since, in this case, the olfactory region is also supplied it will be called the orbito-nasalis artery.

The third and hindermost arch to leave the heart is the pulmonary artery. It passes laterally for a short distance parallel with the other two arches and then turns suddenly and passes back to the lungs, giving several small branches to the oesophagus as it goes.

At the point where it turns posteriorly a vessel goes across to unite with the systemic arch. This is the ductus Botalli and in all specimens examined was well developed.(No.2) The pulmonary artery passes down the medial border of the lung giving off vessels along the ringed areas.

Arteries of the Pectoral Region. (Plate V, figI)

Shortly after the union of the two systemic arches to form the dorsal aorta the subclavian artery arises. It passes laterally,along with the brachial plexus,gives off several small branches and continues as the axillary to the arm where it becomes the brachial.

The first branch to be given is the costo-cervicalis. It is a small branch running posteriorly on the dorsal wall of the body cavity. Distally to this two branches are given off, one passing dorsally and then again branching to form the subcoraco-scapularis(scapularis of the frog) and the scapularis posterior. The former goes to supply the subcoraco-scapularis muscle and the latter to the muscles on the ventral surface of the scapula,i.e. the serratus magnus, etc. The second branch passes laterally to about the margin of the rectus abdominis where it turns and passes posteriorly as well as developed vessel giving off branches to all the various segments in the abdominal muscle. This is

described by Wiedersheim(Fig.262) as a cutaneous vessel but as it is a deeper vessel the term anterior epigastric artery used by Bronn seems preferable. This corresponds to the thoracic artery in the human. Posteriorly it anastomoses with the inferior epigastric. Shortly after its origin the anterior epigastric gives off a branch which passes ventrally to supply the pectoral muscles. This is the coracoideus which corresponds to the clavicular of the thoraco- acromial in man and to the coraco-clavicularis in the frog.

Laterally a fourth branch is given off from the subclavian. It passes toward the region of the glenoid cavity following its margin and giving off a few branches to it and to the procoraco-humeralis muscle. This apparently corresponds to the circumflex humeri arteries in man. From this vessel near its origin a branch passes antero-mediad which itself divides into several small vessels to supply the muscles on the dorsal surface of the scapula, i.e. the scapularis dorsalis and latissimus dorsi. This is the scapularis superior(Ecker) or the scapular circumflex(Bronn) This is similar to the scapular circumflex in man.

There were found in this part of the system many variations. No two specimens were alike and some not all the vessels were found. The preceding account is a fairly typical one however.

The subclavian artery passes across the axillary fossa and down the inner surface of the humerus as the brachial artery. At the elbow joint a branch is given off which again divides, one vessel passing forward to supply the flexor

muscles of the forearm, the other passing up the arm to the biceps. Below the elbow the brachial passes into the interosseal space and proceeds down the arm along the inner margin of the ulna. It crosses through a foramen in the intermedio-ulnare carpal to the dorsal surface of the hand where it divides into three parts, each branch again dividing sending one vessel to the radial margin of one digit and the ulnar margin of the next. This seems to correspond in distribution at least to that described by Ecker as the ulnar artery.

About half way between the wrist and elbow two more branches are given off from the brachial artery, one on the inner surface of the forearm which sends off small branches to the flexor muscles and to the palm of the hand, also one branch passes forward, across the ulna to supply the outer and inner lateral margins of the fourth finger. This corresponds in small part only to the digital branch of the ulna in the frog(Ecker).

The second branch to be given off from the brachial passes dorsally through the interosseal space sending off numerous small branches to the extensor muscles along the outer border of the ulna from the elbow to the wrist. One branch passes forward to supply the muscles on the dorsal surface of the hand. This may be homologous with the radial.

Vessels of the Brain. (Plate XI, fig. 26)

The internal carotid enters the cranium through a foramen in the spenoid bone. Inside the cavity it sends off a short branch which soon divides to form the posterior and

anterior ramus. The posterior ramus passes caudad around the pituitary body and dorsal to it to join up with the corresponding vessel from the opposite side at the base of the medulla. The vessel thus formed is the basilar artery. This passes backward along the medio-ventral line of the spinal cord as the anterior spinal artery. The anterior ramus passes forward laterally to the infundibulum to the region of the optic chiasma where it again divides forming two branches, one passing anteriorly along the groove in the cerebral hemispheres and supplying vessels to that region. This is the lobi-hemispherici inferior externa (Ecker) The second branch passes dorsally in the groove between the telencephalon and diencephalon, then turns anteriorly on the inner margin of the cerebral hemispheres to supply that region. This is the lobi-hemispherici superior interna.

The internal carotid passes forward to the optic foramen where, together with the optic nerve, it goes out to supply the eyeball and its muscles, especially in the posterior medial. region.

Arteries of the Alimentary Tract. (Plate VI, fig.I4)

Immediately posterior to the origin of the subclavian arteries a branch arises on the ventral side of the aorta, passes posteriorly and divides, sending one branch to the oesophagus and one, which again divides, to the dorsal wall of the stomach. This is known as the anterior gastric artery.

Some distance farther back a branch arises, the coeliaco-mesenteric (Ecker) or gastro-mesenteric (Bronn) Soon after it leaves the aorta it divides to form two vessels, the posterior

gastric and the mesenteric. The gastric again divides, one branch, the ramus dexter, going to the right side of the stomach and one, the ramus sinister, to the left side of the stomach, and a third to the pancreas and duodenum. The ramus dexter sends off a large branch to the liver, the hepatic artery, one to the gallbladder and one to the pancreas. The ramus sinister sends off a large branch to the spleen, the splenic artery. The mesenteric sends out numerous branches to supply the anterior portion of the small intestine. This may be called, for that reason, the superior mesenteric artery.

Posteriorly along the aorta four branches arise to supply the remainder of the small intestine. These are called by Bronn the accessory mesenteric arteries. These are followed by four or five posterior mesenterics to the large intestine.

All of these arteries originate from the ventral surface of the aorta.

In the male on the lateral surface, in the region of the first three accessory mesenteric arteries three pairs of branches come off, one of each pair on either side, to supply the testes. These are followed by numerous pairs of small branches to the kidneys, the renals. In the female, several branches similar in position to the spermatics are given off to the ovaries.

Arteries of the Pelvic Girdle and Hind Limb.

In the inguinal region the aorta gives off two large vessels, one on either side, the iliacs, which pass out to

supply the hind limbs. Near the origin of the iliacs a small median branch arises from the aorta slightly to the left so that it appears to come from the left iliac artery. It passes caudad for a short distance sending two pairs of small renal arteries to the posterior part of the kidney and divides to form two branches which suppy the cloaca and its glands.

The iliac artery gives off three branches, the epigastric, the hypogastric and the vesicular. The epigastric passes anteriorly, sending a few small branches to the hip joint, along the abdominal wall to anastomose with the anterior epigastric. The hypogastric passes out to suuply the muscles of the pelvic girdle and the vesicular passes posteriorly to the urinary bladder.

The iliac continues down the leg as the femoral or crural artery. It sends off several small branches to the muscles of the proximal part of the leg. Just below the knee joint a large vessel arises which divides immediately. One branch goes to the knee joint and the distal portion of the biceps; a second branch passes forward on the plantar surface and supplies the muscles in that region; the third and largest branch passes through the interosseal space to the dorsal surface of the foot where it supplies the anterior margin and the superficial muscles. This third branch is homologous with the anterior tibial artery.

The crural continues as the tibio-peroneal along the upper margin of the fibula and passes through between the intermedial and central tarsals to the dorsal surface where it divides to supply the digits.

From the dorsal side of the aorta arise several intercostal arteries which pass dorsally, dividing in two, one branch going into the spinal column, the other passing out to supply the inner wall of the body cavity.

The dorsal aorta continues posteriorly along the tail as the caudal artery , giving off two small branches to the cloaca as it passes that region.

THE VENOUS SYSTEM. (Plate VIII)

The venous distribution is very similar to the arterial but the veins are in most cases more superficial than the arteries. The veins are much more prone to variation than the arteries.

The sinus venosus is made up of the two common cardinals and the post caval veins.

The common cardinal, or duct of Cuvier, is made up of the anterior and posterior cardinals. The anterior cardinals receive a supply from the external jugular, the internal jugular and the subclavian branches. The external jugular is made up of two branches, one from the tongue, the lingual, and one from the outer anterior margin of the lower jaw, the mandibular. These come together at the thyroid gland. The external jugular also receives a small cutaneous branch from the angle of the jaw and one from the dorsal surface of the heart. The internal jugular comes from within the skull. Just before joining the anterior cardinal the internal jugular receives a branch made up of two smaller branches, one from the subscapularis muscles, the subscapularis, and the other from the choroid plexus of the brain. The larger portion is made up from vessels within the cranium.

The subclavian is the continuation of the axillary which is formed by the junction of the cephalic, brachial and cutaneous. The cephalic comes in over the outer border of the muscles of the upper arm. It begins in the palmar surface of the forelimb by the coming together, on the anterior margin

of the radius, of the veins from the four digits. It receives branches from the skin and muscles of the forearm and, near the elbow, receives a branch made up of small vessels from the dorsum of the hand. The vessel thus formed passes along the anterior margin of the radius to the elbow where it curves round to the middle of the lateral surface of the upper arm. It passes over the shoulder into the body cavity between the procoracoid and scapula to meet with the axillary.

About the centre of the dorsal surface of the scapula a branch goes across to meet with the axillary on the posterior border of the scapula. This may correspond to the basilic. At the point where the connection is made a small vessel enters from the region dorsal to the scapula, the suprascapularis.

In the axillary fossa near the subclavian artery and brachial nerve a small vein comes in from the skin and muscles of the inner surface of the upper arm. This is homologous with the brachial vein in man although it is very much reduced. In T. torosus.

The cutaneous vein is made up of several fairly large branches from the lateral and ventral abdominal wall. One large branch arises well back and runs forward just inside the lateral line between the skin and muscles. Posterior to the junction with the brachial vein it receives a branch from the ventral wall. (See Figures)

The abdominal vein is formed from the two pelvic branches which come across from the femoral. The right pelvic receives a fairly well developed vessel, the vesicular, from the bladder and anterior part of the cloaca and its glands.

The vein corresponding to this on the left side consists of but one small branch.

The abdominal also receives a branch, which may be called the vesiculo-mesenteric, from the large intestine and bladder. This joins the abdominal about one centimeter anterior to its formation by the union of the two pelvics. This may be regarded in part as homologous with the inferior mesenteric in man.

The abdominal meets with a branch from the anterior portion of the intestine to form the hepatic portal. The branch may be termed the mesenteric with superior and inferior patts. These vessels accompany the arteries in the mesentery of the small intestine. Anterior to the junction a third branch comes in from the stomach and oesophagus. This is the gastric vein. The hepatic portal proceeds to the liver in which it is broken down. From the capillaries two new veins, the hepatics, are built up and pass forward to join the post caval.

The post caval arises as two branches in the median line in the posterior part of the kidneys. It passes anteriorly, receiving numerous small branches, the renals, from the kidneys and from the testes in the male, the spermatics (or ovaries in the female) It crosses through the liver to the anterior margin where it receives the two hepatic veins and then empties into the sinus venosus.

The renal portal system is made up of vessels from the caudal region and hind limbs. One branch comes forward from the tail, lying in the median line ventral to the artery.

Immediately posterior to the kidneys it divides, one branch passing to the outer, lateral margin of each kidney and supplying it with branches.

Two large veins enter from the hind limbs, the femoral, the most anterior, arising in the dorsal and ventral portions of the foot by branches which come together on the anterior margin of the tibia. The sciatic arises from several cutaneous vessels on the dorsal and outer borders of the limb in the region of the knee joint and passes medially along the posterior margin of the thigh. Prior to its entrance it receives a branch from the cloacal region.

The sciatic may unite with the femoral to form the common iliac and enter as such into the renal portal or the two vessels may, as in several cases noted, pass separately into the renal portals. The two vessels are connected by a vessel passing around the dorsal surface at the base of the thigh. This is the iliacus communicans.

From the angle formed by the junction of the femoral and iliacus communicans the pelvic passes out to meet with the corresponding vessel from the opposite side and go forward as the abdominal vein.

The posterior cardinals in the majority of cases were represented by two small veins in the body wall in the region of the pericardial cavity. In one specimen it was found connecting the common cardinal with the post caval just before the entrance of the first hepatic vein.

The two pulmomary veins pass along the lateral margin of the lungs. The right crosses on the dorsal surface of the

heart to meet the vessel from the left side. The vessel thus formed passes on the dorsal surface of the sinus venosus anteriorly, to enter the left auricle.

8. THE RESPIRATORY SYSTEM. (Plate II, fig.5)

The respiratory apparatus of Triturus is very simple. It consists of two long sac-like lungs extending, when expanded, all the way from the region of the heart to the posterior part of the body cavity. The right is slightly longer than the left. They are straight sac-like bodies annulate in appearance, with the pulmonary vein running along the lateral margin and the pulmonary artery along the medial border, the smaller blood passing out to anastamose along the ringed areas.

The lungs open into a very short laryngo-tracheal chamber which in turn communicates, by means of the glottis, with the cavity of the mouth.

There is a slight indication of the separation into bronchus and lung by the narrowing of the sac towards its anterior end.

With the development of the lungs the olfactory organ begins to be used for respiration. It opens anteriorly by the external nares. It will be discussed later with the sense organs.

The skin of this form is also used in the process of respiration. Hence, as in the frog, the skin is well supplied with blood vessels.

THE NERVOUS SYSTEM.

The Brain (Plate X)

The Amphibian brain, especially that of the Urodeles, is very simple. It lies quite straight within the cranium.

Viewed from the dorsal surface, the telencephalon shows no distinct division between the olfactory lobes and cerebral hemispheres. The hemispheres are well developed, elongated bodies separated about half way back by the pallial fold. This is quite different from that of the frog for in the Anura there is an anterior connection between the two lobes and there is a distinct demarkation of the olfactory lobes. Posteriorly, between the hemispheres, there is a fairly wide separation covered by a choroid plexus, the anterior plexus. This passes in as a narrow stalk to send wide leaf-like structures to the lateral ventricles, a narrow branch to the third ventricle, and one to the ventricle of the infundibulum. This plexus is very vascular and carries the blood supply to the interior of the ventricles.

Posterior to this are two narrow projections, the roof of the diencephalon. In this roof is a small opening into the third ventricle. This seems to represent in position the pineal body.

The mesencephalon is made up of two optic lobes, somewhat smaller than those of the Anura. They lie close together in the median line and there is little indication of division into two separate lobes.

The metencephalon or cerebellum is represented merely by a small shelf-like projection over the anterior end of the fourth ventricle.

Posteriorly is the medulla oblongata or myelencephalon, which extends for a short distance caudad finally merging into the spinal cord which passes to the posterior end of the vertebral column. Situated in the medulla and surrounded by it is a large ,triangular cavity, the fourth ventricle, covered by the posterior choroid plexus.

From the ventral aspect the telencephalon has a similar appearance to that of the dorsal, in that there is no distinct division between the olfactory lobes and cerebral hemispheres. There can be seen, however, the lateral bulbs near the anterior end from which the olfactory nerves arise.

Of the diencephalon the most anterior portion is the optic chiasma which is not very strongly developed. It has the appearance merely of the straight continuation of the optic nerves.

Immediately behind the chiasma is a fairly large flattened body, the infundiblum, from the posterior end of which projects a gland-like hypophysis. No saccus vasculosus, lamina terminalis or tuber cinereum were found.

The Ventricles of the Brain. (Plate XI, fig. 25)

The ventricles are similar to those of the frog. The foramen of Monro is much wider, forming a large cavity before opening into the third ventricle which is a narrow tube-like passage in the diencephalon. There is no distinct line of

demarkation between the foramen of Monro and the third ventricle. Opening posteriorly from the third ventricle is the aqueduct of Sylvius. Since the optic lobes are so close together the optocoeles appear merely as an expansion of the iter. The aqueduct of Sylvius opens into the fourth ventricle which, as already stated, is situated in the medulla.

The Spinal Nerves. (Plate XII, fig 27)

The spinal nerves are similar in origin and the trunk nerves in distribution to those of other vertebrates.

The Brachial Plexus.

The brachial plexus is made up of branches from the third and fourth spinal nerves and one small connection from the fifth. This plexus goes to supply the muscles of the pectoral region and forelimb.

From the anterior or third nerve a branch runs ventrad through the foramen in the coracoid. This is the supracoracoideus. It divides sending branches to the supracoracoideus, coraco-radialis propius and procoraco-humeralis muscles. Near the origin of this nerve the third divides, one branch going to meet the fourth nerve, thus forming the median nerve which will be discussed along with the ulnar.

The remainder of the third, together with a branch from the fourth, goes out between the triceps and humerus, and, sending branches to that muscle, crosses over the bone to the radial side of the forearm. Here it divides sending one branch to the brachio-radialis; the remainder goes on to supply the extensor muscles of the hand. Thsi is the radial nerve.

Lateral to the origin of the supra-coracoideus a branch leaves the third nerve to supply the muscles on the dorsal surface of the scapula, the suprascapularis nerve.

The main part of the fourth goes out to form the ulnar The median and the ulnar pass down, one on either side of the brachial aretery, to the forearm, where the three pass under the flexor muscles to the interosseus space. The ulnar nerve crosses over the ulna to supply the flexor muscles of the hand. The median passes, together with the artery, between the radius and ulna and parallel with them, branching on reaching the metacarpus to the supply the deeper muscles on the palm of the hand.

Posterior to the brachial plexus are seven spinal nerves arising between the vertebrae and passing out to supply the muscles of the body wall. Here the metameric nature is retained. The nerves run round as far as the rectus abdominis.

The Sacral Plexus.

The thirteenth, fourteenth and fifteenth nerves make up the lumbo-sacral plexus. The three nerves are well developed and the nature of the plexus is very similar to that of the brachial plexus.

The thirteenth passes out, sending off the cutaneous branch to the oblique muscles. At the head of the femur it receives a branch from number fourteen. It also sends a branch, the obturator, ventrally which crosses through the obturator foramen and branches to supply the adductor and gracilis.

muscles. The nerve then continues as the femoral through the biceps muscles of the thigh along the anterior margin of the tibia. It supplies a few small branches to the muscles and skin on the anterior surface of the foot. It corresponds to the saphenous nerve in the human.

The fourteenth and fifteenth come together to form the sciatic nerve. At the point of junction a branch passes back to supply the muscles of the cloacal region. The sciatic crosses between the triceps and the femur to divide very shortly into the peroneal and tibial. The tibial crosses over the peroneal along the ventral surface of the interosseum to supply the flexor muscles on the sole of the foot. The peroneal goes around the medial end of the fibula, passes diagonally across to the distal end of the tibia where it branches to supply the extensor muscles on the dorsal surface of the foot.

The Sympathetic System.

The sympathetic system is very difficult to see distinctly. It is represented by small, fine nerves arising from the spinals and passing out to the mesentery of the digestive tract. Farther than that it was not traced.

THE SENSE ORGANS.

The Ear.

The ear of T.torosus may be considered more primitive than that of the frog because in the former there is no middle ear. There is no tympanic membrane and no columella. Sound is transmitted by means of the stapes in the fenestra ovale.

The membranous labyrinth is protected by the bony labyrinth.

There is a sac-like ventriculus, somewhat elongated. Connected with it are the three semicircular canals.

Ventral to the utriculus and communicating with it by means of a small opening is a second sac-like body, the sacculus. In the sacculus is a large calcareous body, almost filling the cavity, corresponding to the otolith in lower forms.

Opening from the sacculus on its medial margin and passing mediad across the utriculus is a small duct, the endolymphatic duct. It meets the corresponding duct from the opposite side on the dorsal surface of the hind brain. The two together form a large sac covering the posterior choroid plexus, and two lateral projections pass forward to form and surround a large calcareous body on each side of the optic lobes. This sac is known as the endo-lymphatic sac.

Opening by means of a small pore from the postero-ventral ventral portion of the sacculus is a small sac-like body, the lagena.

The Eye.

The eye is in all respects quite like that of the frog with the exception of the position of the gland. In T. torosus it is situated ventral to the margin of the lower eye-lid, extending from the anterior to the posterior border of the orbit along the lateral margin. It corresponds to the gland of the eye which does not as yet show the differentiation into two separate glands, lacrymal and Harderian, as in the higher forms.

The shape of the eye-ball, also, is very similar to that of the frog. It is in T. torosus also flattened on the outer surface.

The three coats, sclerotic, choroid and retina are all represented here, as in the Anura.

The lens is practically spherical.

The Olfactory Organ.

The olfactory organ is situated within the skull. The sac is broadened considerably at its posterior end. On the walls of the cavity are numerous ridges. These are said by Wiedersheim to be comparable to the turbinals of the higher forms.

The Lateral Line Sense Organs.

The lateral line system of sense organs is very similar, in distribution and nature of the pores, to that described by Kingsbury in Diemyctylus viridescens (Am. Mic. Soc. Vol. 17, I 1895)

THE URINOGENITAL SYSTEM.

The urinary system is more primitive than that of the Anurans. (Plate XIII)

The Kidney consists of two parts, a posterior non-sexual portion and an anterior sexual one. Both of these are made up of very much coiled tubules. Collecting tubules pass from both of these to the Wolffian duct which communicates posteriorly with the cloaca, The two mesonephric ducts open separately into the cloaca.

In the male the collecting ducts from the caudad part of the kidney and the Wolffian duct are much more strongly developed structures than they are in the female. In the male the Wolffian duct is used as a urino-genital duct. No Müllerian duct was located in this species in male individuals.

All female specimens examined had the ovaries filled with eggs. In some of the specimens eggs were found in various parts of oviduct. These were removed and examined. The gelatinous layers increase in size as the egg passes down the oviduct. The oviduct is the Mullerian duct.

The oviduct itself is a long much coiled duct extending from the cloaca anteriorly to be attached by means of a mesentery to the anterior wall of the pleura-peritoneal cavity. The ostia are situated ventral to the scapula and just posterior to the pericardial cavity. The openings are formed by a continuation of the mesentery from the body wall to form a funnel-shaped opening. The oviduct consists of three apparently distinct portions-the anterior is wide and glandular

in appearance. It is followed by a narrow much coiled portion which in turn leads to a very thick region. When the eggs are being laid this latter portion is particularly well developed. A small coiled portion leads from this to a slightly widened area. the uterus. The two uteri open separately into the cloaca.

The cloaca of the female of this species is very similar to that described by Kingsbury in his article on the spermatheca of Diemyctylus, (Am.Mic.Soc.Vol.17, 1895). In T. torosus the cloaca is also provided with flask-shaped spermathecae. Many of them were found to contain spermatozoa. The elevation on the ventral wall and the dorsal depression bearing papillae are present in T. torosus.

On examination, the eggs in the oviduct and uterus showed no trace of segmentation, so that fertilization could not have taken place. The egg must therefore be fertilized during its passage through the cloaca.

The manner in which the spermatozoa get into the spermatheca has not yet been discovered.

The male cloaca has a much more complicated system of glands. These are also fully described by Kingsbury(Am.Mic. Soc.Vol.17,1895) for Diemyctylus , and they are very similar in T. torosus.

The testis is multi-lobed, the number of lobes varying from two to four. Only one animal was found to possess a four-lobed testis and that only on one side. Anteriorly, the testis is attached to the posterior wall of the lung, posteriorly to fat bodies. Numerous vasa efferentia pass across to the

anterior tubules of the kidney. Thus the spermatozoa pass from the testis, across the vasa efferentia through the anterior part of the kidney, by the collecting tubules to the Wolffian duct and hence to the cloaca. In the cloaca they are attached to a gelatinous substance to form spermatophores.

Considerable discussion has been going on and is still taking place as to the nature of the formation of these multi-lobed testes. Humphrey (1922, 1925) believes that the new lobe is formed at the caudal end of the germ-cell cord and that the anterior lobes degenerate. It is the manner in which these processes go on that causes the multi-lobed appearance. He believes it to be due to the slow caudo-cephalic movement of the spermatogenetic "wave" and the delayed regeneration of the emptied lobules. Obreshove (1924), on the other hand, believes that new lobes are formed at either end of the primary lobe and it is not dependent on the degeneration and regeneration. He thinks that new lobes may develop from the sex cells at the extreme periphery of the terminal lobes or from germcell islands oriented in direct line with the gonads, but at first having no communication with it.

From what can be made out from external dissection the conditions found in this form seem to corroborate what Humphrey believes to be the case. In figure 31 the posterior portion of the germ cord may be degenerating and hence forming a new lobe. On the other hand, in figure 32 the left testis has at its cephalic end a body having the appearance of a degenerating lobe. Although these are very superficial observations, Humphrey's hypothesis of a definite process seems

much more reasonable than that of Obreskove which seems to be more or less a matter of chance.

The Glands.

The spleen is a long three-sided body situated on the dorsal wall of the posterior part of the stomach. It resembles more closely, in shape and position, the spleen of higher vertebrates than does that of the frog.

The thyroid consists of two small oval bodies lying on the external jugular vein just posterior to the second ceratobranchials. (See Plate VIII, fig. I9). They are very vascular bodies.

The thymus also consists of paired oval bodies, somewhat more spherical than, and about one sixth as large as, the thyroid. It is situated near the angle of the jaw and postero-dorsally to the thyroid. It also is vascular.

The carotid, like the two foregoing glands, is a paired structure. It appears as the widening of the common carotid artery at the point of division of that vessel to form the internal and external carotids. It is also vascular in appearance. (See Plate V, fig. I2)

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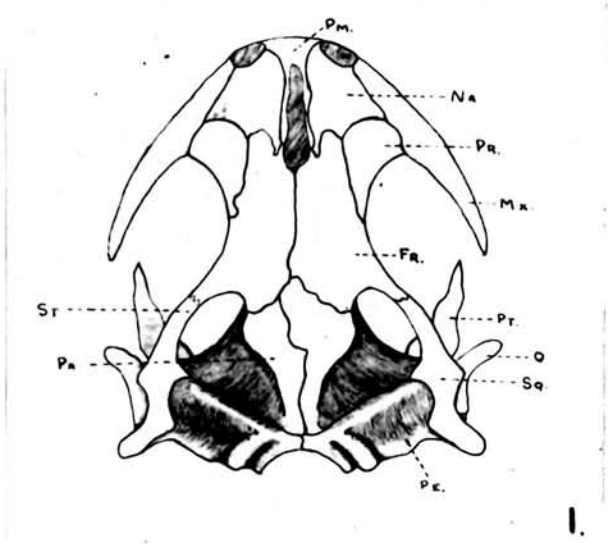
PLATE I.



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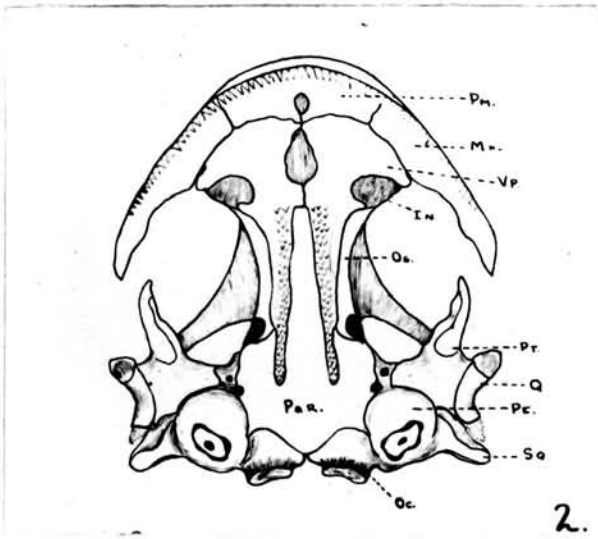

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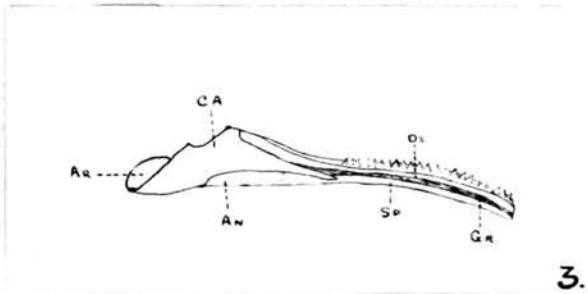


3.

Explanation of Plate I.

Figs. 1 and 2 -- Ventral and Dorsal View of Skull.

Fr. -- Frontal.

In. -- Internal Nares.

Mx.-- Maxilla.

Na. -- Nasal.

Oc. -- Occipital.

Os. -- Orbitosphenoid.
Pa. -- Parietal
Par.-- Parasphenoid.

Pe. -- Periotic.

Pm. -- Premaxilla.

Pr. -- Prefrontal.

Pt. -- Pterygoid.

Q. -- Quadrate.

Sq. -- Squamosal.

St. -- Supra-temporal Bar

Vp. -- Vomero-palatine.

Fig. 3 -- Lower Jaw, Inner Surface.

An. -- Angular.

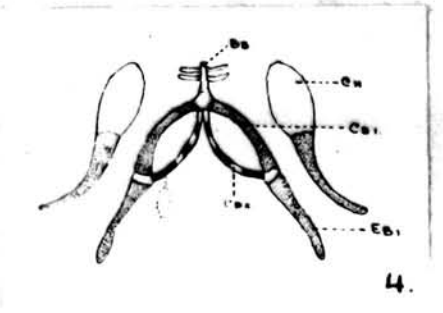
Ar. -- Articular.

Ca. -- Coronary and Supra-angular.

De. -- Dental.

Sp. -- Splenial.

PLATE II.



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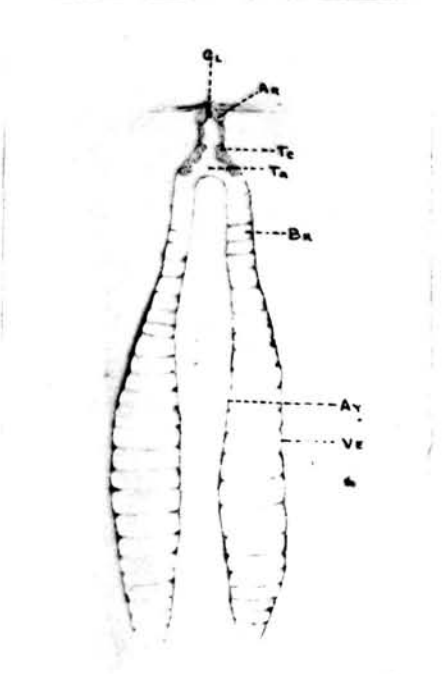


5.

X 2.

Explanation of Plate II.

Fig. 4 -- Hyoid Apparatus, opened laterally.

Bb. -- Basibranchial.

CbI -- First Ceratobranchial

Cb2 -- Second " "

Ch -- Ceratohyal

Ebí -- First Epibranchial.

Fig. 5 -- Respiratory Organs and Cartilages.

Ar. -- Arytenoid cartilage

Ay -- Pulmonary Artery

Br -- Bronchus

Gl -- Glottis

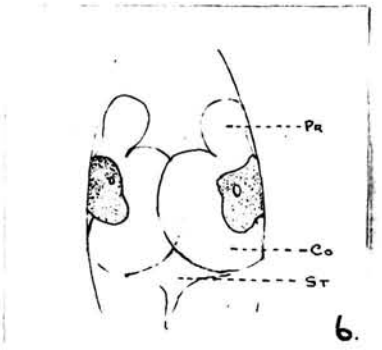
Ta -- Trachea

Tc -- Tracheal cartilages

Ve -- Pulmonary Vein.

Ventral View.

PLATE III.



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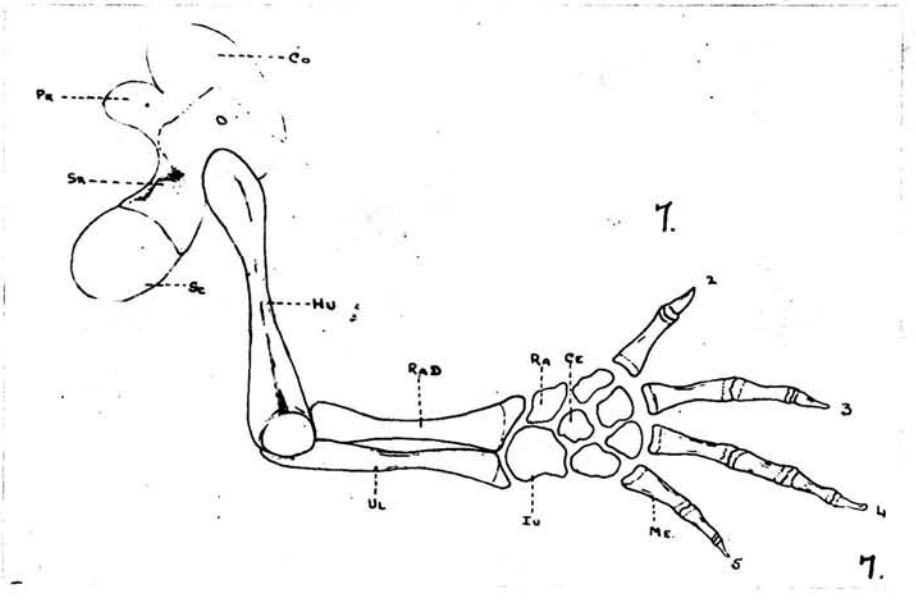

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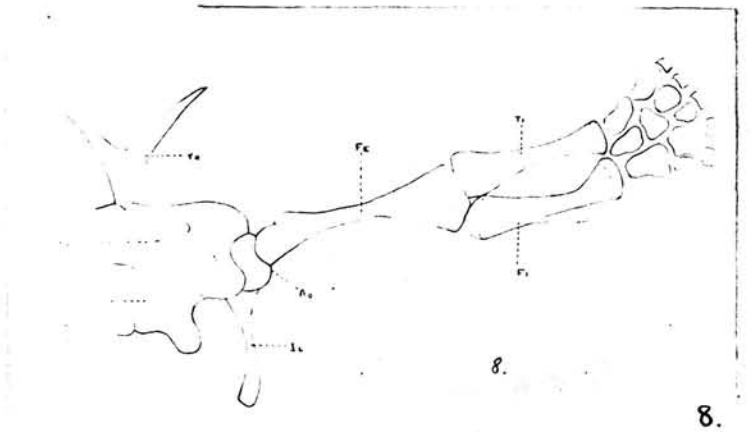


8.

X 3.

Explanation of Plate III.

Fig. 6 -- Pectoral Girdle, Ventral View.

Fig. 7 -- Pectoral Girdle and Fore Limb, Dorsal.

Ce -- Central Carpal

Co -- Coracoid

Hu -- Humerus

Iu -- Intermedio-ulnare Carpal

Me -- Metacarpals

Pr -- Procoracoid

Ra -- Radial Carpal

Rad -- Radius

Sc -- Scapula

Sr -- Scapular Ridge

St -- Sternum

Ul -- Ulna.

Fig. 8 -- Pelvic Girdle

Fe -- Femur

Fi -- Fibula

Il -- Ilium

Oi -- Ossified portion of Ischium

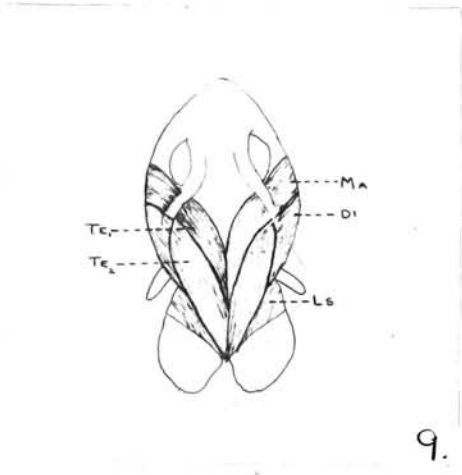
Pp -- Pubic Plate

Ti -- Tibia

Yo -- Ypsiloid Cartilage or Epipubis

Ossified portions shaded.

PLATE IV



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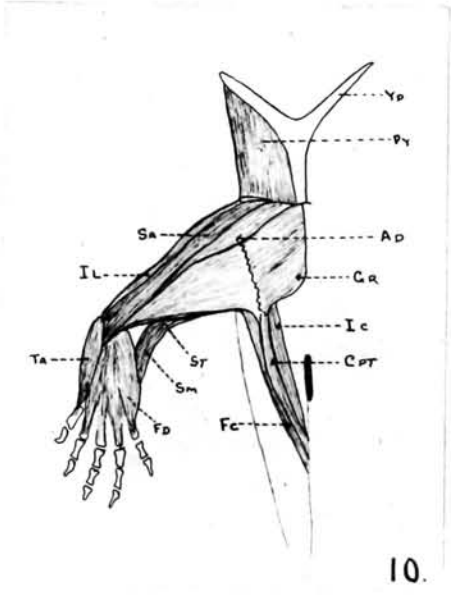

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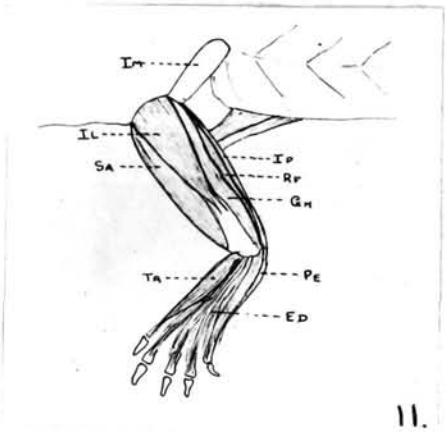


11.

Explanation of Plate IV.

Fig. 9 -- Muscles of Dorsal Surface of Head

Di -- Digastric

Ls -- Levator Scapulae

Ma -- Masseter

Te1 and Te2 -- Temporal.

Fig. 10 -- Muscles of Pelvic Region (Ventral), and

Fig. 11 -- Flexor Muscles of Hind Limb.

Ad -- Adductor

Cpt -- Caudali-pubo-ischio-tibialis

Ed -- Extensor Digitorum

Fo -- Femoro-caudal

Fd -- Flexor Digitorum

Gm -- Gluteus Maximus

Gr -- Gracilis

Ic -- Ischio-caddal

Il -- Iliacus

Ip -- Ilio-peroneal

Pe -- Peroneal

Py -- Pyramidalis

Rf -- Rectus Femoris

Sa -- Sartorius

Sm -- Semimembranosus

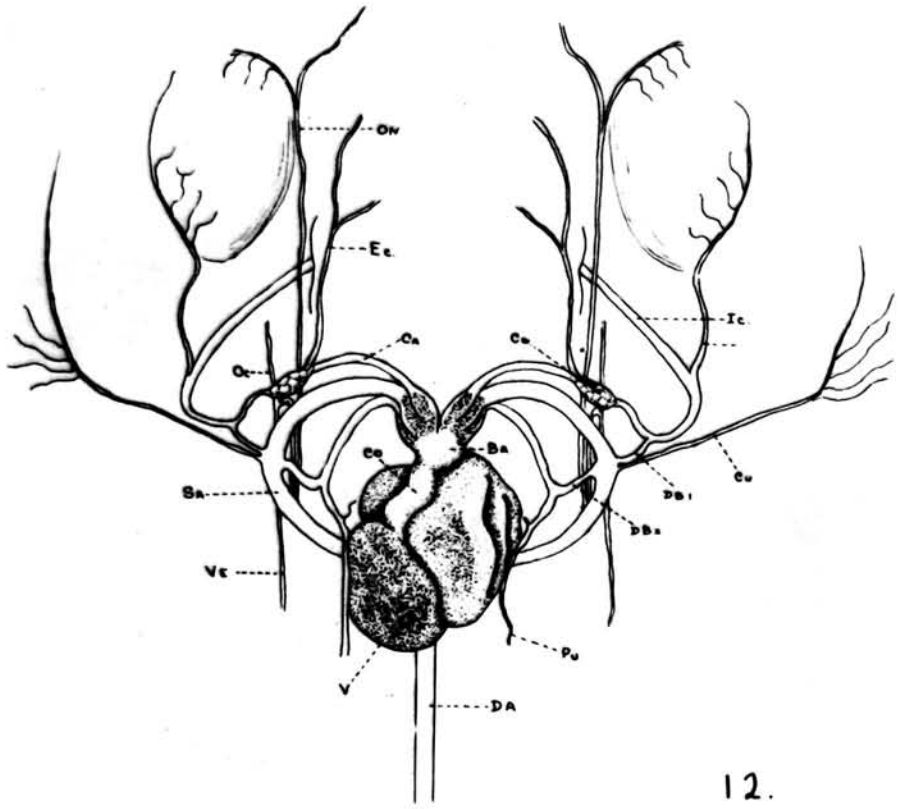
St -- Semitendinosus

Ta -- Tibialis Anticus

Ys -- Ypsiloid Cartilage

Is -- Ilium.

PLATE V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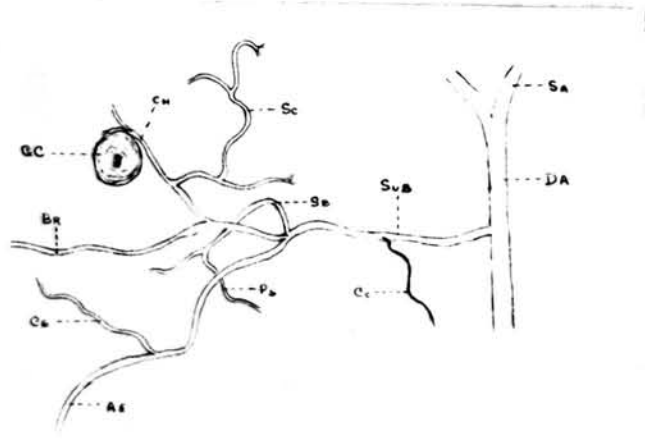
Ec
Ic
Ca
Cc
Cp
Ba
Cu
Ba
DBi
DBs
Ve
Pu
V
DA

12.


Ch
Sc
Sa
GC
DA
SuB
Se
Ba
Pa
Cc
Cb
As

13.

Explanation of Plate V.

Fig. I2 -- Heart and its Arches (Ventral)

Ba -- Bulbus Arteriosus

Ca -- Carotid Arch

Cg -- Carotid Gland

Co -- Conus Arteriosus

Cu -- Cutaneous Artery

Da -- Dorsal Aorta

DbI and Db2 -- Ductus Botalli I and 2

Ec -- External Carotid Artery

Ic -- Internal " "

Oc -- Occipital Artery

On -- Orbito-nasalis 2

Pu -- Pulmonary Artery

Sa -- Systemic Arch

V -- Ventricle

Ve -- Vertebral Artery.

Fig. I3 -- Right Subclavian Artery and Branches.

Ae -- Anterior Epigastric

Br -- Brachial

Cc --Costo-cervicalis

Ch -- Circumflex Humeri

Cs -- Coracoideus

Gc -- Glenoid Cavity

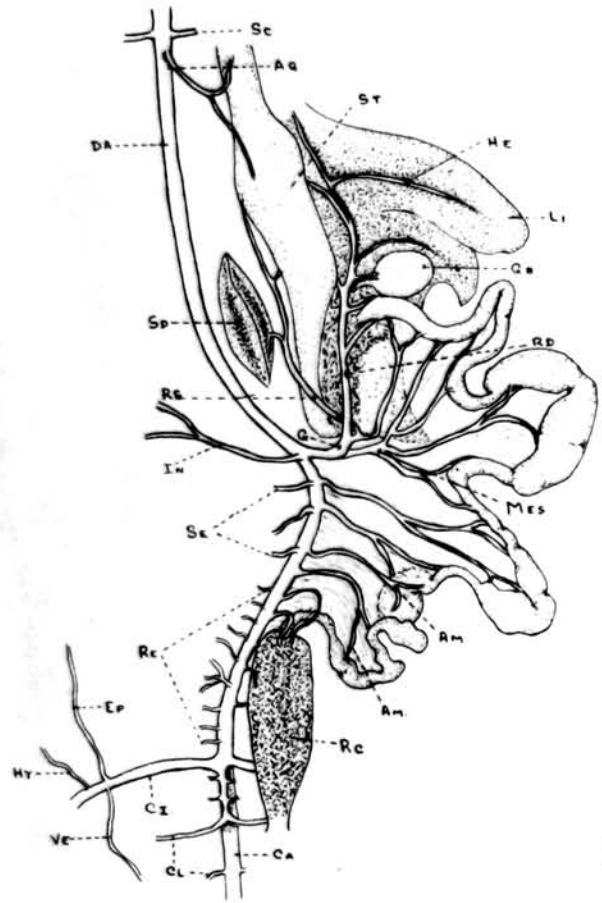
Ps -- Post Scapularis

Sb -- Subcoraco-scapularis

Sc -- Scapularis Superior

Sub --Subclavian.

PLATE VI.



14

Explanation of Plate VI.

Fig. I4 --Arterial Supply of Alimentary Tract Organs turned to Right Side.

Ag --Anterior Gastric

Am -- Accessory Mesenteric

Ca -- Caudal

Ci --Common Iliac

Cl -- Cloacal

Da -- Dorsal Aorta

Ep -- Epigastric

G -- Gastric

Gb -- Gall Bladder

He -- Hepatic

Hy -- Hypogastric

In -- Intercostal

Li -- Liver, Sp -- Spleen

Mes -- Mesenteric

Rd -- Ramus Dextra, Rs -- Ramus Sinistra

Re -- Renal

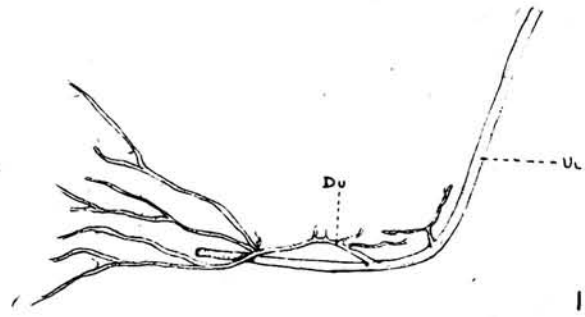
Sc -- Subclavian

Se -- Spermatic

St -- Stomach

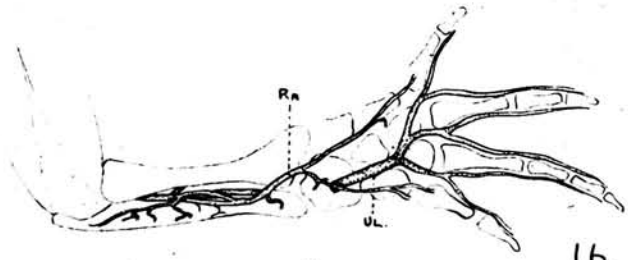
Ve -- Vesicular.

PLATE VII



15.

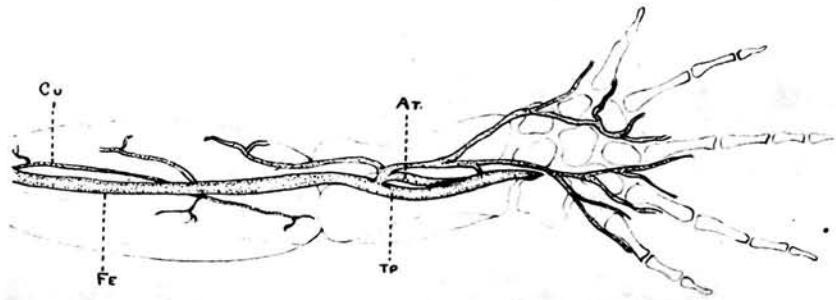
VENTRAL.



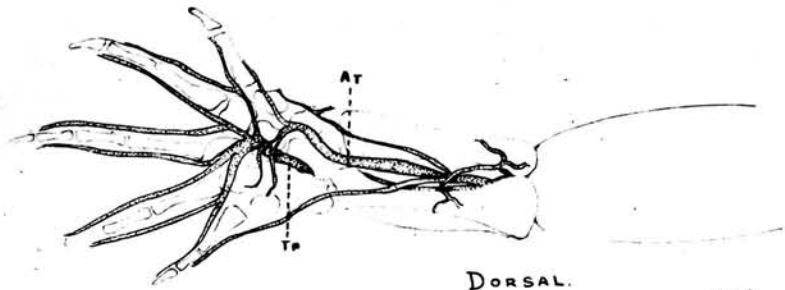
16.

DORSAL.

X 5.



VENTRAL. 17.



DORSAL. 18.

X 5.

Explanation of Plate VII.

Fig. 15 and 16(Ventral and Dorsal) Right Fore Limb Arterial Supply.

Du -- Digital Branch of Ulnar Artery

Ra -- Radial Artery

Ul -- Ulnar "

Fig. 17 and 18 (Ventral and Dorsal) Left Hind Limb.

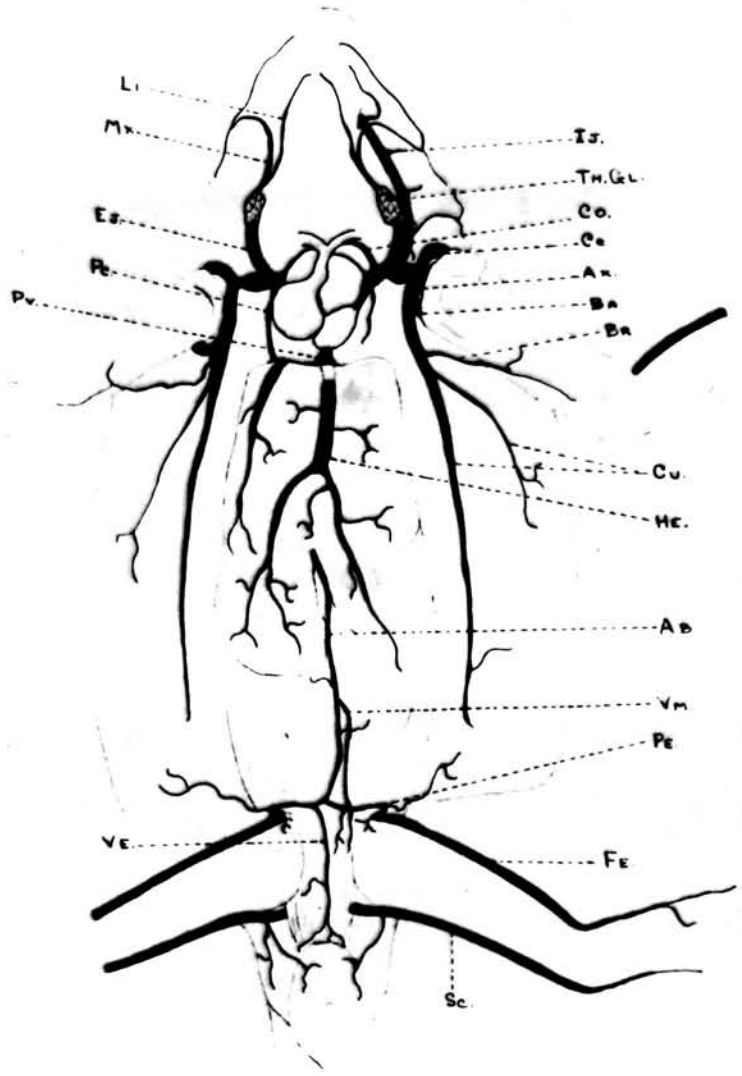
At -- Anterior Tibial Artery

Cu -- Cutaneous Branch

Fe -- Femoral Artery

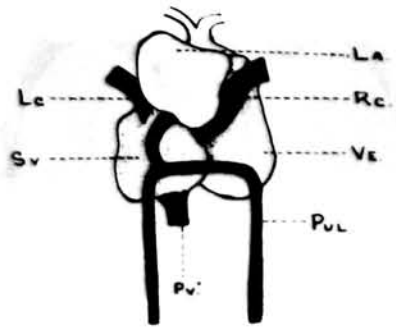
Tp -- Tibio-peroneal Artery.

PLATE VIII.



19

HEART DORSAL VIEW.



20.

Explanation of Plate VIII.

Fig. 19 -- Venous System (Ventral)

Ab -- Abdominal

Ax -- Axillary

Ba -- Basilic

Br -- Brachial

Ce -- Cephalic

Co -- Coronary (?)

Cu -- Cutaneous

Ej -- External Jugular

Fe -- Femoral

He -- Hepatic

Ij -- Internal Jugular

Li -- Lingual

Mx -- Maxillary

Pc -- Posterior Cardinal

Pe -- Pelvic

Pv -- Post Caval

Sc -- Sciatic

Ty Gl -- Thyroid Gland

Ve -- Vesicular

Vm -- Vesiculo-mesenteric

Fig. 20 -- Heart (Dorsal)

La -- Left Auricle

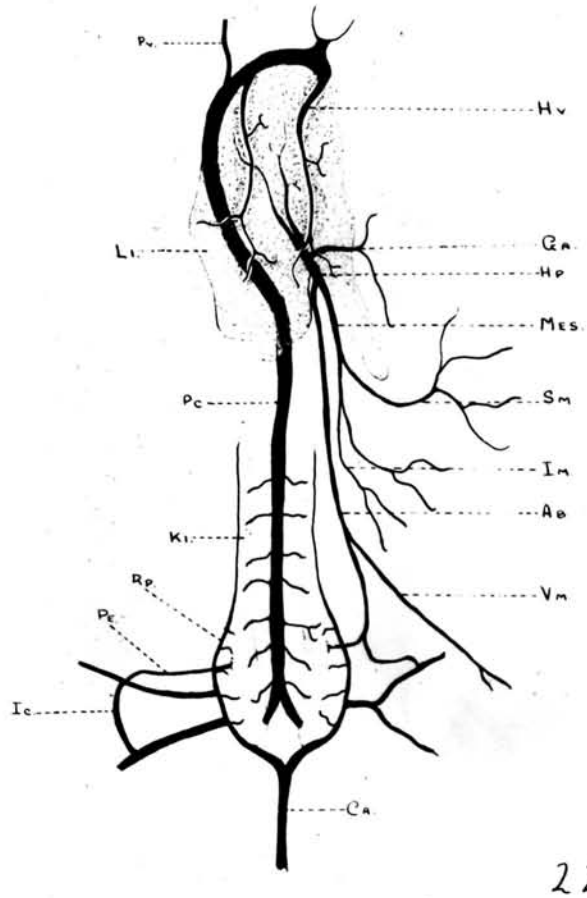
Lc -- Left Cardinal, Rc -- Right Cardinal

Pul -- Pulmonary

Sv -- Sinus Venosus.

PLATE IX.

21.



22.

Explanation of Plate IX.

Fig. 21 -- Venous System(Lateral View)

Ax -- Axillary

Ce -- Cephalic

Fem -- Femoral

Ic -- Iliacus Communicans

Il -- Ilium

Lc -- Lateral Cutaneous

Pe -- Pelvic

Sca -- Scapula.

Fig. 22 -- Hepatic Portal, Renal Portal and Post Caval Veins.

Ab -- Abdominal.

Ca -- Caudal

Ga -- Gastric

Hp -- Hepatic Portal

Hv -- Hepatic Vein

Ic -- Iliacus Communicans

Im -- Inferior Mesenteric

Ki -- Kidney , Li -- Liver

Mes -- Mesenteric

Pc -- Post Caval

Pe -- Pelvic

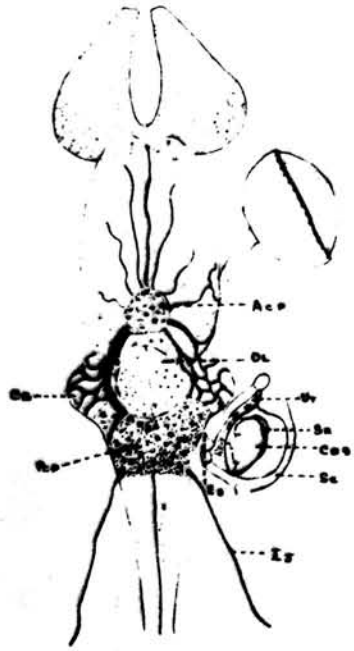
Pv -- Posterior Cardinal

Rp -- Renal Portal

Sm -- Superior Mesenteric

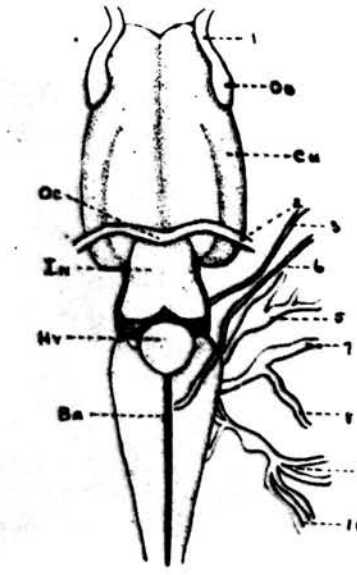
Vm -- Vesiculo-mesenteric.

PLATE X.



23.

X 6.



24.

X 6.

Explanation of Plate X.

Fig. 23 -- Brain (Dorsal)

Acp -- Anterior Choroid Plexus

Cb -- Calcareous Body in Endolymphatic Sac

Cbs - " " " Sacculus

Ij -- Internal Jugular Vein

Cl -- Optic Lobes

Pcp -- Posterior Choroid Plexus

Sa -- Sacculus

Sc -- Semicircular Canals

Ut -- Utriculus.

Fig. 24 -- Brain (Ventral)

Ba -- Basilar Artery

Ch -- Cerebral Hemispheres

Hy -- Hypophysis

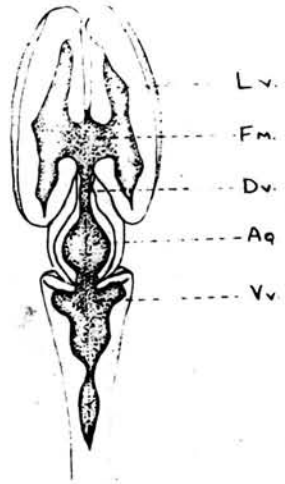
In -- Infundibulum

Ob -- Olfactory Bulb

Oc -- Optic Chiasma

I---IO -- Cerebral Nerves.

PLATE XI.



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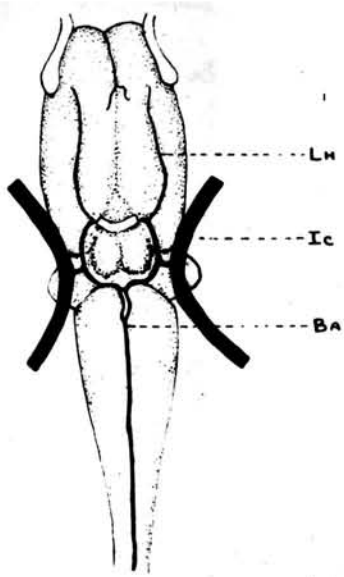


26.

Explanation of Plate XI.

Fig. 25 -- Ventricles of Brain (Dorsal Wall Removed)

Aq -- Aqueduct of Sylvius

Dv -- Third Ventricle

Fm -- Foramen of Monro

Lv -- Lateral Ventricles

Vv -- Fourth Ventricle

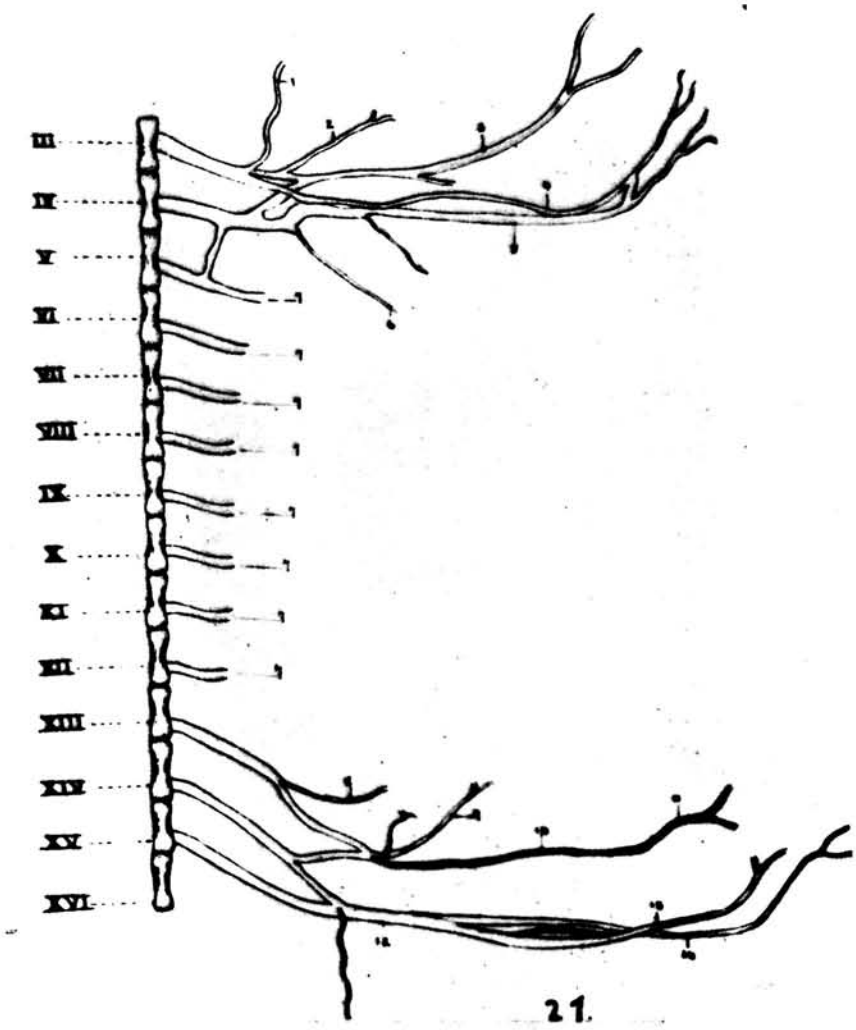
Fig. 26 -- Blood Supply of Brain (Ventral)

Ba -- Basilar Artery

Ic -- Internal Carotid Artery

Lh -- Lobi-hemispherici-inferior externa

PLATE XII.



21.

Explanation of Plate XII.

Fig. 27 -- Brachial and Sacral Plexuses (Left)

I -- Supracoracoideus Nerve

2 -- Suprascapularis "

3 --Radial "

4 --Median "

5 -- Ulnar "

6 -- Abdominal "

7 -- Spinal "

8 -- Lateral Femoral Cutaneous "

9 -- Obturator Nerve

I0 -- Femoral "

II -- Saphenous "

I2 -- Sciatic "

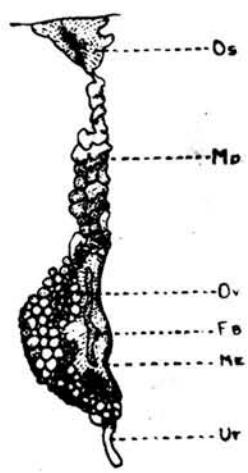
I3 -- Tibial "

I4 -- Peroneal "

III-XVI -- Vertebrae.

PLATE XIII.

28.



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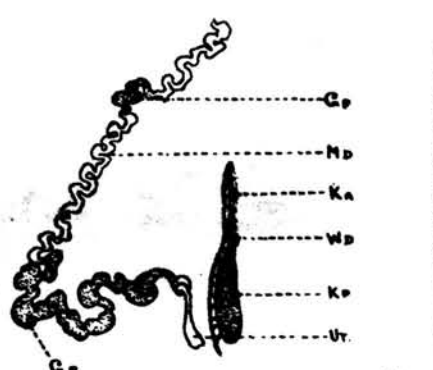


30.

Explanation of Plate XIII.

Fig. 28 -- Male Urinogenital Organs (Right)
Wolffian Duct turned laterally

Ct -- Collecting tube

Fb -- Fat Body

Ka -- Kidney Anterior Sexual Portion

Kp -- " Posterior Non- " "

Ter -- Testis (right)

Wd -- Wolffian Duct

Figs. 29 Female Urinogenital Organs, and
30 " " " (Ovaries removed)

Fb -- Fat Body

Gp -- Glandular Portion of Oviduct

Ka and Kp -- Same as Fig. 28

Md -- Mullerian Duct

Me -- Mesentery

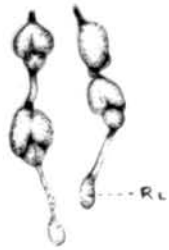
Os -- Ostium

Ov -- Ovary (with eggs)

Ut -- Uterus

Wd -- Wolffian Duct

PLATE XIV



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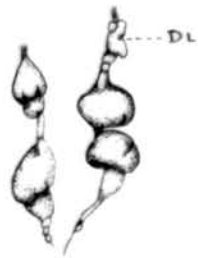
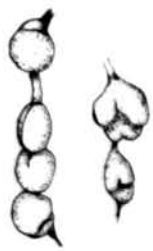


32.

33



34

×2.

Explanation of Plate XIV.

Fig. 31 --34 -- Variations of Lobes in Testes.

Rl -- Regenerating lobe (?)

Dg -- Degenerating Lobe (?)