

The ducts of the Liver are called **Hepatic Ducts**. The duct from the Gall Bladder is called the **Cystic Duct** and that from the Pancreas is called the **Pancreatic Duct**. Both the Cystic Duct and the Pancreatic Duct open into the Duodenum by a common Bile Duct.

Endocrine Organs or Ductless Glands :

There are certain glands in the body of the toad which do not discharge their secretions directly by definite tubes or Ducts but they pour their secretions direct into the blood whereby they can control certain chemical and physiological actions of the body. These are known as Endocrine organs or Ductless glands. They are :—(1) Thyroid,

(2) Supra-renals or Adrenals,

(3) Thymus.

(4) Pituitary.

(5) Spleen.

The **Thyroid glands** are a pair of round bodies lying on the external Jugular veins. The change from tadpole to the adult toad is brought about by it. The **Adrenal bodies** lie on the ventral surface of the kidneys.

The **Thymus** is a small body lying behind the angle of the jaw. Its functions are unknown.

The **Pituitary body** lies in the skull below the Brain. Its secretion stimulates the growth of the animal and the growth of bones. *Certain chemical agents* are secreted by these endocrine glands called **Hormones** which stimulate or inhibit the function of other organs of the body.

The **spleen** lies in the Mesentery of the Abdomen. Its cells remove and destroy effete red blood corpuscles and pathogenic organisms. Its removal is not fatal.

Fat bodies :

The **fat bodies** are found anteriorly to the Reproductive Organs of the toad. They increase in summer and are used in winter mostly as nourishment.

The Heart and Circulatory System .

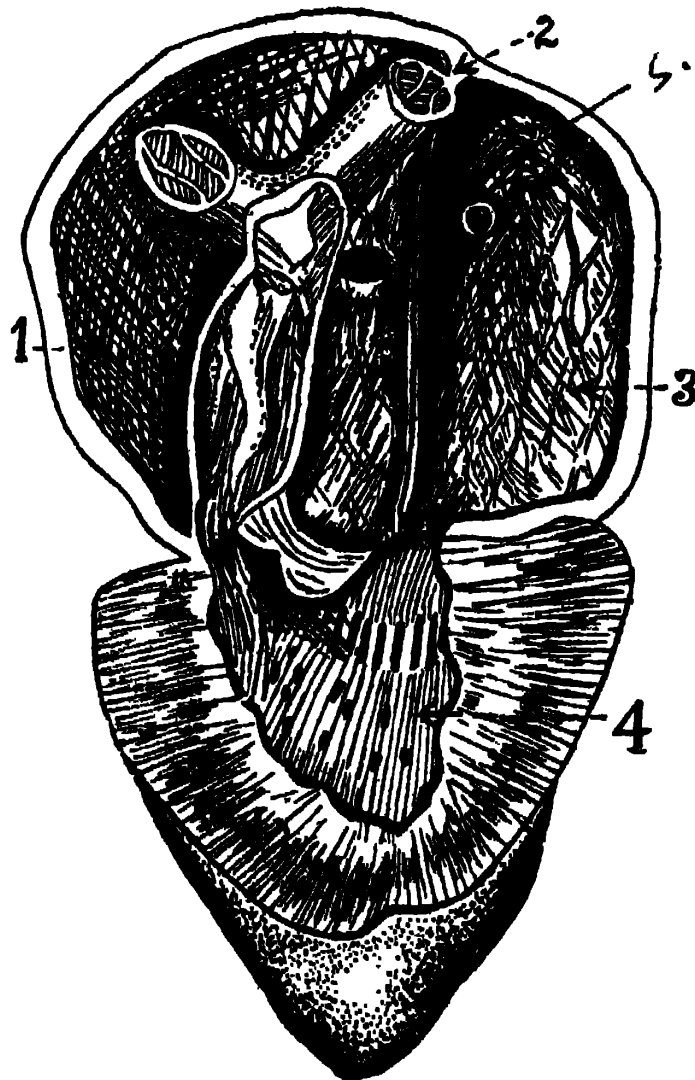
(The description of the Heart and the Circulatory System has been done according to Mr. J. L. Bhaduri's excellent paper published in the Journal of the Asiatic Society of Bengal).

The Heart of Toad is a hollow organ covered by a membranous sac called the **Pericardium**. The Heart has a triangular portion at the back called the **Sinus Venosus** into which the principal veins of the body open. There are **two auricles right and left and a single Ventricle** which gives rise to the main Blood vessels. The Apex of the Heart is directed backwards into the body cavity. The different chambers of the Heart are guarded by valves so that blood can flow in one direction only. The Heart, therefore, has the following structures :

- (1) **The Sinus Venosus.**
- (2) **Right Auricle.**
- (3) **Left Auricle.**
- (4) **Single Ventricle and**
- (5) **Conus Arteriosus.**

The **Sinus Venosus** is a triangular chamber into which the principal veins of the body open *viz.*, Two

anterior veins and a single posterior vein. The Sinus Venosus opens into the right auricle by an aperture called sino-auricular aperture guarded by two flap-like valves. The blood is allowed to pass from the Sinus Venosus to the Right Auricle but not in the opposite direction owing to the presence of valves. The Right Auricle is a thin-walled sac separated by a partition from the Left



Section of Heart.

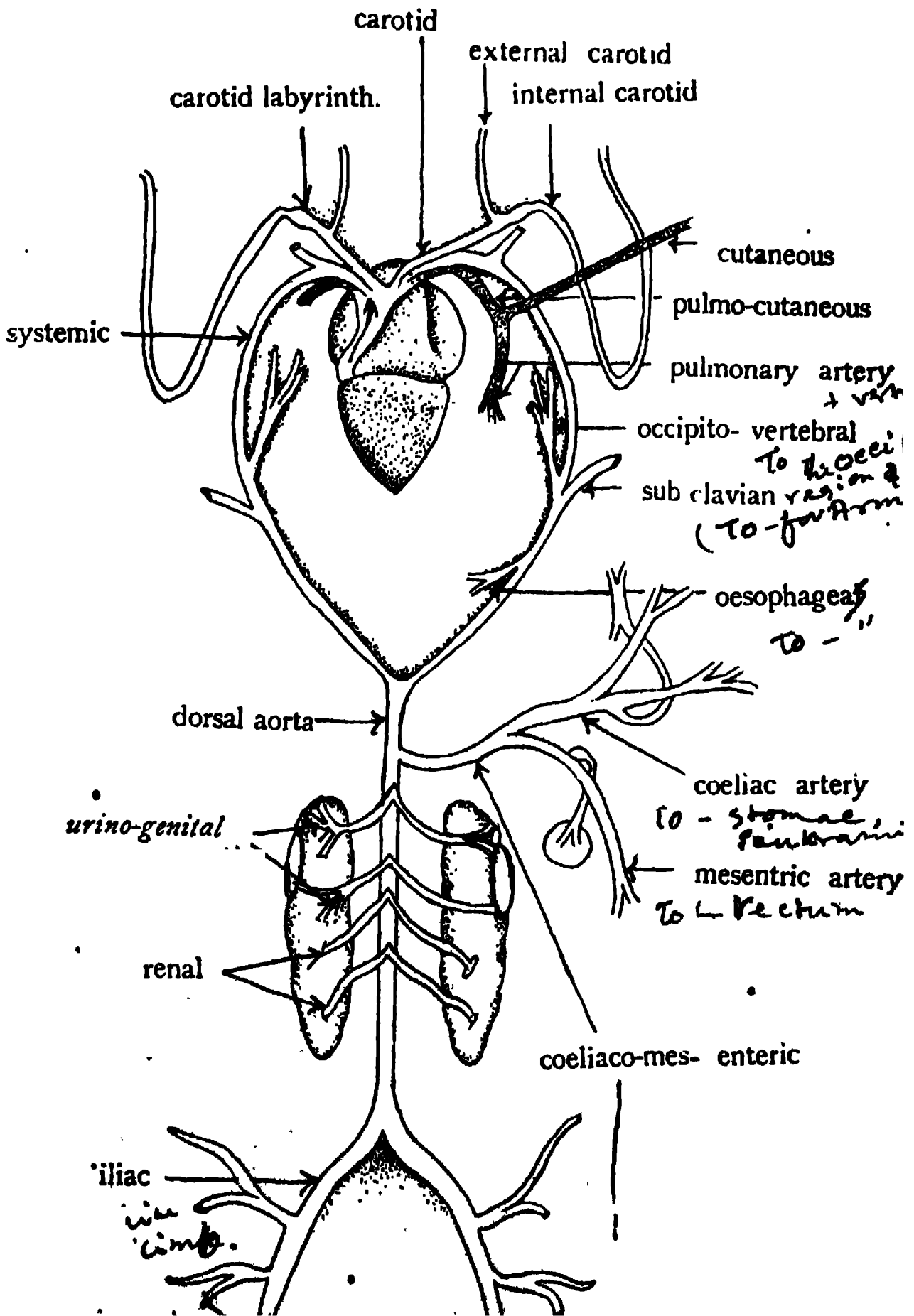
1—Right auricle, 2—Truncus arteriosus sinister, 3—Left auricle, 4—Ventricle.

Auricle called the **Septum Auricularum**. The Right Auricle receives the blood from the Sinus Venosus and

communicates with the Ventricle by the Auriculo-ventricular aperture which is guarded by Valves. The Left Auricle is situated on the left side being smaller in size than the Right Auricle. It receives pure oxygenated blood coming from the two Lungs by the two Pulmonary veins which open together by a common aperture. The Left Auricle communicates with the Ventricle by the common Auriculoventricular aperture guarded by valves. The valves are attached to the wall of the ventricle by fibrous cords called Chordæ tendinæ. The valves allow the blood to pass from the Left Auricle to the Ventricle and not in the opposite direction. There are four valves guarding the auriculoventricular aperture between the two auricles and the ventricle. There is one anterior, one posterior and two lateral valves.

The Ventricle is a thickwalled conical organ having strong muscular walls. It is a single chamber where the two auricles open and the openings are guarded by Auriculo-ventricular valves. A large blood vessel rises from the right side of the Ventricle and is known as the Conus Arteriosus. The opening of it is guarded by three semilunar valves which allow the blood to move from the Ventricle to the Conus and not otherwise.

The Conus Arteriosus arises from the right side of the Ventricle. Its basal portion is called Conus proper which is continued into a short common portion called Truncus Arteriosus impar. This divides into two trunks called Truncus arteriosus dexter on the right side and Truncus Arteriosus Sinister on the left side. The two trunks have three vessels in each which run ~~for a distance~~ enclosed by a common sheath. Each trunk ~~is divided~~ internally by two partitions to form the Canalis



Caroticus, the Canalis Aorticus and the Canalis Pulmocutaneous. The three vessels run in a common sheath for a short distance and then the three arterial arches are separated on each side forming the **Carotid arch, the Systemic arch and the Pulmocutaneous arch**

Arterial System :

The **Conus Arteriosus** is continued into **Truncus Arteriosus Impar** which bifurcates into **Truncus Arteriosus Dexter (Right)** and **Truncus Arteriosus Sinister (Left)**. Each trunk carries the three canalicular vessels in a common sheath which form the three arches called **Carotid Arch, the Systemic arch and the Pulmocutaneous arch.**

Carotid Arch :

The **Carotid arch** is the anterior one and supplies the head and brain. The **Carotid arch** shortly after its origin forms a swelling called the **Carotid Labyrinth** or '**Carotid Gland.**' The arch gives off a branch near the **Carotid gland** called the **External Carotid Artery** which gives a branch to the **thyroid, the hyoid apparatus** and its main trunk supplies the **tongue.** The other main branch is known as the **Internal Carotid Artery.** It runs superficially for a distance and then takes a sharp turn to enter into the skull where it supplies the **Brain.**

Systemic Arches

The **Systemic arch or Aortic arch** is the median arch of each side. Each arises from the **Canalis Aorticus** and winds obliquely round the **oesophagus** and then turns

inwards and backwards to join its fellow from the opposite side at about the level of the sixth vertebra. The right systemic arch is continued as the Dorsal Aorta in the middle line just ventral to the vertebral column and between the Kidneys to about the middle of the urostyle where it bifurcates into two Iliac arteries. The left Systemic arch after its union with the right arch continues as the Coeliaco-mesenteric artery. The right systemic arch gives out three branches while the left systemic arch gives out four branches. The right arch having no oesophageal branch. The branches of the Systemic arches are :—

- (1) **Laryngeal** artery arising from the inner border of the systemic arch supplies the Larynx and its muscles.
- (2) **Occipito-vertebral** artery arises near the subclavian artery and runs forwards to divide dorsally into the occipital and the vertebral arteries.
- (3) **Subclavian** artery the largest branch arising from the Systemic arch. It supplies the Pectoral girdle and the forelimb.
- (4) **Oesophageal** artery is present only in the left systemic arch. It supplies the oesophagus.

The **Coeliaco-mesenteric** artery arises by a single trunk from the point of union of the two systemic arches, and supplies the alimentary canal and its various appendages. It divides into two main branches

- (1) **Coeliac** artery and (2) a **Mesenteric** artery.

The **Coeliac** artery is small. It supplies the stomach, Liver, Gall-bladder and the Pancreas.

The Mesenteric artery is a large branch which supplies the spleen, the whole intestine and the rectum.

Dorsal Aorta :

The Dorsal Aorta is continued through the whole of the abdomen. The urino-genital arteries arise as paired arteries from the Dorsal Aorta. About four paired arteries called the renal arteries supply the kidneys, the fat bodies and two genitals supply the reproductive organs.

Lumbar arteries are absent in the toad.

Posterior Mesenteric artery is also absent in the toad.

Iliac Arteries are the ultimate bifurcations of the Dorsal Aorta near the urostyle. The Iliac artery is continued to the thigh as the **Sciatic** artery. Before reaching the thigh the Iliac artery gives off two important branches *viz.*, the Epigastricovesicalis artery which supplies the bladder and its adjoining muscles, and the **Femoral** artery which supplies the muscles of the thigh. The rest of the hind limb is supplied by the Sciatic artery.

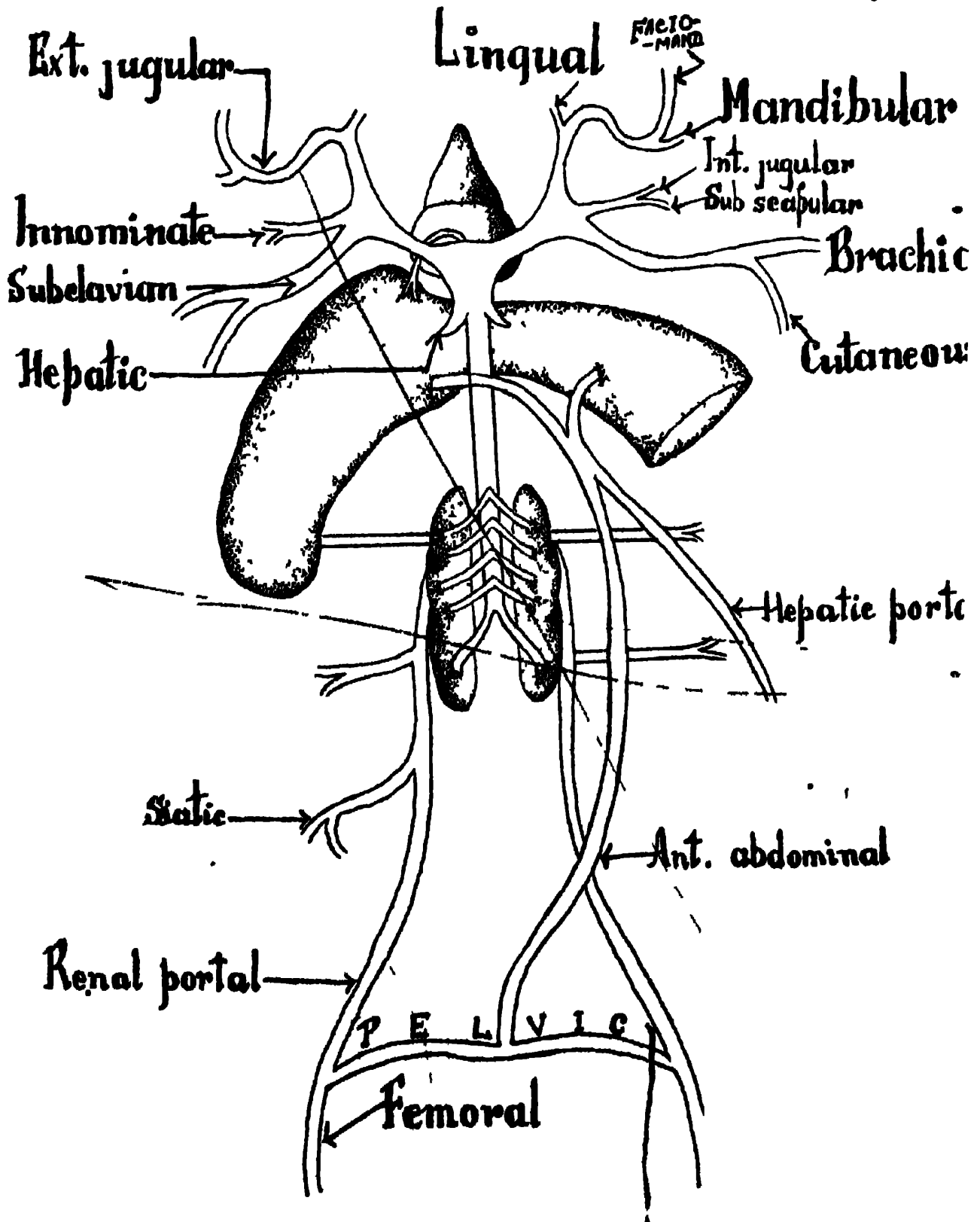
Pulmo-Cutaneous Arch :

The hindmost of the three arches is the **Pulmo-cutaneous** arch. It passes to the Lung as **Pulmonary artery** on each side where it ramifies by a number of branches. Before entering the Lung a fine branch is given off to the skin as Cutaneous artery. On entering the skin it branches and forms several anastomoses.

Venous System :

There are two kinds of veins in the toad, *viz.*, the systemic veins and the Portal veins. The systemic veins bring blood directly to the Heart whereas the Portal

veins break down into capillaries into an intermediate organ or organs before opening into the Heart.



Systemic Veins :

Blood which is distinctly visible through the veins which are comparatively thin-walled than the arteries and due to the presence of pigments in the venous blood comes from the front part of the Toad's body by two principal veins called the **Anterior Venae Cavae** or **Superior Venae Cavae**. Each Anterior Vena Cava opens into the Sinus Venosus. It is formed by the union of three veins viz.,

- (1) **External Jugular vein** which is formed by
 - (a) The **lingual vein** from the floor of the mouth and tongue.
 - (b) The **Facio-Mandibular vein** from the margin of the lower jaw.
- (2) The **Innominate Vein** which is formed by
 - (a) **Internal Jugular vein** returning blood from the interior of the skull.
 - (b) **Subscapular vein** from the back of the arm and shoulder.
- (3) The **Subclavian vein**, the largest of the three, which is formed by
 - (a) **Brachial vein** from the forelimb.
 - (b) The **Musculo-cutaneous vein** returning blood from the skin and muscles of the side and back of the body.

The Right and the Left Anterior Vena Cava are similar in their course and distribution.

The **Posterior Vena Cava** is a single median vein bringing blood from the lower part of the body. It

begins between the Kidneys and runs forwards and receives blood from the Liver and opens into the Sinus Venosus. The veins which the Posterior Vena Cava receives are :—

- (1) Four pairs of Renal veins from the two Kidneys.
- (2) Genital veins, called ovarian in the female and Spermatic in the male, also open with the Renal veins into the Posterior Vena Cava.
- (3) Right and Left Hepatic veins open into the Posterior Vena Cava just before it joins the Sinus Venosus.

The **Pulmonary Vein** is formed by the union of two Pulmonary veins bringing blood from the two Lungs after oxygenation. This vein opens into the Left Auricle.

Portal System :

- There are two portal systems in Toad viz.,
 - (1) **Renal portal system** and
 - (2) **Hepatic portal system.**

There is a stout vein bringing blood from each leg called femoral vein. The Femoral divides on leaving the thigh into two veins of which one goes to the ventral part and is called **Pelvic vein** which joins with its fellow of the other side. The other vein is called the **Renal portal vein** which passes to the dorsal part of the kidney and breaks up into capillaries in its substance and then by renal veins the blood passes into the Posterior Vena

Cava. The Left and the right Renal portal veins are similar. Each Renal portal vein receives :—

- (a) The sciatic vein from the muscles and skin of the thigh
- (b) The Dorso-lumbar veins receive blood from the dorsal wall of the body. They join the Renal portal vein opposite the Kidney.

The Hepatic Portal System :

This system is formed partly by the Anterior Abdominal vein and partly by the veins of the Alimentary canal. The Anterior Abdominal vein is formed by the union of the two pelvic veins which runs just along the middle line of the body wall ventrally. Near the Liver it divides into two veins passing into the two lobes of the Liver. It receives the following veins in its course :—

- (a) The **Vesical** veins from the bladder.
- (b) The **Parietal** veins from the ventral body-wall.

The Hepatic portal vein receives the following veins from the Alimentary canal :—

- (a) The **Gastric** veins from Stomach.
- (b) The **Intestinal** veins from the intestines both small and large.
- (c) The **Splenic** vein from the Spleen.

Blood :

The blood of Toad consists of a colourless fluid called the **Liquor Sanguinis** or **Plasma** in which float the blood corpuscles. The corpuscles are of two kinds viz :—

- (1) **White Blood corpuscles** or **Leucocytes**, which are nucleated and amoeboid.

(2) **Red Blood corpuscles** which are oval and also nucleated but not amoeboid.

Circulation :

The impure or venous blood is brought to the Sinus Venosus by three Venæ Cavæ. Blood is prevented from



White and red blood corpuscles

going back on account of the presence of valves at the junction of the principal veins. The Sinus Venosus opens into the Right auricle. Pure blood comes to the Left auricle from the Lungs by the Pulmonary veins. When the two auricles contract one after another, blood passes into the ventricle. The venous blood first comes to the ventricle. When the ventricle contracts the venous blood passes into the Pulmocutaneous arch and then into the Lungs for purification because there is the least resistance in these arches. With the second contraction of the Ventricle blood passes into the systemic arches and is distributed to the different parts of the body. But this blood is to some extent mixed blood. The third contraction gives the most vigorous jerk and forces the blood to enter into the Carotid arches where the greatest resistance is offered by the Carotid gland. The Carotid arch receives the pure blood. The Carotid and Systemic arches distribute the blood to the different parts of the body where ultimately the arterics break down into capillaries. The impure blood from the tissues of the

body is brought to the Heart by the Veins. This cycle is ever repeated as long as the animal lives.

There is another form of circulation through the skin. Blood comes to the skin by the Cutaneous artery where it is oxygenated specially while the animal is hibernating. The pure blood passes by the Musculo-cutaneous vein into the Anterior Vena Cava and thence returns to the Heart. Blood from the lower part of the body comes either by the Renal Portal System or through the Hepatic Portal System. This blood ultimately comes to the Posterior Vena Cava, and then to the Heart.

Lymphatic System :

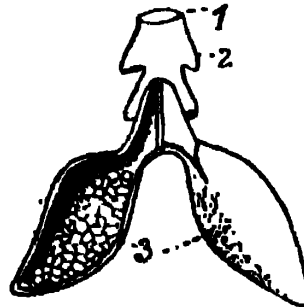
This consists of a system of minute vessels and irregular spaces in the body containing a colourless fluid called the Lymph. The Lymph has a number of colourless corpuscles called Lymphcells or Lymphocytes. The Lymph spaces occur in the ventral body-wall below the skin. There are two pairs of Lymph Hearts, one pair below the supra-scapula and the other pair near the Urostyle.

Respiratory System :

There is an aperture at the floor of the Pharynx which is known as the Glottis. This Glottis leads into a chamber which is known as Laryngo-tracheal chamber which corresponds to the Larynx and Trachea of the Mammals. The walls of the chamber are made of cartilages. The chamber opens into the two Lungs. The Lungs are composed of Elastic fibres, connective tissue and unstriped muscles. They are lined with pavement epithelium on the inner side, while the outer surface is covered with the pleural membrane.

Air on entering through the nostrils finds its way into the Buccal cavity when the floor of the mouth is raised by the Hyoid muscles and the gullet remains closed in a contracted condition. The mouth is closed except during swallowing whereby air enters by one way only due to the pressure of the muscles. The air then passes into the Lungs. This is called Inspiration which is helped by the suction action exerted by the inflation of the Lungs. This incoming air contains oxygen which supplies the blood contained in the capillaries of the Lungs. The other process which is called expiration is due to the elastic recoil and contraction of the Lungs, whereby the air is driven out. This expelled air contains CO_2 derived

- 1—Glottis,
2—Laryngotracheal chamber,
3—Lungs.



from the venous blood. Thus by inspiration the blood in the lungs is oxygenated and by expiration CO_2 is got rid of.

Voice :

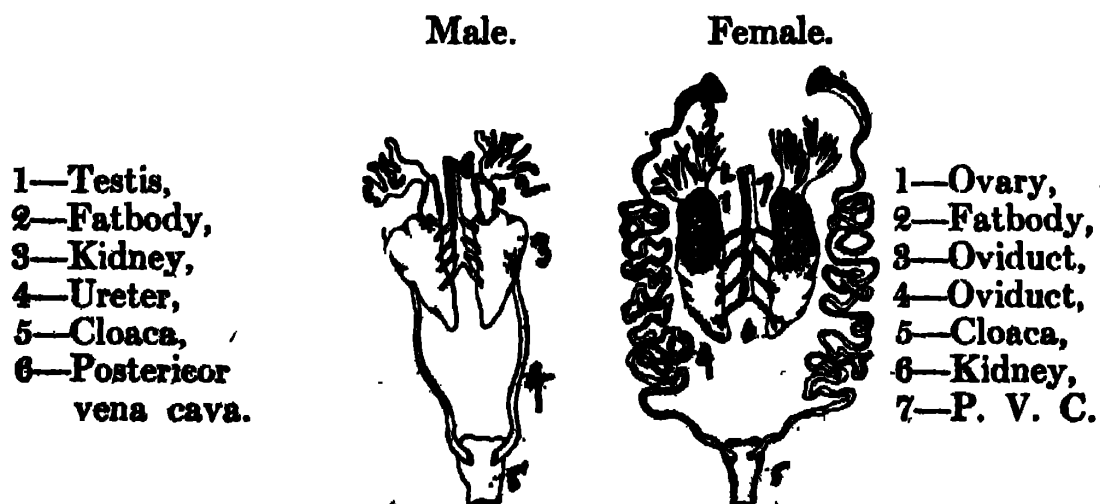
The Glottis and the Laryngo-tracheal chamber are supported by cartilages. The largest pair of cartilage is the Arytenoid which bound the Glottis right and left. The mucous membrane of the Arytenoids is raised into the vocal cords the vibration of which produces the peculiar croaking sound of the Toad.

The Excretory System :

There is a pair of flattened dark red kidneys one on each side in the dorsal lymph sac above the Cœlome and just below the back bone or Vertebral column. Waste products of the body in the form of CO_2 and water vapour pass out of the system through the Lungs but the other waste products in the form of urea, uric acid and other solid crystalloids circulating in the blood are got rid of through the kidneys dissolved in water as urine. The kidneys therefore act as filters of waste materials of the blood. Each kidney consists of a number of tubules. Each tubule begins as a blind sac called the Glomerulus and after making several coils joins with the other tubules and finally emerges out of the kidney as ureter. The ureter carries the urine to the Cloaca from which it might be voided immediately or it may be collected in a sac called the Urinary Bladder. Glomeruli receive blood from the Renal artery and the tubules from the Renal Portal vein.

Reproductive System :

The animals have separate sexes *i.e.* they are either male or female.



Male :

The organ in which the male elements are formed is known as **Testis**. There are two testes on the ventral side of the kidneys. They are ovoid bodies and yellow in colour. Each testis has a fat body in the anterior part. The testes are composed of seminiferous tubules which produce the male cells or spermatozoa. Each sperm has a nuclear head and a long tail. The sperms pass out of the testes by a number of ducts into the tubules of the kidney. The ducts are called **Vasa Efferentia**. From the kidney the sperms are taken away by the ureter to the **Cloaca**. Here the Ureter also acts as the **Vas Deferens** and is known as the **Woolffian Duct**. The two ducts join before finally opening into the cloaca.

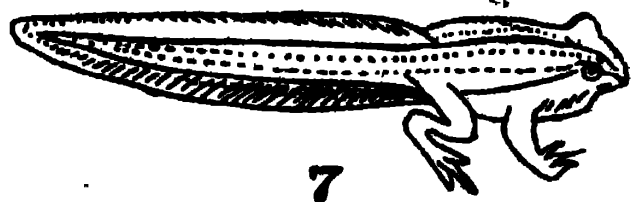
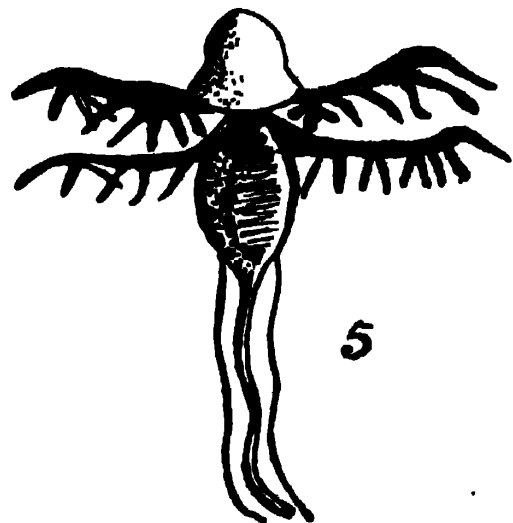
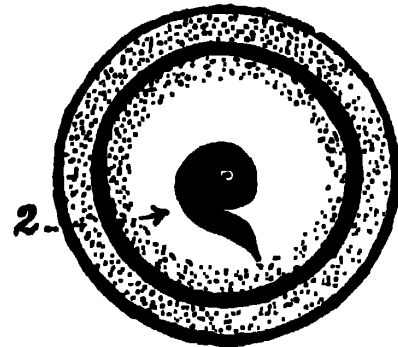
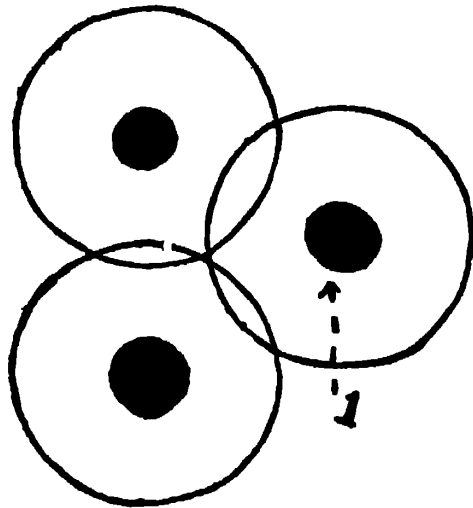
Female :

The female generative organs consist of the two **ovaries**. The ovaries become very large during the breeding season on account of the development of numerous eggs therein. When the ovary is mature and the eggs are ripe there is a bursting of the wall of the ovary and the eggs called **ova** are discharged into the abdominal cavity. Each ovum makes its way into the **Oviduct** which is a much coiled tube and passes thence into the water where they are fertilized by the male elements called **Spermatozoa**.

Metamorphosis of Toad :

The female Toad lays the eggs in a mass called the **spawn**. Each egg has a jelly-like covering by which the eggs are attached to one another to form a mass. Each egg is round and contains a large nucleus. The male

toad sheds off the sperm cells (male elements) near the spawn and fertilisation takes place in water. A single



Metamorphosis of Toad
 Read 3 pairs of gills in figs. 4 and 5.
 1a—Aquatic weed, 2a—Tadpole.

male cell combines with a single female cell and result in the development of a tadpole. The fertilised egg separates out of the spawn and undergoes development. Mortality is great among these fertilised eggs because the toads do not nurse their young ones in any way. So that the majority of them are either eaten up or destroyed by other aquatic animals.

The Embryo at first has a large head, a long tail but no limbs. The Larva is at first very sluggish and does not take any food but attaches itself to some water weed by means of a sucker on the under surface of its head. Later on the Tadpole becomes active and swims about in water. On both sides of the head appear three branched gills for respiration. At first there is no connection between the mouth and the alimentary tube but



1 to 9 represent the stages of development,

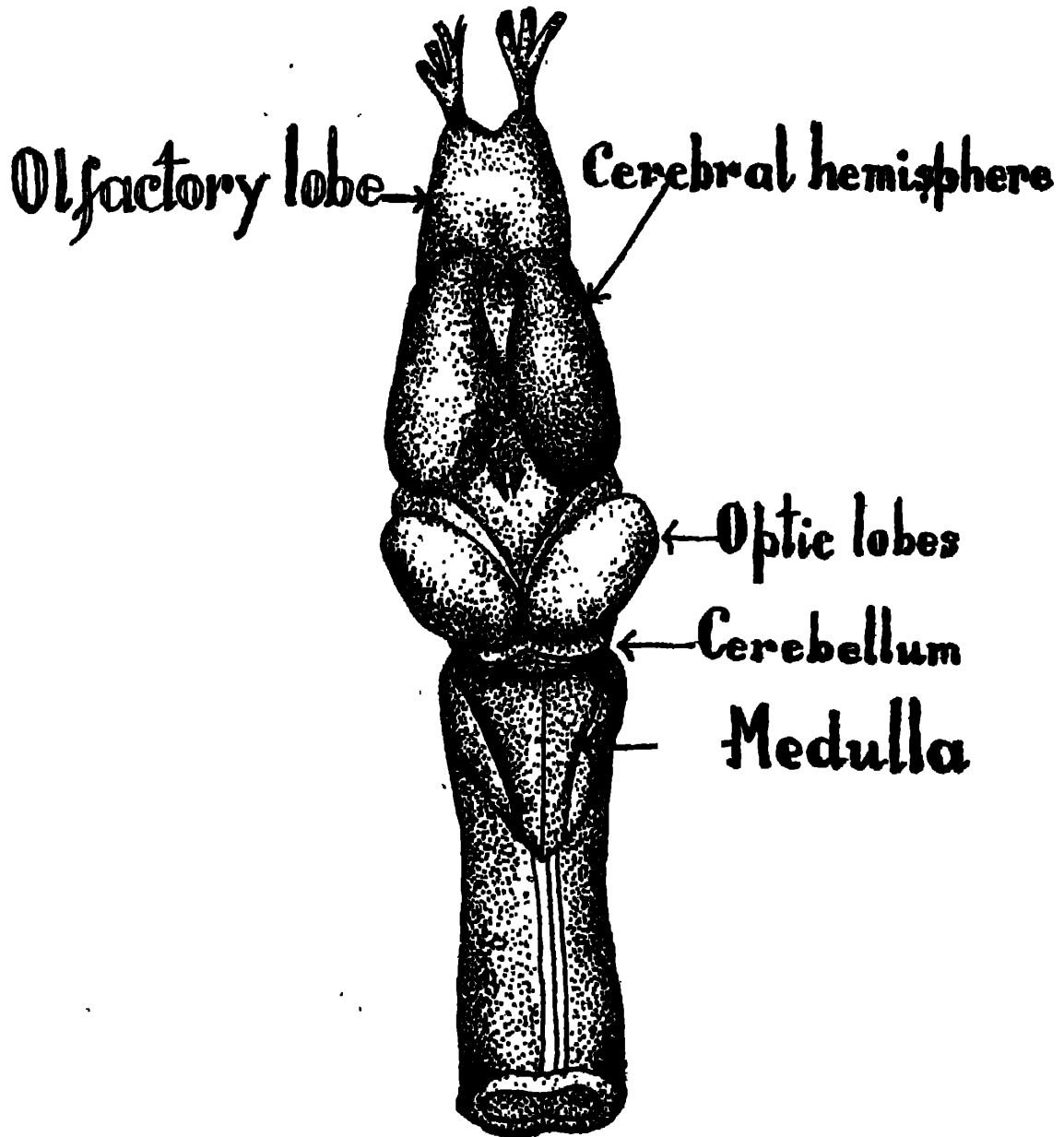
there is a cloaca. The mouth later on becomes connected with the food canal and the intestine is seen like a watch-spring and is a much coiled tube. The long size of the intestine is due to the vegetable diet which necessitates a comparatively large size of the gut. The gills at a subsequent period degenerate and are replaced by internal gills arising from the Branchial arches. They are covered by a fold of skin called Operculum.

The Tadpole at this stage seems to have a fish-like life. The Operculum later on closes and there is left only a single aperture on the left side through which the current of water passes out. Subsequently Lungs appear and the gills are lost. The Tadpole periodically rises to the surface of water for oxygen. The limbs at this time begin to appear, one pair as slight projection at the root of the tail and another pair just below the head. The tail gradually atrophies but the most peculiar phenomenon noticed is that the tail supplies nourishment to the Embryo at this stage until ultimately the tail is lost and the legs are fully developed. The adult toad gives up its vegetable diet and hops about on land in search of insects which forms the main animal food of the full grown animal.

Brain :

The Brain of Toad is divided developmentally into three regions as the fore-brain, mid-brain and hind-brain. The fore-brain gives rise to two cerebral hemispheres and the thalamencephalon. The thalamencephalon lies just in front of the mid-brain. The thalamencephalon bears on the ventral side a body called the hypophysis or Pituitary Body. This Pituitary body is composed of non-nervous matter. On the dorsal side the thalamencephalon bears a body called the Pineal body. In the Tadpole stage this is stalked and represents the remnant of the third eye. Ventrally the thalamencephalon shows a hollow structure called the Infundibulum. The cerebral hemispheres bear the two olfactory lobes in front. The mid-brain lies in front of the cerebellum and medulla oblongata. It consists of the two optic lobes. The hind-

brain is continued in the vertebral column as the Spinal Cord.



Brain of Toad .

The Cerebellum is the narrow median portion just above the medulla oblongata.

On the ventral aspect of the brain the two optic nerves cross each other and the structure is known as the optic chiasma.

The different portions of the brain have cavities which are known as Ventricles. The cavity of the medulla oblongata is known as the Fourth Ventricle. There is a narrow passage between the optic lobes called the Aqueductus Cerebri which is continuous with the Fourth Ventricle. The cavity of the Thalamencephalon is known

Ventral view of Brain

- 1—Olfactory lobe,
- 2—Cerebral hemisphere,
- 3—Optic nerve,
- 4—Pituitary,
- 5—Optic lobe,
- 9—Medulla oblongata.
- 6-8—Nerves.



as the Third Ventricle. The cavity of the Cerebral hemispheres of each side is known as the Lateral Ventricle. Each lateral ventricle communicates with the Third Ventricle by the Foramen of Monro.

Cranial Nerves :

There are ten pairs of cranial nerves in the Toad. The **Olfactory nerve** is the first cranial nerve of each side which rises from the Olfactory lobe of the Brain and supplies the olfactory organ in the nostril.

The second or **optic nerve** starts from the side of the mid-brain and crosses its fellow of the other side just below the thalamencephalon to supply the eyeball

of the the opposite side. This crossing is known as optic chiasma and is seen on the ventral side only. The third or **oculomotor nerve** supplies the muscles of the eye. The fourth or **Pathetic** or **Trochlear nerve** arises between the optic lobes and the cerebellum. It supplies the superior oblique muscle of the eye. It is the only nerve which is found to rise from the dorsal side of the Brain.

The fifth is known as the **Trigeminal nerve**. It arises from the anterior side of the medulla. It has a swelling in its course called the Gasserian Ganglion.

The fifth nerve divides into an Ophthalmic branch which runs in the orbit and supplies the skin of the head. The second branch is more prominent and goes to the hinder part of the orbit and divides into two branches called Maxillary branch to the upper jaw and Mandibular branch to the lower jaw.

The sixth nerve is small and is called the **Abducent nerve**. It arises from the ventral side of the medulla and supplies the external Rectus muscle of the eye.

The seventh or **facial nerve** arises from the side of the medulla and joins the Gasserian Ganglion. It then passes forwards and divides into Palatine branch which supplies the palate of the mouth and Hyomandibular branch which supplies the muscles of the Hyoid.

The Eighth or **Auditory** or **Acoustic nerve** rises also from the side of the medulla to supply the ear or Auditory apparatus.

The ninth or **Glossopharyngeal** arises also from the side of the medulla and proceeds towards the mouth.

It gives off a branch to the Hyomandibular nerve and others to the tongue and the mouth.

The tenth nerve is called the **Vagus nerve**. It supplies the important organs of the body. It has a ganglion at the base and is called the **Vagus Ganglion**. It then proceeds downwards and supplies the Larynx, Heart, Lung and Stomach.

The Sympathetic System :

The sympathetic system of nerves consists of two cords of nervous tissue lying by the side of the vertebral column. The spinal cord inside the vertebral column gives out numerous nerves called spinal nerves. The sympathetic cord is united to the spinal nerve by a **Ramus Communicans**. At the junction of each ramus communicans there is a ganglion of the sympathetic cord. The sympathetic cord passes to the skull and is connected with the tenth nerve and ends in the **Gasserian Ganglion**. The ganglia of the sympathetic cord give out small nerves to the viscera and blood vessels.

Sense Organs :

There are five principal senses *e.g.*, sight, hearing, smell, taste and touch. The senses are controlled by the Brain through the spinal cord and the nerves. The brain and spinal cord form the central nervous system while the sensory and motor nerves form the peripheral system.

Eye :

The eyeball of the toad consists of :—

- (1) The outer coat or sense capsule. It consists of dense connective tissue with some cartilage and

is known as the sclerotic. In front it is transparent and is known as the Cornea.

- (2) The cornea is covered over by a delicate transparent tissue called conjunctiva which is kept moist by the secretion of the Harderian glands.
- (3) Inside the sclerotic or sense capsule is the choroid coat which consists of numerous highly vascular connective tissue with pigment cells. In front the choroid separates from the sclerotic as a partition screen and is known as the Iris across the hollow of the eyeball and divides it into anterior and posterior chambers. The former chamber, the anterior, is small and is filled with a liquid called the Aqueous Humour while the latter chamber, the posterior, is large and is filled with Vitreous Humour. There is a gap in the centre of the Iris which is called the Pupil.
- (4) The Lens, a transparent biconcave or spherical body lies behind the Iris. It focusses light that comes through the pupil on to the Retina.
- (5) The sensitive surface or coat of the eye is the Retina which receives the images of all objects that are seen. It consists of two primary layers of which the outer consists of pigmented cells and the inner layer is the Retina proper where the fibres of the optic nerve end after piercing it.

Ears :

The ear in toad has two parts *viz.*, the middle ear and the internal ear. There is no external ear like that.

of the mammals. The middle ear has got an outer membrane called the Tympanic membrane by which sounds are carried to the Internal Ear. The Internal Ear on each side communicates with the mouth by the eustachian tubes which open by apertures at the angles of the jaws. The cavity of the middle ear has a bone called the Columella Auris which is opposed to the tympanic membrane. The Columella is attached internally to a nodule of cartilage called the stapedial plate. The essential part of the Internal Ear is the membranous Labyrinth which consists of two sacs called the Utriculus and the Sacculus. The utriculus gives origin to the three semicircular canals which are arched tubes opening into the utriculus at both ends. The membranous Labyrinth contains a fluid called the Endolymph. The Labyrinth is placed inside the Auditory capsule which contains a fluid called Perilymph. The semicircular canals end in bulb-like swelling at one end which are known as Ampulla. The Ampulla has a projection inside which has long sensory hairs and are connected with the fibres of the Auditory Nerve.

Olfactory Organs :

The olfactory apparatus of the toad consists of the Nasal sacs which open into the exterior by two apertures called the Nostrils, and internally by the posterior Nares inside the mouth. The olfactory nerve runs into the sac of either side.

Organ of Taste :

The tongue is the organ of taste. The outer part, (external surface) of the tongue is studded with special

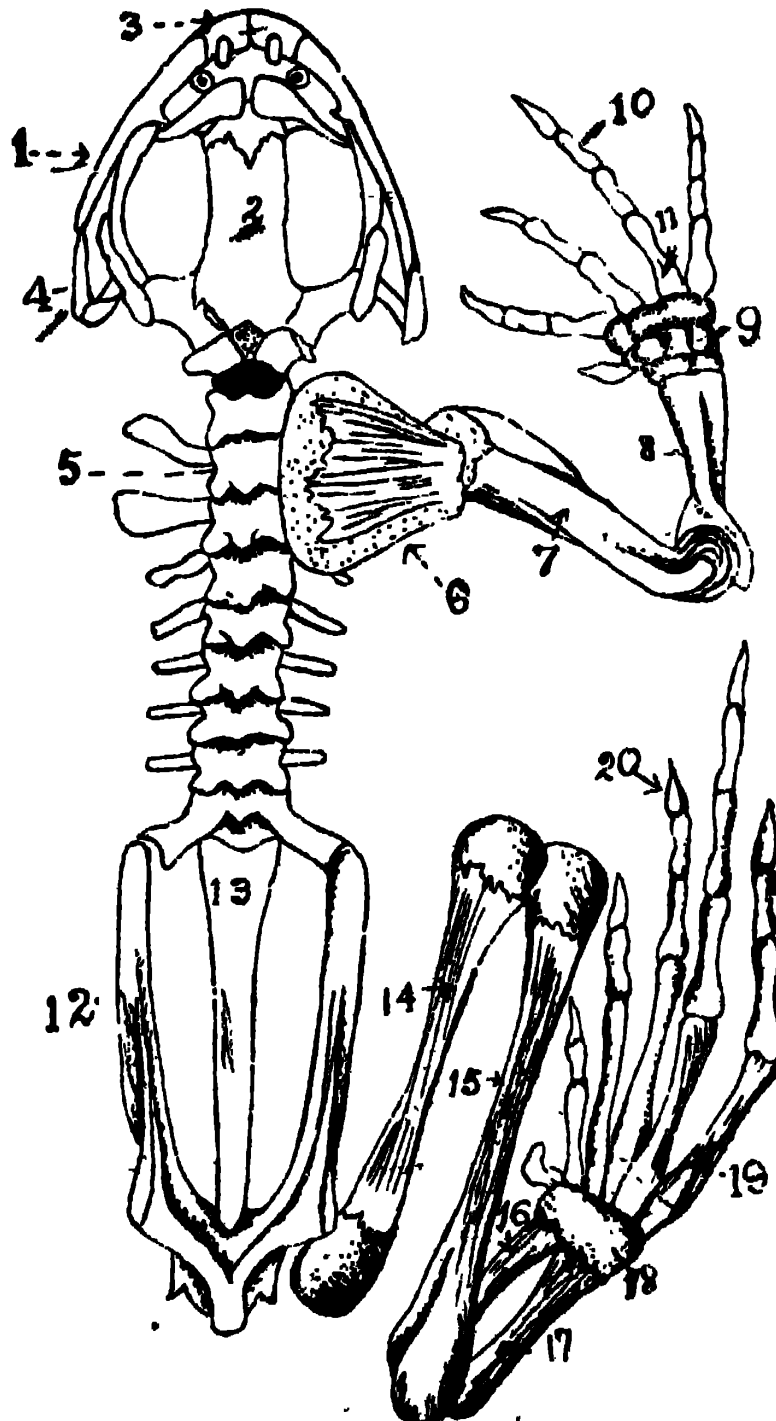
cells called Taste-buds which give rise to particular sensation. The internal lining of the mouth has to some extent been provided with similar sense organs of taste. It is supplied by the Glossopharyngeal nerve.

Skeletal System or Skeleton :

The back of the skull has a large aperture called the Foramen Magnum which is bounded on either side by the exoccipital bones. Below the foramen magnum are a pair of projection called the occipital condyles which articulate with the first vertebra. On the outer side of foramen magnum is a small aperture for the exit of the 9th and 10th cranial nerves. There is the Pro-otic bone at the side of the exoccipital which fuses with it in the adult stage. The roof of the cranium is formed by the pair of Fronto-parietals which are formed by the fusion of two frontals and two parietals. The two nasals occur in front of the frontoparietals. Between the nasals and the fronto-parietals occur the Sphenethmoid. On the outer side of the pro-otic lies the hammer-shaped or T-shaped squamosal. The slender columella auris projects from the fenestra ovalis beyond the exoccipital. On the ventral aspect in front of the two exoccipitals is the Parasphenoid. The two small Vomeres lie in front of the parasphenoid. The Pterygoid lies as a three-rayed bone on the outer side of the parasphenoid. The two palatines are placed anteriorly to the parasphenoid and extend to the pterygoid.

The upper jaw is formed by the premaxilla, maxilla and Jugal. The quadrate is attached to the Jugal and articulates with the lower jaw.

The lower jaw consists of two halves called Rami with a cartilaginous core called the Meckel's Cartilage. On the outer face of it is the Dentary and the Angulo-



1—Maxilla, 2—Fronto-parietal, 3—Pre-maxilla, 4—Quadrato-jugal, 5—Vertebra (2), 6—Scapula, 7—Humerus, 8—Radio-ulna, 9—Carpals, 10—Phalange, 11—Metacarpal, 12—Ilium, 13—Urostyle, 14—Femur, 15—Tibio-fibula, 16—Astragalus, 17—Calcaneum, 18—Tarsal, 19—Metatarsal, 20—Phalanx of digit.

VERTEBRA

Splénial on the inner face but in the adults they are fused.

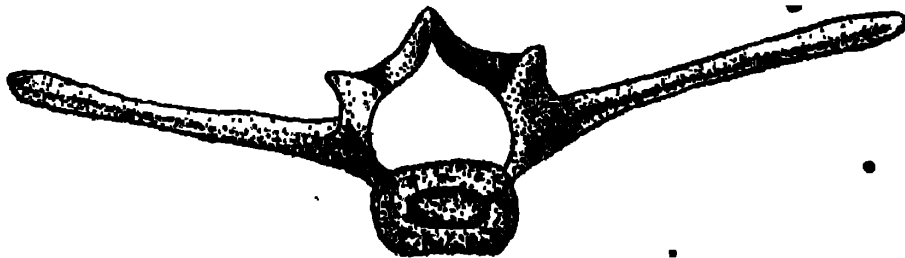
Hyoid :

The hyoid apparatus of toad consists of a shield-shaped cartilage called the Body of the Hyoid. The anterior side is produced into slender rods called the Anterior Cornua and its posterior angles into partly ossified rods called the Posterior Cornua embracing the glottis.

The Vertebral Column :

The Vertebral Column is formed of nine movably united pieces called the Vertebrae and an unsegmented bony rod called the urostyle which represents a number of fused vertebrae of the tail region. Each vertebra looks like a ring and has a solid structure at the base called the Centrum and there is a cavity or hole through

Vertebra



which the spinal cord passes down to the tail. The two walls on the two sides are known as Neural arches and a spine-like projection seen at the back is called the Neural spine. The cavity of the arches is known as the

Neural canal. From the two sides of the vertebra projections are found which are called the Transverse Processes. The third vertebra has a large process which is pointed downwards.

The solid centrum is concave in front and is convex behind. This type of vertebra is called **Procoelous**. The vertebra are joined or articulated with one another by facets or Zygapophyses. On the anterior surface of each vertebra the facets are smooth and flat and are known as Prezygapophysis. On the posterior part the two facets slightly point downwards and are known as Postzygapophyses. The first vertebra has no transverse process. It articulates with the condyles of the skull. The Eighth Vertebra is peculiar in having the centrum concave on both the surfaces and is known as **Amphicoelous**.

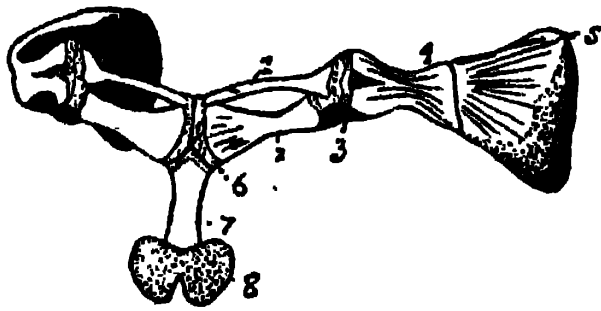
The ninth vertebra has two large transverse processes. The urostyle is a bony rod at the tail end of the vertebral column.

The Pectoral or Shoulder Girdle :

The ninth vertebra has two large transverse processes. scapula at the back. The scapula has another piece called Suprascapula. In the front, the girdle has a bone called the Clavicle below which is the Coracoid. The coracoids at their meeting place in front are known as Epicoracoids. In the Toad the Epicoracoids are twisted. There is a breast bone called the sternum which has a cartilage called xiphisternum. In the Toad there is no oncosternum. There is a cavity at the junction of the scapula and the coracoid. This is known as the Glenoid

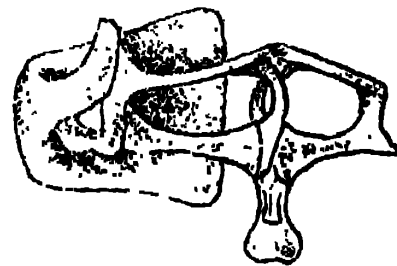
cavity and here the bone (Humerus) of the fore limb is attached. The humerus has a ball-like end and the socket is provided by the glenoid cavity. This sort of joint is known as Ball and socket joint which allows the hand considerable freedom of movement.

Pectoral girdle of Toad.

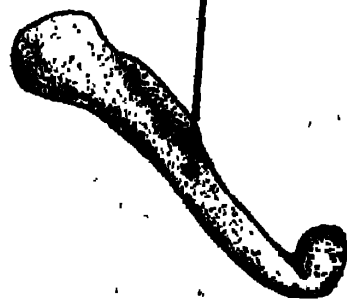


- 1—Clavicle, 2—Coracoid. 3—
- Glenoid cavity, 4—Scapula, 5—
- Suprascapula, 6—Epicoracoid. 7—
- Sternum, 8—Xiphi-sternum.

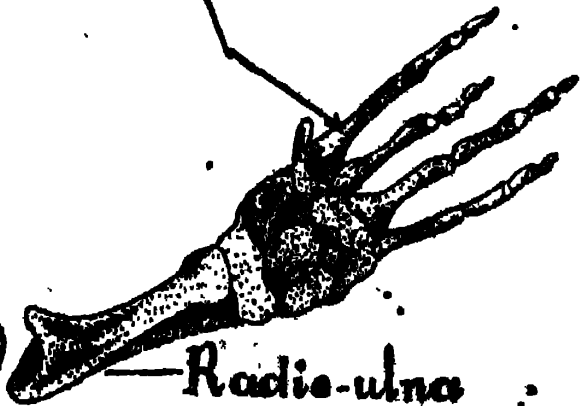
Pectoral girdle.



Humerus



Phalanges

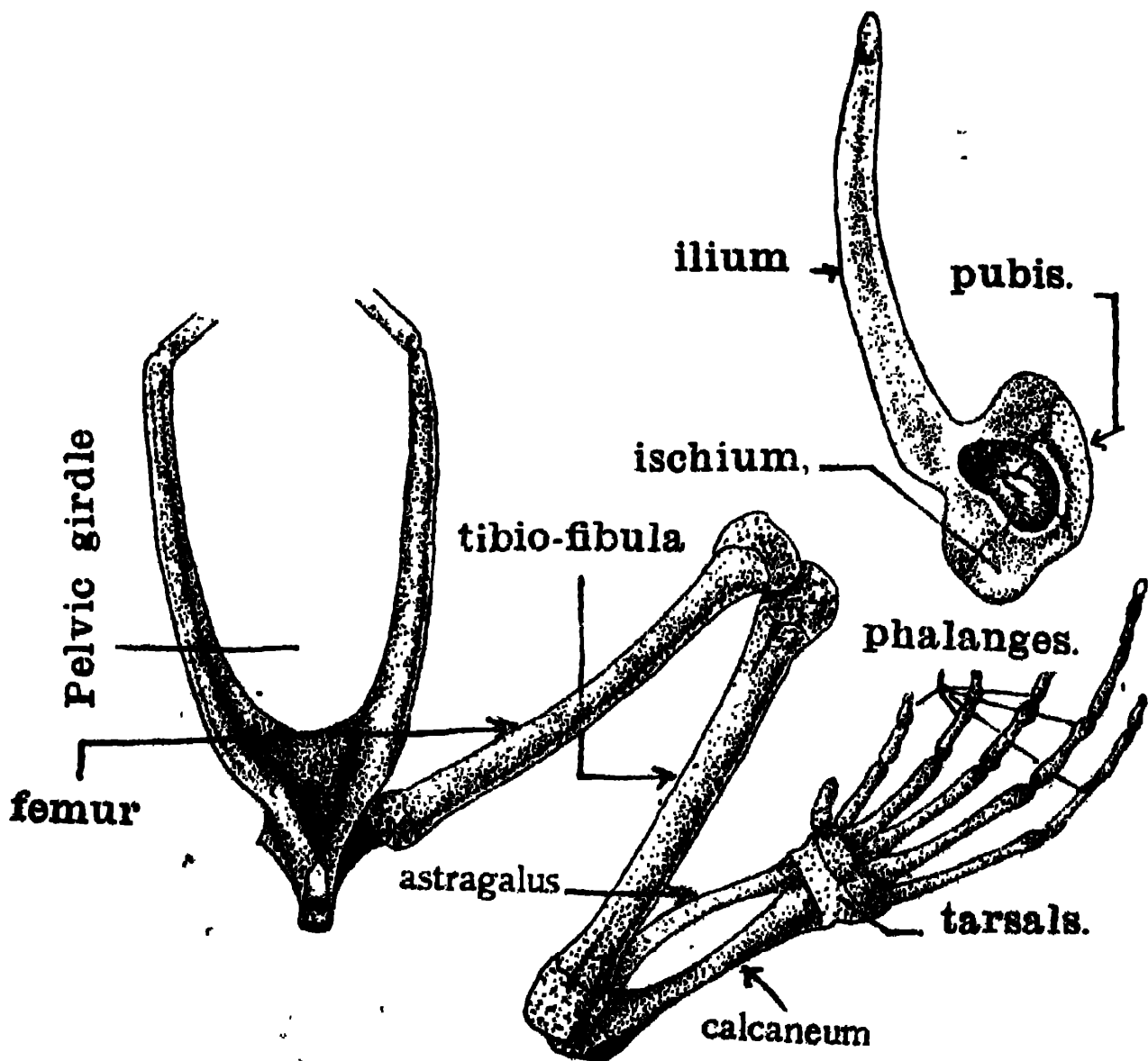


Radius-ulna

Forelimb of toad

Fore Limb :

The first bone of the forelimb is a long bone called the **Humerus** which has one end in the glenoid cavity and the other end is connected with the **Radio-ulna**, the two bones **Radius** and **Ulna** being fused together. The



Humerus has a large head and a prominent ridge. Next come the six pieces of carpal bones arranged in two rows. There are four long slender **Metacarpal** bones with which the four digits of the hand are attached.

Each digit has either two or three phalanges. The phalanges from the radial side are numbered as 2, 2, 3 & 3.

The Pelvic Girdle :

The pelvic girdle has on each side a long bone called the **Ilium** and **Pubis** in front and the **Ischium** below and dorsally. The Pubis is united with its fellow of the other side and is cartilaginous at the junction.

The three bones by their union form a cavity called the **Acetabulum** which is the socket for the Hind limb.

Hind Limb :

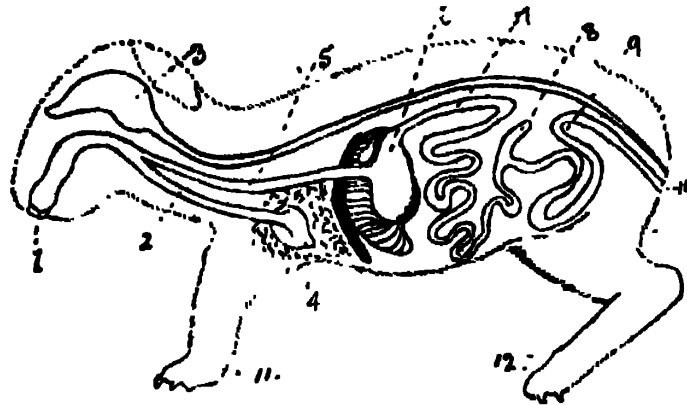
The hind limb consists of a long bone called the **Femur** whose round end called the Head articulates with the acetabulum. The other end has two ridges with a furrow and meets the two other fused bones called **Tibiofibula** and a small bone called the **Patella** at the knee. The Tibio-fibula articulates with the **Tarsus**, two of which form the ankle joint and are known as **Calcaneum** (Fibulare) on the outer side and **Astragalus** (Tibiale) on the inner side. The other two bones of the **Tarsus** are small. The Tarsal bones are followed by the five **Metatarsal** bones. Each metatarsal bone has a digit consisting of a number of phalanges. The phalanges are numbered 2, 2, 3, 4 and 3 counted from the inner side. On the inner side of the first or big toe called **Hallux** there is an extra toe or **Calcar**.

Guineapig :

This animal is a type of the class **Mammalia**. The word "mammalia" is derived from the Latin root.

“mammæ” meaning breast. All animals belonging to this group namely man, monkey, elephant, tiger, cat, dog and guineapig have to nurse their young ones with the breast milk. It is one of the warm-blooded animals *i.e.*, its temperature is constant and does not depend upon the variations of the medium as atmosphere or water in any way. Therefore the Guineapig is called **homiothermal** animal. The animal has an external

Section of Guineapig.



- 1—Mouth, 2—Trachea, 3—Brain, 4—Lung, 5—Esophagus,
6—Stomach, 7—Duodenum, 8—Caecum, 9—Rectum, 10—Anus,
11—Forelimb, 12—Hindlimb.

covering of hairs which is sometimes coloured. The ventricle of the Heart is completely divided by a partition into two distinct chambers. The Guineapig like all other mammals perspires and gives out some waste products through the pores of its skin.

Body—External Features :

The body is divisible into a **head, neck and trunk**. It has no tail. The trunk is divided internally by a partition called the diaphragm into thorax and abdomen.

MAMMALIA.



The Guinea pig.

The thorax is bounded by the ribs and contains the vital organs *viz.*, the Heart and the Lungs. There are two nostrils at the end of the snout. There are two eyes, each eye has two lids, upper and lower and a membrane called the Nictitating membrane. The mouth is placed below the nostrils and has upper and lower lips. The abdomen on the ventral side has teats or *mamæ* in the female. The anus opens posteriorly by an aperture and the genital organs open by a common opening with the urinary system in the male and by separate apertures in the female.

The forelimb has four digits which are all provided with claws. The hindlimb has three digits which are also clawed.

The skin consists of Epidermis on the outer side, dermis is below or beneath it followed by layers of muscles held together by connective tissue called fascia.

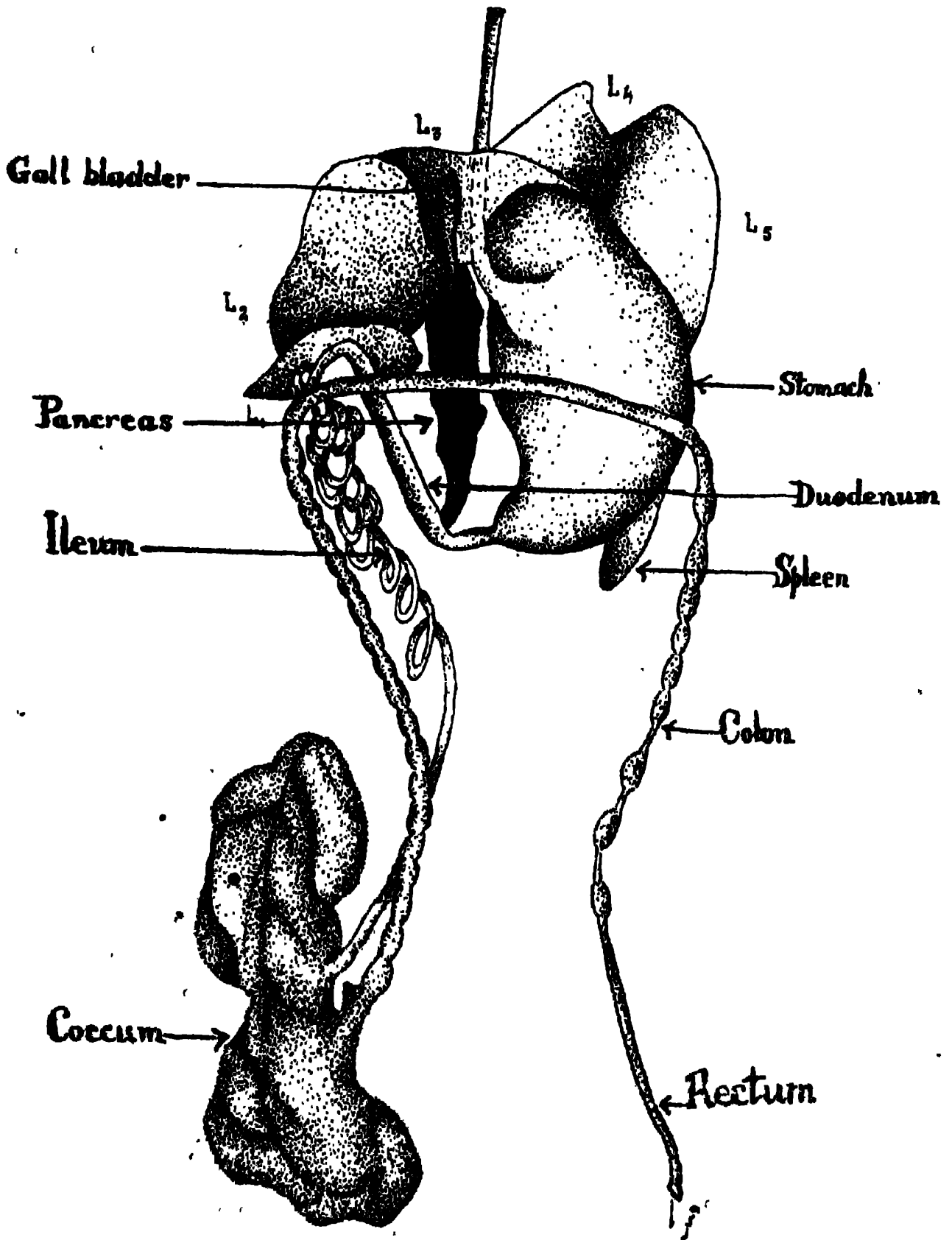
Each ear has three parts *viz.*, the external ear provided with a pinna, the middle ear and the internal ear.

Body-Cavity :

The body-cavity is a *cœlome* and is divided into thorax and abdomen. The thorax is lined by a membrane called Pleura and the abdomen is lined by a similar membrane called Peritoneum.

Alimentary System :

The mouth leads into a cavity called the Buccal cavity. This cavity has a roof called the Palate which is divided into two portions called Hard palate in front



and soft palate behind. The hard palate is strengthened by palatine bones while the soft palate is entirely fleshy and therefore soft. The internal nares (opening of the nose) of the Guineapig open into the back of the mouth called the Pharynx. The tongue is an elongated muscular organ which covers the floor of the mouth with the tip free in front. The teeth are not all alike and are planted in sockets on the jaw bones. The front teeth are large, chisel shaped and slightly curved. They are used for cutting away delicate vegetables which the animal eats as food and are known as Incisors. Then there is a free space on each side on both the upper and lower jaws which is known as Diastema. The Canine teeth are absent in the Guineapig as it is not a flesh-eating animal. The gap above mentioned would have been occupied by the Canines had they been present. Then there is one premolar and three molars on each side of both upper and lower jaws. The dental formula therefore is :—

$$1 \frac{1}{1} \quad 0 \quad 0 \quad Pm \frac{1}{3} \quad M \frac{3}{3}$$

giving ten teeth on either side or 20 in all.

Inside the buccal cavity four salivary glands open on each side by ducts. The Infraorbital gland is placed just below the eye. The Parotid gland lies in the cheek. The submaxillary lies near the angle of the mandible and the sublingual is situated on the inner side of the ramus of the lower jaw. The back portion of the buccal cavity is called the Pharynx. It has two divisions, one above, which is called the Nasal portion where the posterior nares opens and also contains the openings of

the two eustachian tubes. The other division is called the **Buccal** portion which contains two apertures of which one is known as the **Glottis** and is guarded by a flap of cartilage called the **epiglottis** which leads into the respiratory organs. The other aperture leads into the alimentary canal, and is behind the glottis.

The first part of the alimentary canal is a narrow tube called the **oesophagus**. The oesophagus goes down through the thorax and by a perforation through the **Diaphragm** enters the **Abdominal cavity**, where it opens into a dilated sac called the **stomach**. The stomach has two ends, the one at the junction of the oesophagus is known as the **Cardiac end** while the other from which the intestine begins is known as the **Pyloric end**. The stomach has many glands on its inner wall which help digestion by their secretion.

The intestine is a much coiled tube and is divided into two portions *viz.*, the **small intestine** and the **large intestine**. The small intestine begins from the stomach, and is again divided into two portions *viz.*, the **Duodenum** and the **Ileum**. The Duodenum is a short U-shaped tube followed by the much coiled Ileum. The Ileum is followed by the **Large Intestine**. The Large Intestine again has three divisions. The first portion of the Large Intestine is called the **Cæcum** which is a thick dilated tube and ends in a process in man called the **Vermiform Appendix** but in the **Guineapig** there is no trace of **Vermiform appendix** found. The **colon** begins from one side of the **Cæcum** and is much coiled and ends in a tube called the **Rectum** which opens into the exterior by an aperture called the **Anus**.

Liver :

This is the largest gland in the body of the Guineapig, and is **five-lobed**. It lies below the diaphragm resting on the stomach. It has five deeply coloured lobes. The gall bladder lies as a pyriform sac on the posterior border of the Liver. The Liver sends out a secretion which is called the Bile. It helps digestion. It comes out through a duct called Hepatic duct which opens into the Duodenum after uniting with another similar duct from the Gall-bladder which is called the Cystic duct. The united duct is known as the Common Bile duct as both of them carries the bile to the intestine.

Pancreas :

The pancreas is a whitish gland lying in the concavity of the duodenum and extending up to the wall of the abdomen. It has a duct which also opens into the duodenum and the secretion of the pancreas helps digestion.

- The coils of the intestine and the stomach are suspended from the vertebral Column and kept in position by folds of peritoneum which are called the Mesentery.

Circulatory Organs :

The Heart, the principal organ of circulation, the central pumping station of blood in the body, is situated in the Thorax lying between the pleural sacs enclosing the Lungs. The heart is covered by a membranous sac called the Pericardium which contains a fluid called the pericardial fluid. The heart of the Guineapig has four chambers called the left auricle and left ventricle on the

left side and the right auricle and right ventricle on the right side. The right and left sides of the heart having their cavities completely and fully separated from one another by partitions called Interauricular and Interventricular Septa.

Right Auricle or Atrium :

The right auricle receives the three large veins called the right and left precaval veins and the single postcaval vein. The right auricle communicates with the right ventricle by a wide opening called the Right Auriculoventricular opening which is guarded by a valve called the Tricuspid composed of three membranous lobes or cusps so arranged that they allow the blood to pass from the right auricle to the right ventricle only and not otherwise. And when the right ventricle contracts the flaps meet and close the aperture so that the blood can pass in one direction only. The Right ventricle is much thicker than the right auricle. The walls inside the cavity are raised up into muscular ridges called the Columnæ Carnæ. The Right Ventricle from its anterior angle gives out the Pulmonary artery the entrance to which is guarded by the three semilunar valves.

Left Auricle or Atrium :

The left auricle like the right one has an auricular appendix. It receives pure blood from the two pulmonary veins which open together from the Lungs. The left auricle communicates with the Left ventricle by the left Auriculoventricular opening which is guarded by the Bicuspid or Mitral Valves consisting of two flaps or cusps.

The Left Ventricle is more thick-walled and stronger than the right one. It has columnae carneæ also. At the base of the left ventricle is the opening of the Aorta, the principal artery for the distribution of blood to the system. Its opening is guarded by three semilunar valves. There is no Sinus Venosus.

The Arterial System :

As the name signifies this system consists of arteries which are vessels meant to carry pure or oxygenated blood from the Heart to the different parts of the body. These vessels have thicker and elastic walls than the veins which carry impure or deoxygenated blood from the different parts of the body to the Heart. The main trunk of the arterial system of the Guinea-pig arises from the base of the left Ventricle. It then forms an arch and is known as the Arch of Aorta. The Aorta gives rise to a number of smaller arteries as branches. In the case of all mammals the Aorta bends only to the left side which is a peculiarity to be noted.

Branches :

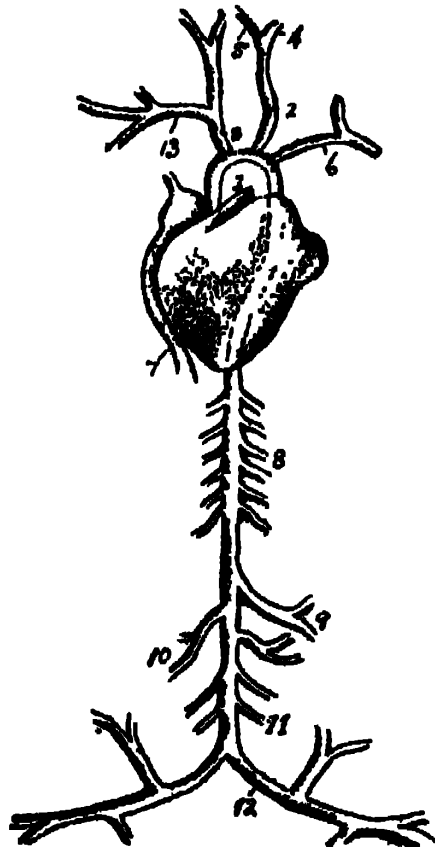
The first important branch is the Innominate artery which arising from the arch divides into Right common carotid and the Right subclavian artery and a left common carotid. The **Right common carotid** divides into right external carotid supplying the right half of the head and face and **Right Internal Carotid** supplying the right half of the Brain. The **Right Subclavian** passes into the right arm as **Right Brachial**. Before passing to the arm it gives off two branches, one to the ventral thoracic wall which is known as the **Internal Mammary artery** and

the other enters the vertebral column as the Vertebral Artery.

The Left Common Carotid arises from the innominate and supplies the left part of the head and face with two branches from it named the **Left Internal Carotid** and the **Left External Carotid**. The Left Subclavian artery arises independently from the Arch of Aorta and passes to the arm as Left Brachial and gives off similar two

Arterial System.

- 1—Arch of Aorta,
- 2—Left common carotid,
- 3—Innominate.
- 4—Int. carotid,
- 5—External carotid,
- 6—Sub-clavian,
- 7—Posteavalvein,
- 8—Intercostal,
- 9—Coeliac,
- 10—Renal,
- 11—Posterior mesenteric,
- 12—Iliac.



Left carotid should arise from innominate.

branches viz., Left Internal Mammary and Vertebral to supply similar areas like the right side.

The Arch of Aorta then passes down the back of the Heart and is placed ventral to the spinal column.

and is known as the **Dorsal Aorta**. The **Dorsal Aorta** may be divided into **Thoracic Aorta** and **Abdominal Aorta** according as it passes through the thorax and abdomen respectively. The **Thoracic Aorta** gives off a number of branches called the **Intercostal arteries** which supply the wall of the thorax.

The **Abdominal Aorta** gives off the following important branches *viz.* :—

- (1) **Coeliac** which supplies the Liver, stomach and spleen.
- (2) **Anterior Mesenteric** which supplies the intestines and Pancreas.
- (3) **Two Renal arteries** to the two kidneys.
- (4) **Two ovarian** in the female or **two Spermatic arteries** in the male. The ovarian arteries supply the ovaries and the spermatic supplies the testis.
- (5) **Posterior Mesenteric** artery supplies the Rectum.
- (6) The **Dorsal aorta** ultimately divides into two **Iliac** arteries. Each **Iliac** artery divides into **External Iliac** and **Internal Iliac** arteries. The **External Iliac** supplies the hind-limb as **Femoral** artery. The **Internal Iliac** artery supplies branches to the **Bladder** and lower abdominal organs.

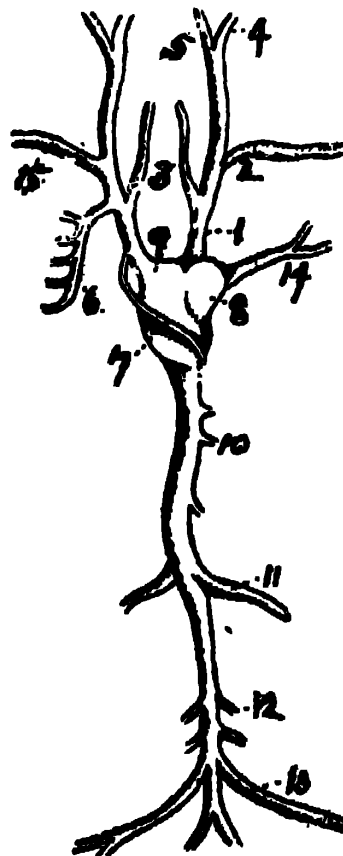
The **Pulmonary Artery** arises from the **Right ventricle** and divides into **Right** and **Left Pulmonary arteries** and each of them goes to the **Lung** of that side.

The Venous System :

The veins are vessels which bring impure blood from the different parts of the body back to the Heart. The veins are thin-walled and contain no elastic fibres and run superficially on the body. There are three principal veins (the body of the Guineapig) two of them bring blood from the region of the head and are known as the Anterior Venæ Cavæ. Each anterior Vena Cava or Precaval vein is formed by a number of veins. They are :—

Venous System.

- 1—Precaval,
- 2—Sub-clavian,
- 3—Internal jugular,
- 4—Posterior facial,
- 5—Anterior facial,
- 6—Intercostal,
- 7—Azygos,
- 8—Auricle,
- 9—Auricle,
- 10—Hepatic,
- 11—Left Renal,
- 12—Genital,
- 13—Femoral or Ext.
iliac. vein,
- 14—Pulmonary vein.



- (1) **External Jugular** from the surface of the head.
- (2) **Internal Jugular** from Brain.

(3) **Subclavian** from shoulder and forelimb.

The **Right Anterior Vena Cava** also receives a vein called **Azygos** from the wall of the chest.

(4) **Anterior Intercostal** from the anterior thoracic wall.

There is a single **Posterior Vena Cava** or **Post Caval** vein which lies by the side of the **Dorsal Aorta**. It is formed by the following veins:—

(1) The two **Internal Iliacs** from the back of the two thighs.

(2) The two **External Iliacs** from the inside of the two thighs.

(3) The two **Ilio-lumbers** from the abdominal walls.

(4) The two **genital veins** from the reproductive organs.

(5) The two **Renal veins** from the two kidneys.

(6) The two **Hepatic veins** from the liver.

The **Renal portal system** is not found but there is a **Hepatic portal system**. Blood is brought to the **Liver** by a number of veins from the parts of the **Alimentary Canal** and they join to form the **Hepatic Portal vein**.

The **Pulmonary veins** bring pure blood from the two lungs to the **Heart** but before opening into the left auricle, the two veins combine. Although the name vein is given to the **Pulmonary veins** but actually they carry pure oxygenated blood from the **Lungs** to the **Heart**. This is an exception. A similar exception is also found in the case of the **Pulmonary artery** which carries venous blood from the **Heart** to be purified in the **Lungs**.

Blood :

The blood of Guineapig like all mammals except that of Camels consists of a fluid portion called Plasma in which float white and red corpuscles. The white blood corpuscles are all nucleated and amœboid in nature. The red blood cells are non-nucleated and biconcave disks. They are not amœboid in nature.

Circulation :

The Circulation in the Guineapig is divisible into greater circulation and lesser circulation. The greater circulation consists of blood running through the body and the lesser circulation through the lungs. The greater

Circulation.

- 1—Ventricle.
- 2—Artery.
- 3—Art,
- 4—Capillary,
- 5—Cap of Lungs.



circulation in the venous blood being brought from the three principal veins to the Right Auricle and then to the Right ventricle. The pure blood from the Left Auricle passes to the left ventricle and is then distributed by the Aorta to all parts of the body. The Arteries are connected by intermediate structures which are very fine and net-like and are known as Capillaries.

The circulation in the Lungs consists in the carriage of the blood from the Right ventricle by the Pulmonary

artery to the Lungs. And from the Lungs the blood returns to the Left Auricle by the Pulmonary veins. •

The Hepatic Portal System :

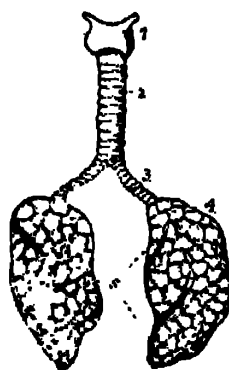
The portal vein brings blood from the intestine which is rich in nutritive material absorbed from the alimentary tube and also impure venous blood from other hinder region of the body. This mixed blood enters the Liver and after receiving blood from the Hepatic veins is then poured into the greater circulation.

The Respiratory System :

The Respiratory apparatus of the Guineapig consists of three parts *e.g.*, Larynx, Trachea and the Lungs. At the back of the mouth there is an aperture called Glottis which is guarded by a flap of cartilage called the Epiglottis.

Lungs of Guineapig.

- 1—Larynx.
- 2—Trachea.
- 3—Bronchus.
- 4—Lung.
- 5—Lung.



The Epiglottis prevents all foreign matter from entering the glottis and closes the aperture when food is passing to the alimentary tube. The glottis leads into a chamber called the Larynx. The Larynx is made of cartilage of which there is a large one in front called Thyroid, a ring like another called the cricoid and other two in the middle

called Arytenoids. Then there are two membranous cords in the Larynx called the Vocal Cords. The Larynx is also called organ of voice. The vocal cords produce sound by the vibration of the air which comes from the Lungs.

The Larynx is continued into the Thorax as a tube called the Trachea. The Trachea is made of cartilage rings which are incomplete dorsally. The Trachea divides into two smaller tubes called Bronchi which are also made of cartilage. They eventually enter into the Lungs. Inside the lung each Bronchus ramifies into finer branches and are known as Bronchioles.

Lungs :

Two spongy sacs are found inside the Thorax called the Lungs. Each lung lies inside a sac called the Pleura. The lungs are very vascular and there are rich capillaries joining the Pulmonary arteries with the Pulmonary veins. Here exchange of gases takes place. Each lung is divided into lobes (Three on the left side and four on the right side).

Respiration consists of two processes *viz.*, Inspiration by which oxygen is taken in and Expiration by which carbon dioxide is driven out. During inspiration muscles of the chest as also the Diaphragm and some muscles of the abdomen and neck contract and as a result the lungs become distended with the distention of the thoracic cavity as a result of which a negative pressure is exerted so that air is sucked in. The air enters through the nostrils, passes down the Larynx and Trachea and enters the Lungs. During expiration the muscles of the chest and Diaphragm relax and the Lungs recoil from the elasticity of their walls. They contract and drive out the

gases from the lungs. The two processes are always going on alternately and form what is known as Respiration.

Endocrine Organs :

There are some organs in the Guineapig which have no definite passages but their secretion is necessary for the due discharge of its bodily functions. They are the following :—

- (1) Thyroid lying in front of the trachea near the cricoid cartilage.
- (2) Thymus is generally present in the young animal near the base of the Aorta.
- (3) Spleen occurs on the dorsal side of the stomach on the left side.
- (4) Suprarenal gland two in number, each lying on the top of the kidney.
- (5) Pituitary Body is found on the ventral aspect of the Brain.

These glands send their secretion to the blood stream directly and help the various functions of the body as growth, maturation of the generative organs etc.

The Excretory System :

The excretory system of Guineapig consists of two dark red kidneys, one on each side of vertebral column and lying within the abdominal cavity. Each kidney is a bean-shaped body and is covered over by the peritoneum. Each kidney has a passage called the ureter which begins at the hilus and the two ureters from the two kidneys open at the lower part of a sac-like organ called

the urinary Bladder. The urine comes from the kidney through the ureter and collects in the Bladder. The Bladder has got a passage called the urethra through which the urine is voided from time to time as the bladder gets filled up.

The kidney is surrounded by a sheath and on section the inner portion is seen divided into (a) an outer portion called the Cortex and (b) an inner portion called the Medulla.

The cortex consists of tubules. Each tubule has a capsule called the Malpighian capsule at the distal end and is convoluted till it ends in the collecting tubule. The tubules open on the surface of a conical process called the Pyramid which projects into the Pelvis which is the innermost sac of the kidney. The ureter begins from the Pelvis. In the male the urethra is continued into a long organ called the Penis. In the female the urethra opens by a separate aperture.

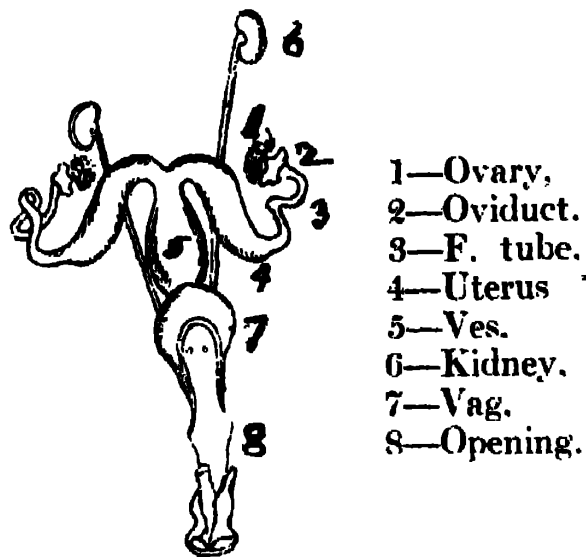
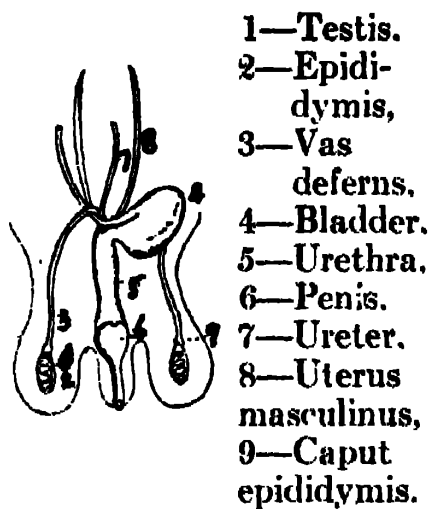
The Reproductive System :

Male --

The generative organs of the male animal are the two testes which lie within the abdominal cavity, but come down to the scrotal sac in the breeding season. Each Testis gives off a number of male cells called Sperms. Each sperm has a large head and a long tail which gives it the power of movement. The cavity of the scrotal sac communicates with the abdominal cavity by a passage called the Inguinal Canal. The testis is covered by a closely adhering duct called the epididymis and from this runs the Vas Deferens, the duct of Testis.

The Vas Deferens carries with it nerves and blood vessels as it enters the abdominal cavity and makes a loop round the ureter of the corresponding side between the spermatic sac which is also called the uterus masculinus and the neck of the bladder. It is then continued as the urethra or Urogenital canal. The uterus masculinus in which the

Male organs.



sperms are stored, opens at the neck of the Bladder on the dorsal side. The Prostate gland is embedded in the wall of the uterus masculinus and has small ducts which open into the urethra. There is a pair of smaller glands called Cowper's glands which also open into the urogenital canal.

The urethra runs as a median passage through the Penis and is covered by a soft vascular portion called the Corpus spongiosum on the ventral side and Corpora Cavernosa on the dorsal side.

Female —

The generative organs of the female are the two ovaries one on each side lying on the dorsal wall of abdomen, and behind the kidneys. The female cells

called the ova are formed from the germinal epithelium of the ovary. Some of these become large and become the ova while the others remain small and serve for nutrition of the larger cells. When the animal is adult and the ovary is mature, the ova come out by the bursting of the ovarian wall and are shed into the abdominal cavity. The ova then make their way to the mouth of the oviduct. There are two ducts to the two ovaries called the oviducts. Each oviduct has a funnel-shaped fimbriated mouth at its anterior part near the ovary and a slightly coiled tube called the Fallopian tube. The next portion of the oviduct is called the uterus. The two uteri join and form a common passage called the Vagina. The ultimate part becomes common with the neck of the bladder and forms the Vestibule. It opens to the exterior by the Valva.

The fertilised ovum is lodged in the uterus. It receives nutrition from the mother through a tissue called the Placenta. The uteri become dilated when six or seven young ones are carried by the animal. It takes about 30 days for the full development of the individual young animals. The Guineapig becomes adult in about three months after which it becomes possible for the adult to reproduce young animals.

Nervous System :

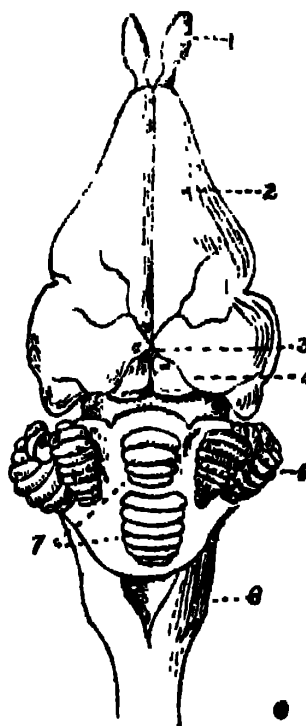
Brain —

The Brain of Guineapig consists of two very large cerebral hemispheres or Cerebrum occupying about two-third of the whole brain matter. They cover the Thalamencephalon and the optic lobes. The two hemispheres

are joined by a band of nerve fibres called the Corpus Callosum. Each cerebral hemisphere has three portions called the Frontal lobe, the Parietal lobe and the Temporal lobe. There are two very large clubshaped olfactory bulbs at the anterior extremities of the cerebral hemispheres. The cavities within the cerebral hemispheres are called the Lateral Ventricles. The lateral ventricles are connected with the third ventricle by the Foramen

Brain

- 1—Olfactory lobe,
- 2—Cerebral hemisphere,
- 3—Pineal body,
- 4—Optic lobes,
- 5—Flocculus,
- 7—Vermis,
- 8—Med. oblongata.



of Monro. The thalamencephalon is overlapped by the cerebral hemispheres. The Pineal body arises from the roof of the thalamencephalon while the floor is produced downwards into a process called the Infundibulum to which the Pituitary body is attached. On the ventral side the optic nerves cross each other and form the optic Chiasma.

In the mid-brain the dorsal part shows that each optic lobe is divided into two portions by a transverse furrow so that two pairs of lobes called the Corpora Quadrigemina are produced.

In the hind-brain the cerebellum appears very large and consists of a central lobe or Vermis and two lateral lobes which are divided by numerous fissures, into a large number of convolutions. Each lateral lobe has a prominence called the flocculus. On section the Cerebellum shows a tree-like pattern.

The Medulla oblongata lies below the Cerebellum and its cavity is known as the Fourth Ventricle.

Cranial Nerves :

There are twelve pairs of cranial nerves in the Guineapig. Two additional pairs are seen namely the spinal Accessory and the Hypoglossal which are absent in the Toad. The nerves are as follows :—

1. The Olfactory nerve supplies the nose.
2. The optic nerve crosses its fellow and forms the optic chiasma and then supplies the eye.
3. The Oculomotor nerve supplies the muscles of the eyeball.
4. The Pathetic nerve supplies the superior oblique muscle of the eyeball.
5. The Trigeminal is a comparatively big nerve. It has a ganglion called the Gasserian ganglion and divides into three branches :—

(a) Ophthalmic—which supplies the eyeball and some part of the head.

- (b) Maxillary—which supplies part of the face.
 - (c) Mandibular—which supplies the muscles of the jaw.
6. The Abducens supplies the external Rectus muscle of the eye.
 7. The Facial nerve supplies the face and supplies a gustatory nerve to the tongue.
 8. The Auditory nerve supplies the internal ear.
 9. The Glossopharyngeal nerve supplies the pharynx, tongue and neck.
 10. The Vagus or Pneumogastric nerve is the most important as it supplies most of the vital organs as Larynx, Trachea, Heart, Lungs and stomach.
 11. The Spinal Accessory nerve arises from the side of the Medulla by a number of roots and emerges from the skull along with the 9th and 10th nerves through the posterior lacerated foramen and supplies certain muscles of the neck.
 12. The Hypoglossal nerve arises by several roots from the ventral aspect of the Medulla in the middle line and comes out of the skull through the condylar foramen to supply the muscles of the tongue.

Spinal Cord :

The spinal cord passes through the vertebral column and gives out a number of Spinal Nerves. Each nerve arises by two roots, viz., one anterior and the other

posterior which join together before the nerve proceeds forwards. There are several plexuses in the spinal nerves *viz.*, cervical and brachial plexuses with the cervical nerves and lumbosacral plexus with the lumbar and sacral nerves. The most important among the spinal nerves is the Phrenic from the fourth cervical nerve which runs backwards and supplies the Diaphragm.

Sympathetic System :

The sympathetic system consists of two cords with two ganglia on each side in the neck, twelve pairs of ganglia in the thorax and twelve pairs in the abdomen. From the hinder thoracic ganglion there starts a splanchnic nerve which runs backwards in the abdomen and ends with its fellow forming Coeliac ganglia round the anterior mesenteric artery. This ganglion having a number of nerves uniting and branching from it constitute the Solar Plexus. A smaller plexus lies around the Posterior Mesenteric artery.

Sense Organs :

The organs of sense in the Guineapig consists of the eyes, ears, tongue, nose and touch.

Eyes :

There are two eyes the structure of which generally resembles that of the Toad except that the Guineapig has the additional Lachrymal or Tear glands. These are situated above the outer corner of each eye as well as the Harderian glands which are similarly situated. The secretion of these glands trickles over the conjunctiva and then passes into the nose by the nasal duct at the inner angle of each eye.

Ears :

The Ear of the Guineapig is its organ of hearing. It has three parts *e.g.*, the External ear, the Middle ear and the Internal ear.

The External ear has the Pinna which is meant for catching the vibrations of sound and is extended by a canal up to the drum or tympanic membrane.

Internal to the membrane and extending up to the bony labyrinth is another cavity called the Middle ear or Tympanic cavity. This cavity communicates with the Pharynx by a tube called the Eustachian tube. Three pieces of small bones are found in the middle ear called the Malleus, Incus and Stapes which are connected to each other and extend from the drum to the Fenestra ovalis of the bony labyrinth. They conduct the vibrations of sound from the external ear to the internal ear.

The Internal Ear consists of the bony Labyrinth with two openings called Fenestra Ovalis and Fenestra Rotunda both of which are covered by membranes. The bony labyrinth contains within it a membranous labyrinth. The bony labyrinth is filled with fluid called Perilymph which lies outside the membranous labyrinth but there is fluid also inside the membranous labyrinth which is called the Endolymph. The membranous labyrinth consists of the utricle with three semicircular canals and a saccule which is connected with the bony Cochlea. The Cochlea has spiral turns like a conch. This cochlea has the Endings of those fibres of the Auditory nerve which subserve the sense of hearing.

Organ of Taste :

The tongue, although a muscular structure, serves as the organ of taste. There are special cells called Taste-buds found on the surface of the tongue and also a few on the palate which are the endings of special nerve and perform the function of taste of the animal.

The Nose :

The epithelium of the nostrils is endowed with special nerve endings of the Olfactory nerve which serve as the organ of smell.

The Sense of Touch :

This sense is developed on the skin due to the presence of Touch Corpuscles which are specialised structures containing ramified special Nerve Endings. The sense of touch is specially developed on the pad of the foot and on the skin of the lips in the Guineapig.

Skeleton :

The skeleton of the Guineapig consists of bones distributed through out the body and are meant for the support of the soft structures.

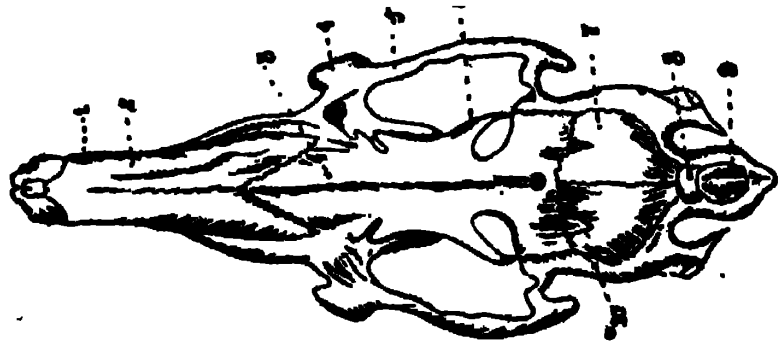
There is a bony case for the Brain which is called the skull or cranium formed of a number of bones. There is an aperture in the skull situated below and posteriorly. At the dorsal part of the animal is a column of small pieces of bone are called the Vertebrae. There are two girdles round the body of which one gives attachment to the forelimb and is known as the Pectoral girdle. The other girdle which gives attachment to the hind-limb is called the Pelvic girdle. Both the forelimb and the hind-limb are formed of a number of bones.

Skull or Cranium :

The skull at the posterior part consists of four bones which in the adult become completely fused with one another. The lowermost of these is the Basioccipital bone bounding the foramen magnum and forming the posterior or hinder part of the base of the skull. It has on the lower part two occipital condyles one on each side. The two ex-occipitals are found on the two sides of the foramen magnum. Each ex-occipital has a downwardly directed process called the Paroccipital process closely adhering to the swelling in front called the Tympanic Bulla. The Supra-occipital bone is placed above the foramen magnum. The middle segment of the skull consists of a bone at the floor of the skull called the Basisphenoid which is visible on the ventral side. On the two sides are the two Alisphenoids and on the dorsal side are the two Parietals. The Alisphenoid is produced ventrally into a Pterygoid process.

Skull-Dorsal view.

- 1—Premaxilla,
- 2—Nasal,
- 3—Frontal,
- 4—Zygomaticarch,
- 5—Jugal,
- 6—Process,
- 7—Parietal,
- 8—Interparietal,
- 9—Supraoccipital,
- 10—Squamosal.



Dorsally between the two Parietals is a small bone called the Inter-parietal. On the front are the two frontals and the two nasals.

The Pterotic bone lies in front of the ex-occipital. It has a swelling below called the Tympanic Bulla. Above and in front of it is the narrow squamosal. The

squamosal articulates with the Frontal and Parietal and in front forms an arch called the Zygomatic arch.

On the ventral side is the Basisphenoid with Presphenoid in front. Anterior to the Presphenoid are the Vomers. Then come the Palatines. In front of the Palatines are the Maxilla and the Pre-maxilla.

Teeth :

The Guineapig has a number of teeth borne both on the upper and the lower jaw bones. They are ten in number altogether arranged thus :—

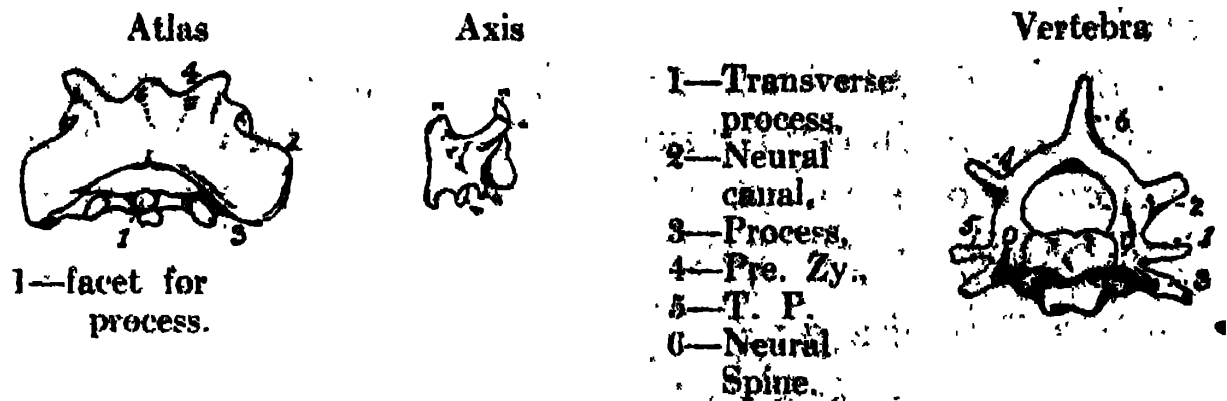
On the upper jaw the two incisors are borne on each side of the bone. There being no canine there is a gap for its absence called the Diastema. Then the Maxilla bears one Premolar and three Molars on each side. The lower jaw or Mandible consists of two pieces called the Rami which are united in front by the symphysis. The upper or Alveolar border bears the teeth; posteriorly the process is called the Coronoid process. Behind it is the Condyle which fits into the Glenoid fossa. Below the condyle is the Angle. The dental formula of the Guineapig therefore is :—

$$I \frac{1}{1} \quad C \frac{0}{0} \quad Pm \frac{1}{1} \quad M \frac{3}{3}$$

The Vertebral Column :

The vertebral column is formed of a number of vertebrae which are named according to the region of the body as Cervical, Thoracic, Lumbar, Sacral and Caudal. Each Vertebra has a solid base called the Centrum. Each vertebra is separated from the other by an intervertebral cartilage except where the vertebrae have fused together. A typical vertebra has the following structure :—

There is a solid base called the centrum. Two arches rise from the Centrum and are called the Neural arches. There is a process above the vertebra at the dorsal side which is called the Neural spine. And the cavity of the vertebra is called the Neural canal. Two processes project from the sides of the centrum and are called the



Transverse processes. The vertebra has a flat process one on each side from the anterior part of the neural arch and are called the Prezygapophysis. They project upwards. On the posterior part from the neural arch there are two similar downwardly projecting surfaces called the Post-zygapophysis. The Pre- and Post-zygapophysis keep the vertebral column in position, i.e., the post-zygapophysis of one vertebra articulates with the Pre-zygapophysis of the next vertebra.

Cervical Vertebrae :

These are seven in number, their spinous processes are short. The first vertebra is called the Atlas. There is no centrum in it. On the front part of this vertebra there are two concave articular surfaces for articulation with the condyles of the skull. The second cervical vertebra is known as the Axis. The centrum of this vertebra is produced anteriorly into a process called the

Odontoid process which goes inside the neural canal and articulates with the first cervical vertebra. The other cervical vertebræ have the typical structure.

Thoracic Vertebrae :

These are twelve or thirteen in number. These vertebræ are characterised by bearing ribs from their sides. The neural spines are tall and transverse processes are short. Each of the first nine vertebræ is provided with a pit on the under surface for the articulation with the tubercle of a rib. The hinder vertebræ become gradually like those of the lumbar region.

Lumbar Vertebrae :

These are six or seven in number and are characterised by their larger size and bigger processes. They have no ribs.

Sacral Vertebrae :

These are three in number and are all fused together to form the sacrum which gives support to the pelvic girdle.

Caudal Vertebrae :

These are seven in number. They become smaller downwards and the last portion degenerates into a rod.

Ribs and Sternum :

There are 12 or 13 pairs of ribs. The ribs are curved bony rods articulated with the vertebræ at the back and the first nine pairs are connected with the breast bone called the Sternum.

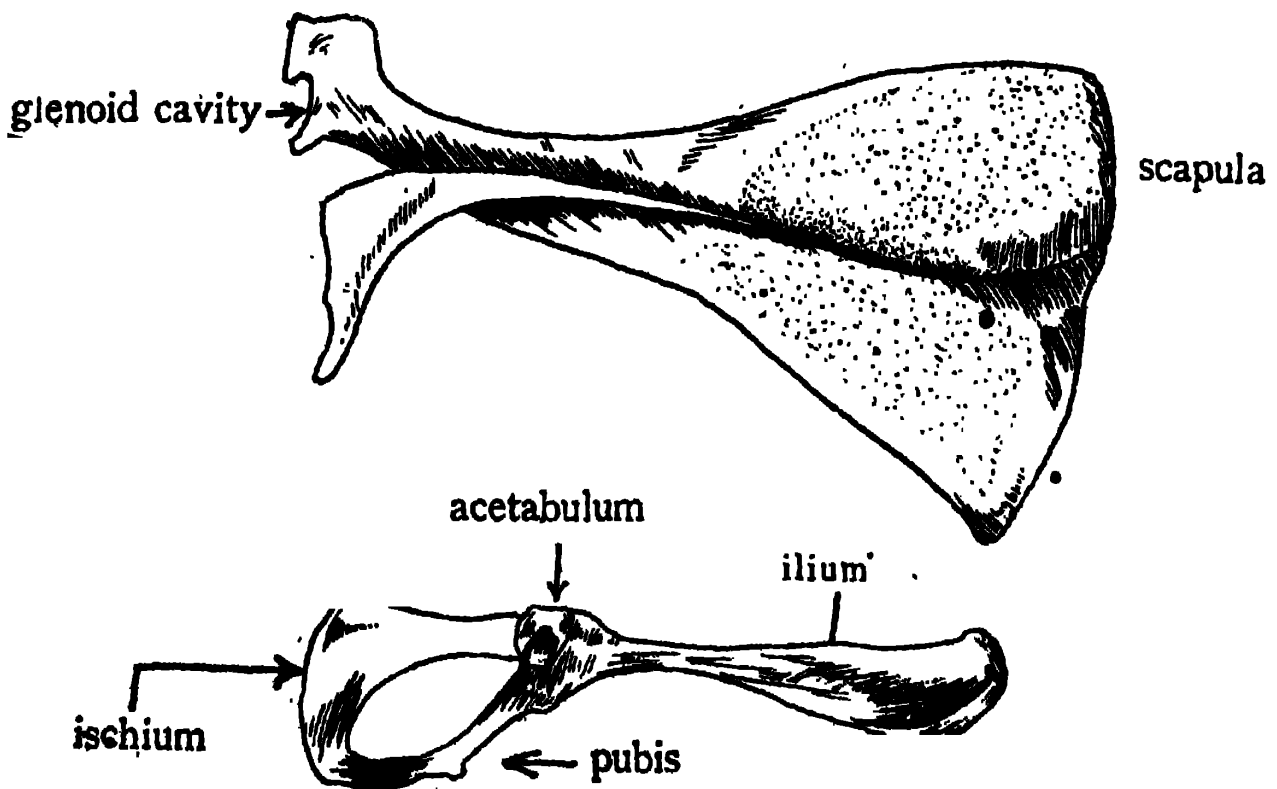
The portion of the rib connected with the sternum is called the sternal portion of the rib. The end which

is connected with the vertebra is called the head or capitulum and there is a second articulation with the transverse process called the tuberculum. The first seven ribs are directly connected with the sternum while the 8th and 9th ribs are connected with the rib in front of them.

The breast bone is called the sternum. It has an upper portion called the manubrium. Next to it, 2 or 3 small pieces and finally the xiphoid process bearing the Xiphoid cartilage.

Pectoral Girdle :

The shoulder girdle practically consists of one bone called the Scapula. This is a flat triangular bone with the apex downwards. It bears a prominent external ridge called the spine which at its lower end becomes free as



Pectoral and pelvic girdles:

an acromion with a long backward metacromion. At the apex, is the cavity for the humerus called the glenoid cavity. There is a small process in front of the cavity called the coracoid process.

The clavicle or collar bone is a long, slender, curved bone between the acromion and the sternum.

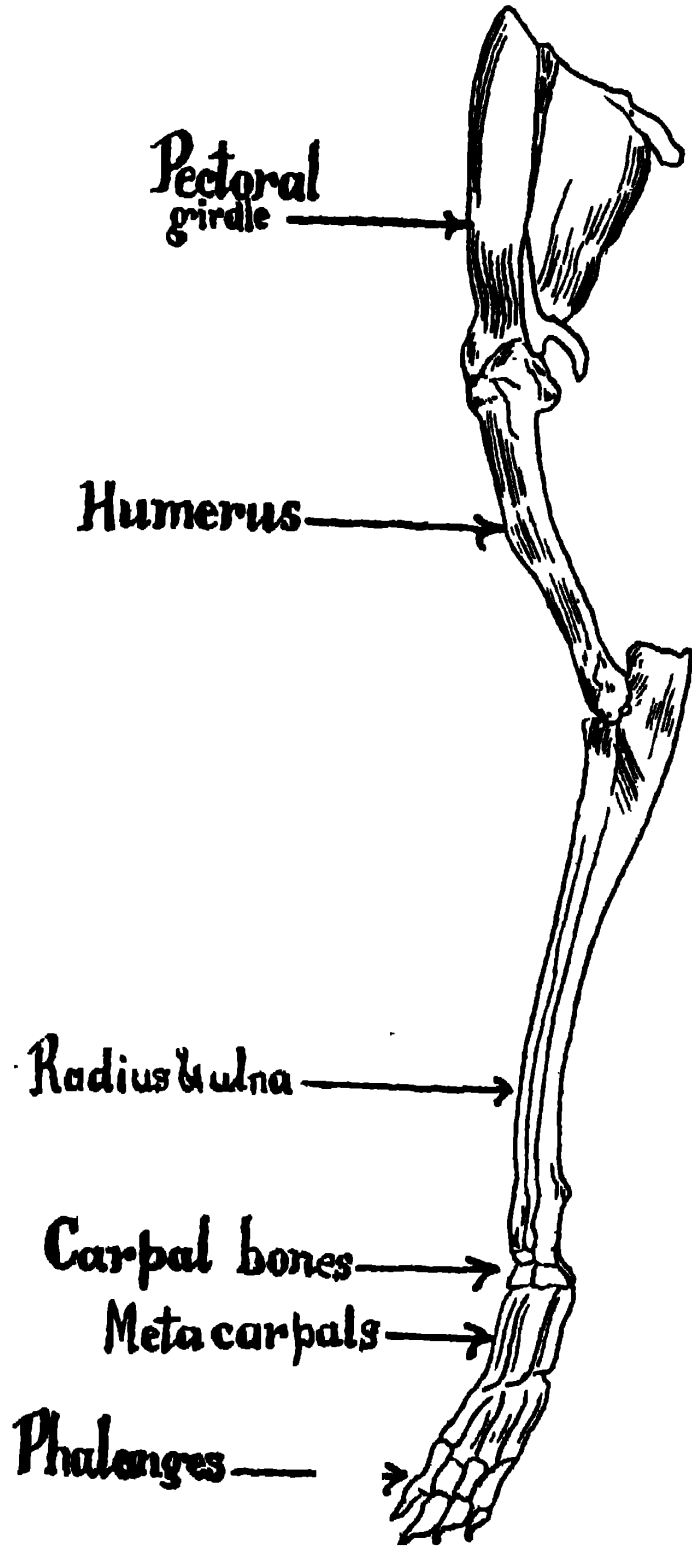
Pelvic Girdle :

The hip girdle consists of two halves, each of which is known as *Os innominatum*. It forms a ring with the sacrum called the pelvis. Each *Os innominatum* consists of a dorsal ilium articulated with the sacrum, a posterior ischium and an anterior pubis. The two pubic bones combine to form the pubic symphysis. The ischium and the pubis are separated by a foramen on each side in front called the obturator foramen. There are two cavities on the two sides called acetabulum for the articulation of the hindlimb.

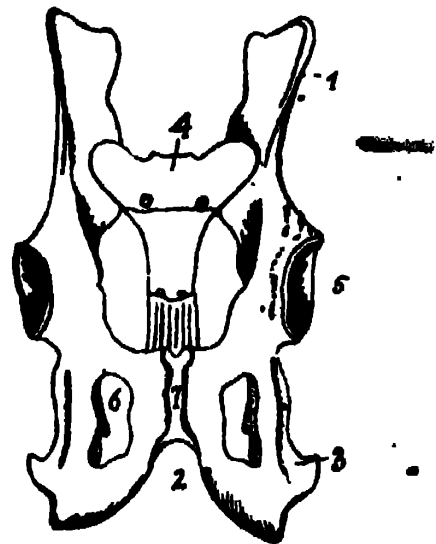
Forelimb :

The first bone which is articulated with the glenoid cavity is the humerus. It has a large head and separated by grooves are two processes, the first one is the greater tuberosity and the inner one is the lesser tuberosity. At the lower end is a pulley-like trochlea, above which are two supratrochlear fossæ, the coronoid fossa in front and the olecranon fossa behind. Next, the two fore-arm bones are the radius and the ulna. The radius lies in front of the ulna. These two bones articulate with the trochlear surface. The ulna has a notch called the sigmoid notch and a process called the olecranon process. Then follows the wrist with seven carpal bones arranged in two rows. The proximal row consists of three bones called the

scaphoid on the inner side, the semilunar and the cunei-
form on the outer side.



Pelvic girdle.



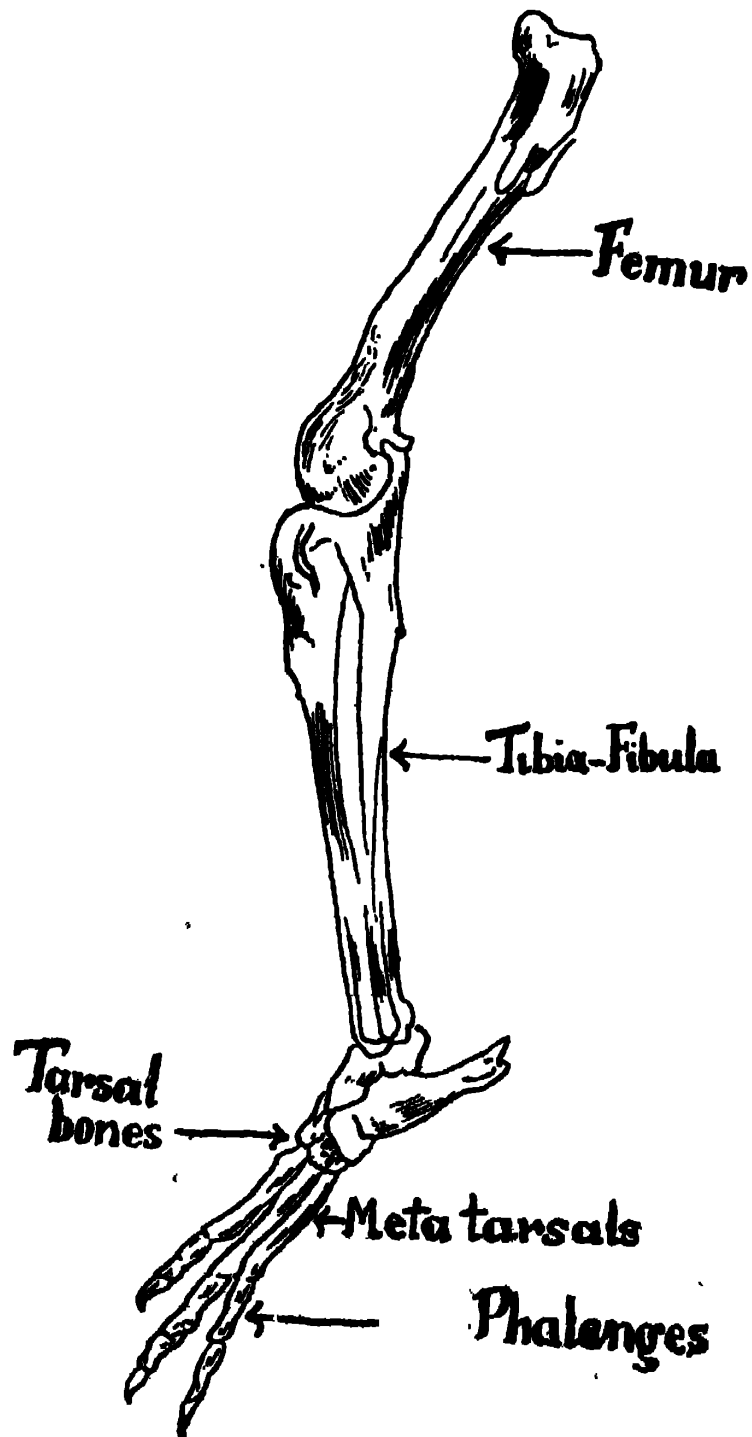
- 1—Ilium, 2—Pubic, Sym
- 3—Ischium, 4—Sacrum,
- 5—Acetabulum,
- 6—Obturator foramen..

The distal row consists of unciform, carpale and the pisiform bones. There is another bone between the two

rows. Then follow the four metacarpal bones bearing the four digits, with three phalanges in each. Each digit is clawed.

Hindlimbs :

The acetabulum gives attachment to the longest Hindlimb.



bone of the body, the hip-bone or the Femur. It has a large head, below which are the three prominences, the greater trochanter on the outside, the lesser trochanter on the inner side and the third trochanter below the great trochanter. At the lower end of the femur are the two large condyles for the tibia. A knee-cap or patella covers the knee-joint and is connected by ligament with the tibia. The tibia and the fibula are the next two bones which are fused at the lower part. The fibula is a feeble bone by the side of the tibia. The tibia is a stout bone and bears the cnemial crest in front. The ankle like the wrist has got 6 bones arranged in two rows. The first row forms the heel and consists of two bones called the calcaneum on the outer side meeting the fibula and the astragalus on the inner side meeting the tibia. There is a central bone called the navicular. The distal row consists of three bones. There are three metatarsals bearing the three digits which are clawed. Each digit has three phalanges.