WELCOME

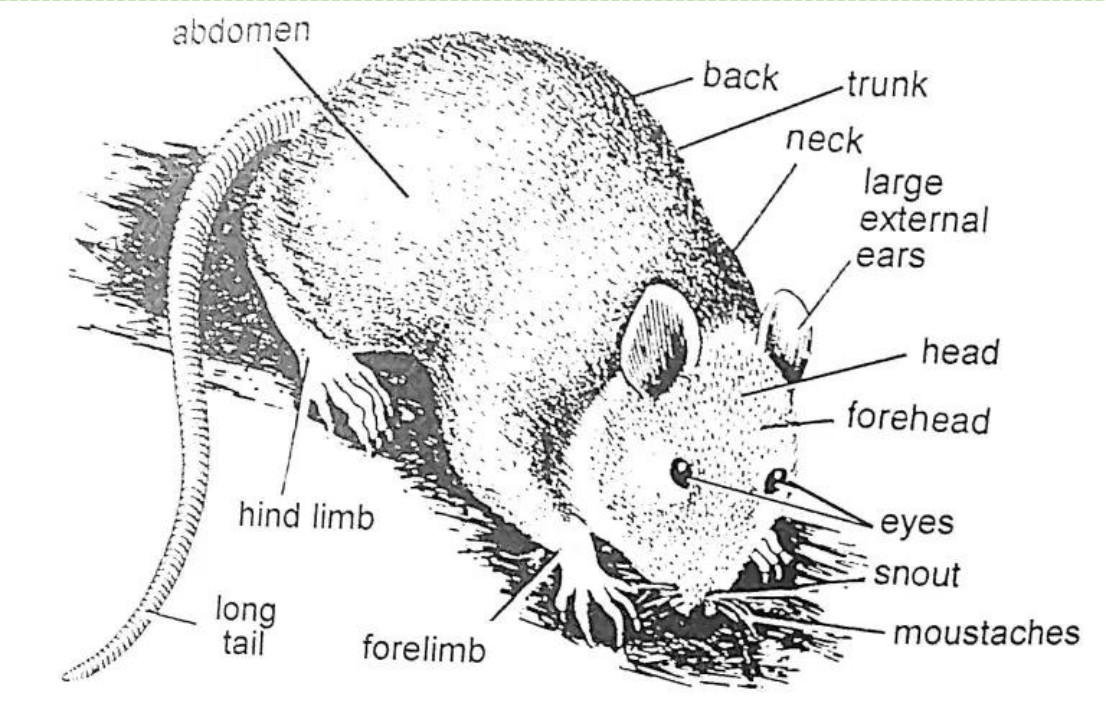
STUDY OF RAT

Prof. Dr. Balasaheb Tapale
Department of Zoology
Adv. M. N. Deshmukh College, Rajur, Tal-Akole. Dist.-Ahmednagar. (MS)
PIN - 422 604
Contact: 7350528733
E-Mail- dr.balasahebtapale@gmail.com

UNIT – 4
STUDY OF RAT

Systematic Position

Phylum	:	Chordata
Sub-phylum	:	Vertebrata
Superclass	:	Gnathostomata
Grade	:	Tetrapoda
Class	:	Mammalia
Sub-class	:	Theria
Infraclass	:	Eutheria
Order	:	Rodentia
Family	:	Muridae
Genus	:	*Rattus*
Species	:	*rattus* (Black rat)



Habit and Habitat:

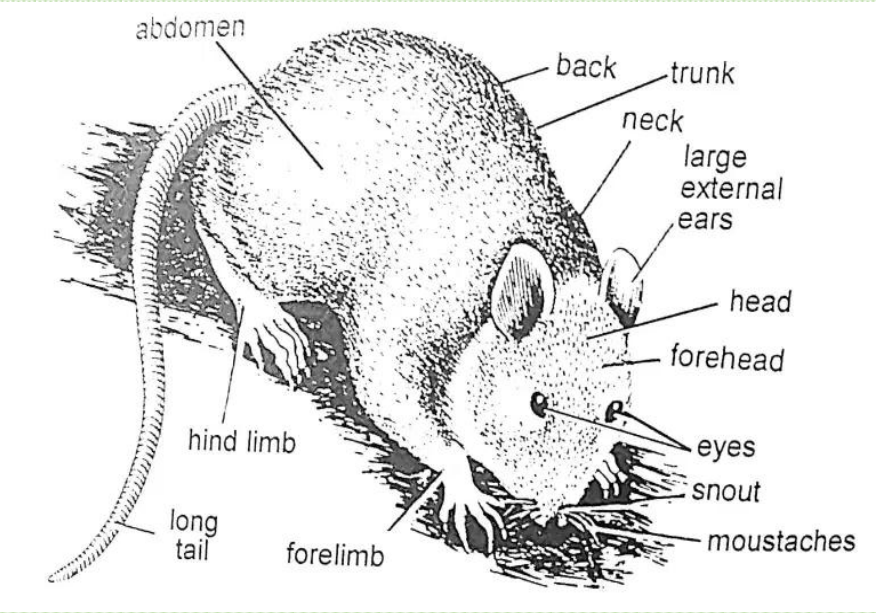
- The common house Rats are cosmopolitan in distribution and found all over the world.
- They are herbivorous, fossorial and nocturnal.
- They also undergoes hibernation.
- They shows sexual dimorphism. Male is larger than female.
- Fertilization is internal.
- The time between fertilization and birth is 22 to 23 days.
- The rat breeds more than 4 times in a year and producing 6 to 8 young ones per litter.
- Newly born young ones are blind, deaf and without hairs.
- Young ones are feed by mother of her milk.
- The average age of rat is 3 years.

External Characters:

- The body of Rat is divisible into head, neck, trunk and tail.
- Most of the body is covered by dense hairs of definite colour.
- The trunk region bears anteriorly pair of fore limbs and posteriorly pair of hind limbs.

1. Head:

- The head is conical in shape, broader at posterior end and narrow towards the anterior end.
- The narrow pointed end of the head forms the snout which bears at the tip of oblique slits called external nostrils or nares.
- Below the nostrils a narrow mouth opening is present bounded by upper and lower lips.
- On the either sides of snout, stiff and bristle like long hairs are present called vibrissae.
- These vibrissae are tactile in function. Depending on the position, the vibrissae are called mystical, superciliary, genal and submental.
- The eyes are situated on the postero-lateral surface of the head. Each eye is protected by movable upper and lower eyelids. Eyelids are bordered with very fine short hairs called eye lashes.
- Besides the eyelids, the nictitating membrane is also present
- A pair of rounded external ears or pinnae is present. Each pinna is large, muscular elastic and can moved in the direction of sound.



2. The Neck:

- It is short and narrow part of the body which lies between the head and the trunk.
- It allows free movements of head in all directions.

3. The Trunk:

- It is a broad and elongated part forming major portion of the body.
- The trunk is divisible into two parts, anterior thorax and posterior abdomen.
- The thorax is enclosed in a framework of bony skeleton formed by a back bone on the dorsal side, ribs on the lateral side and breast bone on the ventral side.
- The thoracic cavity lodges the heart and lungs.
- The ribs protect the heart and lungs from external shocks.
- The abdomen lies behind the thorax and the abdominal cavity remains separate from the thoracic cavity by a thick muscular partition called diaphragm.
- In the female rat, the ventral surface of the trunk possess six pairs of teats or mammae, three pairs on thoracic region and three pairs on abdominal region.
- In case of male rats, teats are undeveloped.

Limbs: The trunk bears two pairs of limbs.

- The anterior pair is called fore limbs and the posterior limb is called hind limbs.
- The fore limbs are shorter than the hind limb.

Fore Limbs:

- The fore limbs shows three segments namely, the upper arm or brachium, the fore arm or anti brachium and the hand or manus.
- The hand bears five fingers, each except the thumb or pollex ending in a curved pointed horny claw.
- The inner fingers are very much reduced with nails.
- The palm on its ventral surface is lacking hairs put with the cushion like muscular pads using for walking.

Hind Limbs:

- The hind limb also shows three segments, the upper one thigh, the middle shank or crus and lower is foot or pes. There are five toes to each foot and all ending in curved pointed claws.
- The hallux or first toe is very much shorter than other four toes.
- The limbs are locomotory in function and also useful in digging and burrowing.

Sexual Dimorphism:

- Scrotal sacs are present in male and absent in female.
- In male, common urinogenital opening is present at the tip of penis. In female, urinary and genital openings are separate.
- Teats or mammae are absent in male but in female, there are six pairs of teats.
- In male, the anus lies below the scrotal sacs at the base of tail and in female, the anus lies at the base of tail.

4. The Tail:

- The tail is longer than the trunk. It is cylindrical and gradually tapers towards the hind end.
- The tail is covered by overlapping epidermal scales and hairs arranged in rings.
- There are about 210 such rings on the tail. The tail is used as a balancing organ.

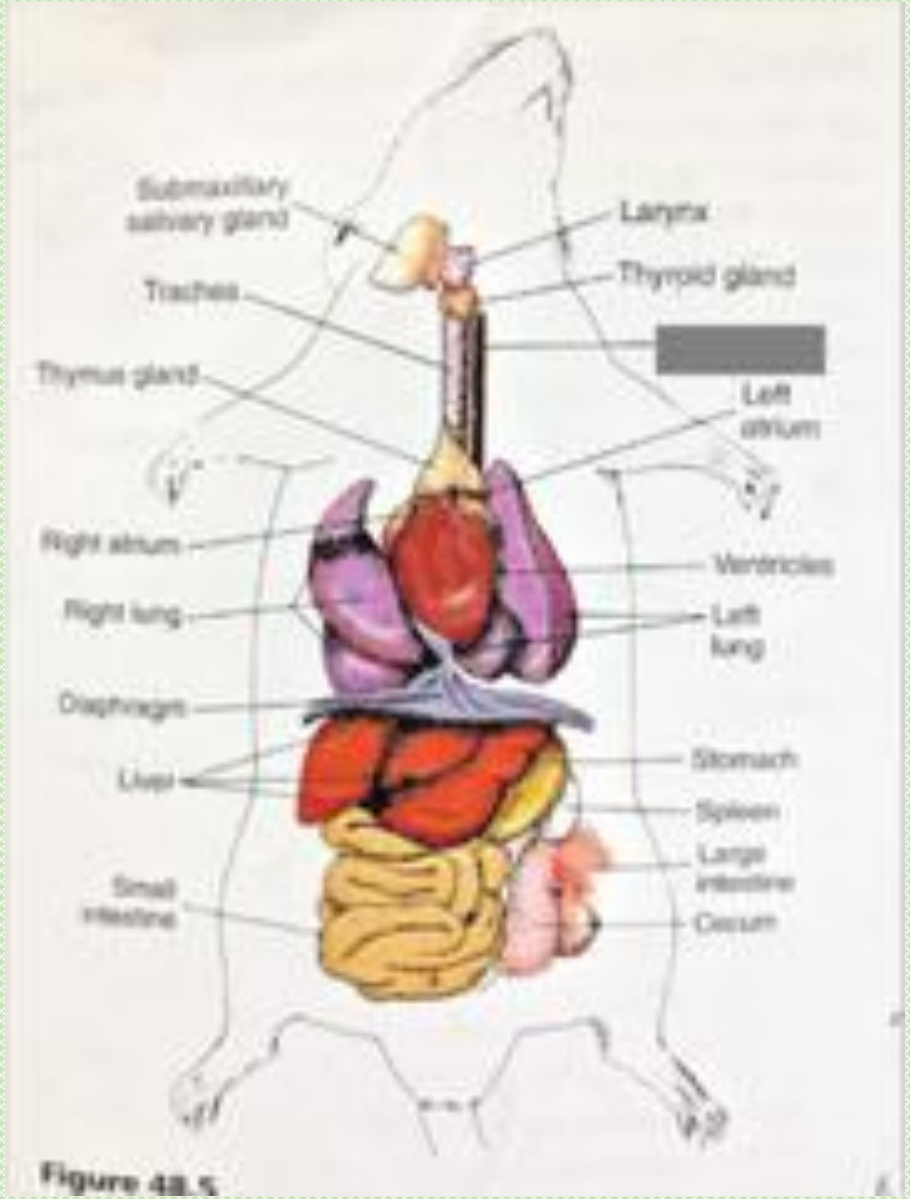
DIGESTIVE SYSTEM:

A. The alimentary canal is consists of following parts

a. Mouth
b. Buccal cavity
c. Pharynx
d. Oesophagus
e. Stomach
f. Small Intestine (Duodenum and Ileum)
g. Large Intestine (Colon and Rectum)
h. Anus

B. Digestive Glands

a. Salivary gland
b. Liver
c. Pancreas


Submaxillary salivary gland
Trachea
Thymus gland
Right atrium
Right lung
Diaphragm
Liver
Small intestine
Larynx
Thyroid gland
Left atrium
Ventricles
Left lung
Stomach
Spleen
Large intestine
Cecum
Figure 48.5

1. Mouth:

- The mouth is the transverse slit like opening at the end of pointed snout.
- It is bounded by upper and lower lips as well as upper and lower jaws.
- Mouth opens into the wide cavity, the mouth or buccal cavity.

2. Mouth Cavity:

- The mouth cavity is the space between mouth and pharynx enclosed by lips.
- It is spacious cavity bounded by upper immovable and lower movable jaws.
- The anterior part of the mouth cavity lying between the teeth and lips is called vestibule while posterior cavity is called the median oral cavity.
- The roof of the mouth cavity is called as palate.
- It possesses numerous palatine glands which secrete mucous to moisten the buccal cavity.
- The surface of hard palate possesses several transverse palatal ridges which prevent the escape of food from mouth cavity.

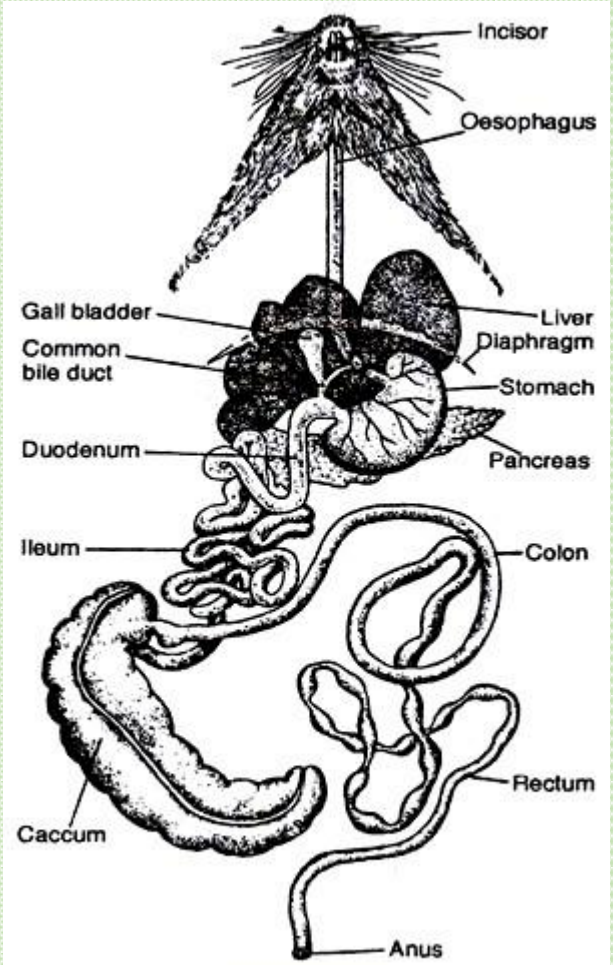


Fig. 1.143 : Digestive system of *Rattus*

Tongue:

- The floor of buccal cavity is occupied by the tongue, a flat, fleshy muscular organ.
- The tongue is free at the anterior end while posterior end is fixed or attached.
- Tongue performs several functions in the mouth cavity such as placing the food below the teeth, cleaning of teeth, prevents the inhalation of dust while gnawing, tasting the food, mixing the food with saliva and swallowing the morsel of food by pushing into the gullet.
- The tongue is containing small elevations or taste papillae are as fungiform, foliate and circumvallate.
- Taste buds taste the chemical nature of the food.
- Mucous glands are also present, there secretion helps in lubricating the food.

Teeth:

- The teeth are present on the both jaws are called as thecodont i.e., they are lodged in the sockets of jaw bones.
- The teeth are also called as heterodont. They vary in shape and size.
- The teeth are of two types as incisors and molars.
- The incisors are useful for cutting the food into small pieces and molars for crushing and grinding the food.
- In rat teeth are monophyodont i.e., there are no milk teeth.

Structure of Teeth:

- A tooth has two parts, crown and root.
- Crown is the visible part and the root remains embedded in a socket on the jaws.
- The tooth is made up of a substance called dentine.
- The dentine of the root region remains covered by cement while the crown region of the tooth remains covered by hard and shiny enamel.
- Each tooth bears an inner pulp cavity. This cavity remains filled up with jelly-like pulp, blood vessels and nerves.

2. Pharynx:

- It is the posterior narrow part of the mouth cavity.
- It is the common chamber for both respiratory and digestive system.
- Posteriorly pharynx is communicated with oesophagus and trachea.
- The pharynx consists of three areas, nasopharynx lying above the soft palate, oropharynx lying below the soft palate and the laryngopharynx the region between the soft palate and the oesophagus.
- The trachea or windpipe opens on the ventral side of pharynx by slit like opening called glottis which is guarded by leaf like muscular structure called epiglottis.
- It prevents falling of food particles during swallowing.

3. Oesophagus:

- It is long, narrow, dilatable straight tube leading from the pharynx through the neck and thorax to abdomen and joins to the stomach.
- It starts at the gullet and lies dorsal to the heart in thoracic region.
- The oesophagus is muscular tube and the lumen is reduced due to foldings of mucous membrane of stratified squamous epithelium.
- It contains mucous glands in submucosa which secrete mucous as food lubricant.
- The wall of oesophagus produce undulating movements called peristalsis.
- It pushes bolus towards the stomach.

4. Stomach:

- It is wide curved part of alimentary canal which lies on the left side behind the diaphragm.
- It has a greater curvature on left side, a lesser curvature on right side.
- The end of stomach towards the oesophagus is called the cardiac end and its opposite end is called pyloric end.
- Due to twisting, the cardiac end has taken a position towards the left and the pyloric end has taken a position towards the right in the abdominal cavity.
- The opening at the pyloric end is guarded by a valve called pyloric sphincter.
- It opens into duodenum. Stomach contains goblet cells for mucus, oxyntic cells for HCL and peptic cells for secretion of pepsinogen.

5. Small Intestine:

- Stomach leads into small intestine, which can be differentiated into three parts duodenum (U - shaped), jejunum (straight) and ileum (coiled).
- The duodenum begins from the pyloric end of the stomach and forms a “U” shaped loop.
- Ileum is much coiled continuation of the duodenum.
- The coiled loops of the ileum are held in position by folds of mesenteries.
- Ileum opens into the large intestine and the opening is guarded by an ileocolic valve.
- Digestive glands of small intestine secrete intestinal juice or succus entericus.
- The same contain lipase, nuclease, peptidase, lactase, sucrase and maltase enzymes.

6. Large Intestine:

- It has three parts as caecum, colon and rectum.
- Caecum is slightly constricted about its middle.
- The constriction sub divides the caecum into two parts, the apical and basal portion.
- The apical portion contains a distinct mass of lymphoid tissue forming the vermiform appendix.
- Caecum opens into the first part of large intestine, the colon which is divisible into an ascending, a transverse and a descending colon leads into rectum.

7. Anus:

- The terminal part of the alimentary canal is represented by an aperture called anus.
- Rectum leads into the anus which is guarded by sphincter muscle.

B. DIGESTIVE GLANDS:

1. Salivary Glands:

- The salivary glands of the rat include three major paired and several minor glands. These major glands are Sublingual glands, submandibular glands and parotid glands.
- All the glands have separate openings into the buccal cavity through ducts.
- The secretion of the salivary glands is known as saliva.
- Saliva helps in moistening food and contains an enzyme called ptyalin.

2. Liver:

- It is the largest gland of the body which is located in the upper and right side of the abdominal cavity below the diaphragm.
- The liver of rat consists of four lobes left, middle, right and caudate.
- The cells of liver are called hepatocytes which secrete bile.
- The rat has no gallbladder. Bile from the rat liver flows directly through the bile duct into the duodenum of small intestine.
- Bile contains no digestive enzymes but helps in maintain alkaline PH and emulsification of fats.

3. Pancreas:

- It is a diffused structure and is present between the duodenal loops.
- It secretes pancreatic juice which contains digestive enzymes such as trypsinogen (proenzyme), amylopsin and lipase.
- The juice is carried to the distal part of the duo-denum by a pancreatic duct.
- Islets of Langerhans of the pancreas secrete certain hormones such as insulin.
- Insulin converts glucose into glycogen in the liver and muscles.

4. Gastric Glands:

These are found in stomach and secrete gastric juice containing digestive enzymes like pepsin and HCL which help in digestion of food.

5. Intestinal Glands:

These are present in the small intestine and secrete intestinal juice containing digestive enzymes like maltase, sucrase and lipase which help in digestion of food.

Food and Feeding:

- Rats are excellent foragers. They eat almost anything from discarded human food, trash, grains, nuts, fruits, birds, leaves, mammals, fish, eggs, human infants and small lizards.
- They use their excellent sense of smell, hearing, touch and sight to hunt.
- Eyesight is not great, but the sense of smell is amazing. They use sharp incisors to grab the prey.
- Food is mashed up in mouth and mixed with saliva to break down starches.
- Then it travels down the oesophagus to the stomach.
- It is further digested with gastric juices which break the bonds holding cells together and kills bacteria.
- In small intestine, nutrients are absorbed from the food and cellulose is digested in the caecum.
- Remaining undigested material expelled from the anus.

RESPIRATORY SYSTEM

The respiratory system is studied under respiratory tract and respiratory organs.

A. Respiratory Tract:

It includes external nares, nasal chamber, internal nares, pharynx, larynx, trachea, bronchi and bronchioles.

External Nares: These are a pair of oval slits under the snout. They lead into the nasal chambers.

Nasal Chambers: The external nares open into nasal passage having olfactory epithelium and respiratory epithelium. It helps in holding up dust particles. It also moistens the air due to mucous secreting cells. Olfactory cells help in sensing smell.

Internal Nares: The nasal passage opens behind into the pharynx by a common aperture called the internal nares.

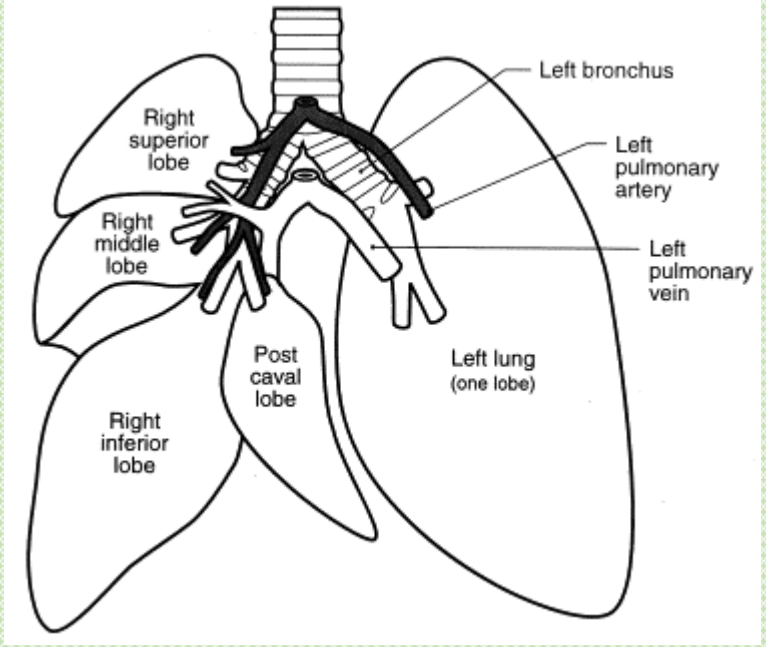
Pharynx: The pharynx is the cavity behind the nasal cavity. It is common passage for food and air. Its upper part, which receives the internal naris is called nasopharynx and its lower part behind the buccal cavity called oropharynx. It connects the nostrils to the trachea, and air passes through it when the rat breathes. A cartilagenous flap, epiglottis is present the anterior end. It closes the glottis during swallowing of food. Glottis leads into larynx.

Larynx: Larynx or voice box is the modified anterior part of trachea. Rats, unlike most other mammals, can use their larynx for two modes of functioning. The first, which causes vocal folds to fibrate, makes sound that humans can hear. The other use of the larynx is to produce ultrasonic sounds, which they use for communications. The larynx continues into trachea.

Trachea: The trachea or windpipe is a long tube that connects the nostrils and pharynx to the lungs. It runs through the neck ventral to oesophagus. It is supported by C-shaped incomplete rings of elastic cartilage. Air passes through this tube when the rat breathes to get from the environment to the gas exchange site. On entering the thorax, it is divided into two branches, the primary bronchi. The primary bronchi enter the corresponding lungs. The primary bronchus divides into secondary and tertiary bronchi inside the lungs. Tertiary bronchii further divide into respiratory bronchioles. The bronchioles divide into fine ducts called alveolar duct which open into small sacs known as alveolar sacs. Each sac is formed by cells called alveoli richly supplied with blood capillaries. The alveoli are the sites of exchange of gasses.

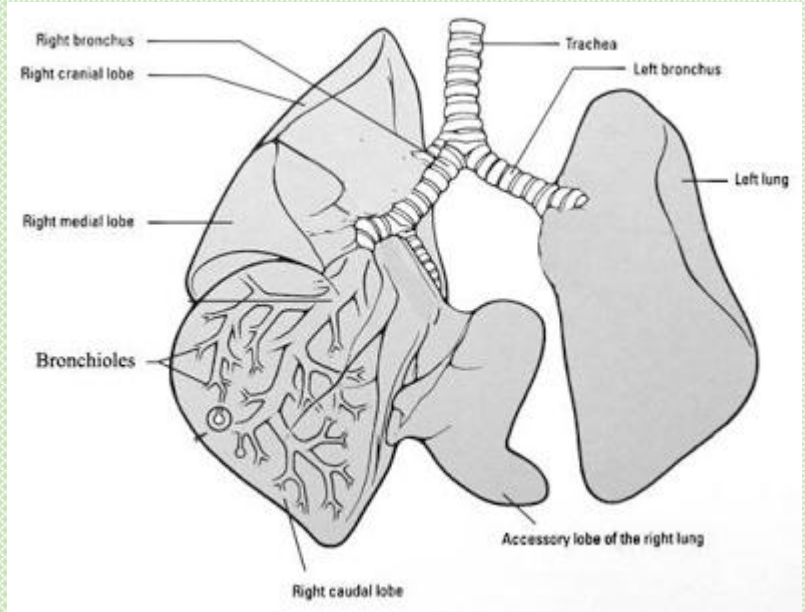
Respiratory Organ:

- **Lungs:** It is main respiratory organs, which is a pair of lungs situated on the sides of thoracic cavity. The right lung has four lobes and the left lung has one lobe. The lungs are sacs that fill with air and contain alveoli. The alveoli exchanges gases with the air held in the lungs. Each lung is enclosed a double walled membrane called pleura. The space between two pleural membrane is called pleural cavity filled with pleural fluid. Inside each lung, bronchioles divide and redivide and finally terminate into alveoli. The presence of numerous alveoli makes lungs spongy.
- **Diaphragm:** It helps to move the lungs as the rat breaths and they fill with air. It moves up and down as the lungs expand and contract.



Gaseous Exchange:

- Rats exchange gases through the alveoli in their lungs. Alveoli are tiny air sacs in the lungs that allow for rapid gas exchange.
- They absorb the gases that the rat needs, such as oxygen, into the rats body and circulatory system.



- Then they get rid of the gases that the rat doesn't need, such as nitrogen and carbon dioxide, by sending them back out into the environment when the rat exhales.
- Rat inhale through their nostrils.
- The air then brought through the pharynx and trachea to get the lungs.
- The lungs are lined with alveoli, which help the rat to absorb the oxygen it needs.
- Oxygen is then put into the circulatory system to transport it around the rats body.
- As the rat breaths, the diaphragm helps to move the lungs in and out allowing them to fill with air and push air back out again.
- Oxygen is transported through out the rats body using the circulatory system.
- Oxygen is transferred through small capillaries in the walls of alveoli.
- Blood also contains oxygen binding protein called haemoglobin.
- Haemoglobin transports the oxygen through bloodstream.

Blood Vascular System – Structure of Heart:

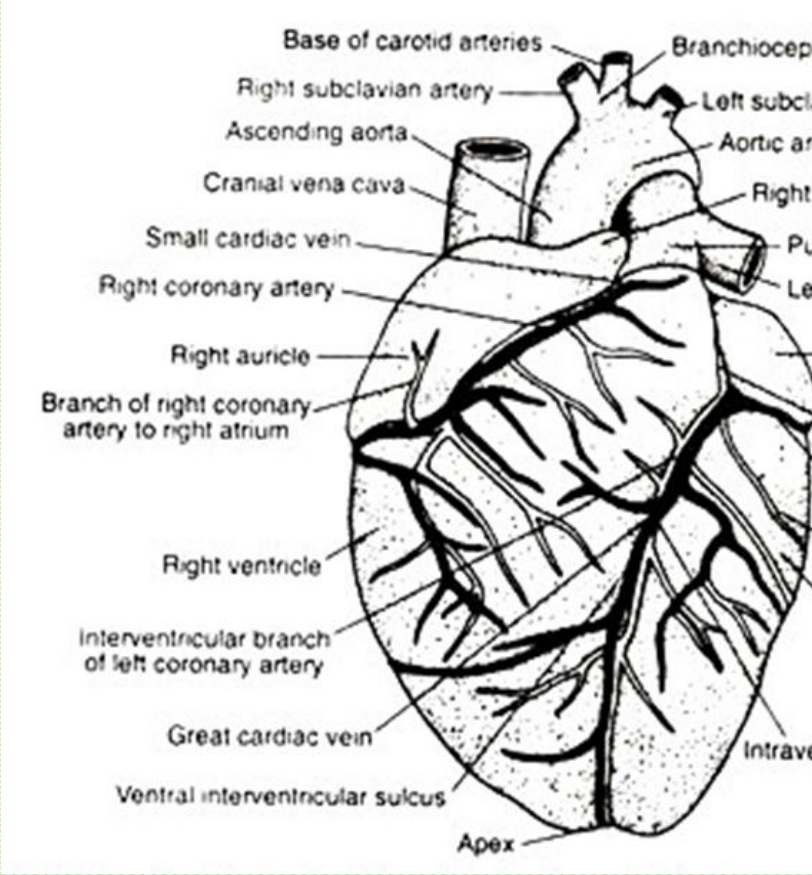
- The circulatory system of rat greatly resembles the circulatory system of humans and mammals.
- The circulatory system is responsible for circulating blood and nutrients throughout the body.
- The circulatory system consists of heart, blood and blood vessels.
- The function of the blood vessels is to transport blood and nutrients throughout the body.

Blood:

- Blood consists of liquid plasma and many corpuscles floating in the plasma.
- The plasma is a pale yellow fluid and contains various inorganic salts, vitamins and hormones.
- There are three types of blood corpuscles.
- They are erythrocytes, leucocytes and thrombocytes.
- Erythrocytes (RBCs) red blood cells are round and biconcave.
- Mature erythrocytes are non-nucleated and contain a red pigment called haemoglobin. Haemoglobin gives red colour to the blood. It has strong but loose affinity for oxygen.
- The red blood corpuscles carry oxygen to different parts of the body and carry back carbon dioxide from different parts of the body to the lungs through the heart.
- Leucocytes (WBCs) or white blood corpuscles are larger than RBC and their number is much less than RBC.
- The leucocytes are of different types and their classification is dependent upon the structure of nucleus and stainability of the cytoplasmic granules.
- These cells move in amoeboid fashion and act as scavengers of the body.
- Thrombocytes or blood platelets are small and non-nucleated. They occur in groups.
- In case of injury these cells break down and produce an enzyme which coagulates the blood and thereby prevents loss of blood.

Heart:

- The heart is a muscular, internally hollow, four chambered and cone shaped structure that occupies most of the thoracic cavity.
- It lies roughly in the midline of the cavity with its base located cranially and the apex caudally.
- The heart is located in a space within the thorax between the two pleural bags.
- The space is known as mediastinum.
- The heart is covered over by a thin peritoneal membrane called pericardium.
- Pericardium is two layered. The outer layer is known as fibrous pericardium and inner layer is called serous pericardium.
- The serous pericardium in reality is again made up of two layers. The innermost layer adherent to heart is called visceral layer or epicardium and outer one is called parietal layer.



- The space between the fibrous layer and serous layer is known as pericardial cavity.
- The pericardial cavity is filled with pericardial fluid which acts as a shock absorber.
- On the surface of heart there are three grooves or sulci.
- The coronary sulcus encircles the heart transversely and externally represents the line of separation between the auricles and ventricles.
- There is mark externally the line of separation between the two ventricles.
- The right auricle receives the venous systemic blood. An internally located ridge within the right auricle divides it into two regions sinus venarum cavarnum and right auricula.
- There are four main openings in the right auricle. Blood enters in the right auricle through three of these openings while through the other, blood passes on to the right ventricle.
- The three blood vessels through which blood comes to the right auricle are two precavals and one post caval.
- Blood from the right auricle flows to the right ventricle through the right atrioventricular aperture.
- The dorsolateral wall of the right auricle demarcated by the inter-auricular septum.
- The left auricle is smaller in size than right auricle and is separated internally from it by the inter-auricular septum.
- It receives the blood through a large pulmonary opening located on its dorsal wall.
- It opens into the left ventricle through the left atrioventricular aperture.

- The conus arteriosus is fused with the right ventricle and is present as the funnel shaped cranial portion of the right ventricle leading to the aperture of the pulmonary trunk internally and bordered externally on the right by the right auricula.
- The lumen of the ventricle is provided with a number of muscular ridges called trabeculae carnae.
- The left ventricle is larger than the right ventricle. It is provided with thick walls. The left atrioventricular ostium is provided with bicuspid or mitral valve.
- The cusps are held in position by chordae that remain anchored to the ventricular wall.
- The valves prevent the backflow of blood into the left auricle.
- The left aortic arch arises from the left ventricle. The aortic ostium is the opening of the aorta and it lies near the centre of the base of the heart.
- The ostium is provided with three aortic valves which prevent backflow of blood.

Mechanism of Circulation Through Heart:

- The heart works day and night by alternate contraction (systole) and relaxation (diastole).
- The two auricles begin their systole at the same time and blood from the auricles is forced into both ventricles.
- Deoxygenated blood goes to the right ventricle and oxygenated blood comes to the left ventricle.
- The backflow of blood is prevented by the atrioventricular valves. The ventricles thus filled up with blood, start systole.

- In this phase the atrioventricular valves become closed and blood from the right ventricle is forced through the pulmonary arch while that the left ventricle is forced through the left aortic arch.
- The ventricular systole is followed by a phase of diastole of the whole heart.
- At this stage the semilunar valves remain closed, deoxygenated blood from the caval veins enters the right auricle and oxygenated blood from pulmonary veins enters the left auricle.

Nervous System - Central Nervous System:

The Central Nervous System of rat includes,

A. Brain
B. Spinal Cord

A. Brain:

- The brain lies in the cranial cavity of the skull. It is covered by three membranes called meninges.
- The innermost is the piamater which is very thin and highly vascular.
- The outermost is duramater. It is thick and lines the cranial cavity.
- The middle one is called as arachnoid mater which is thin and vascular.
- The space between piamater and arachnoid mater (subarachnoid space) and space between arachnoid and dura mater (subdural space)
- Both space is filled with cerebrospinal fluid which protects the brain from desiccation and external shocks.

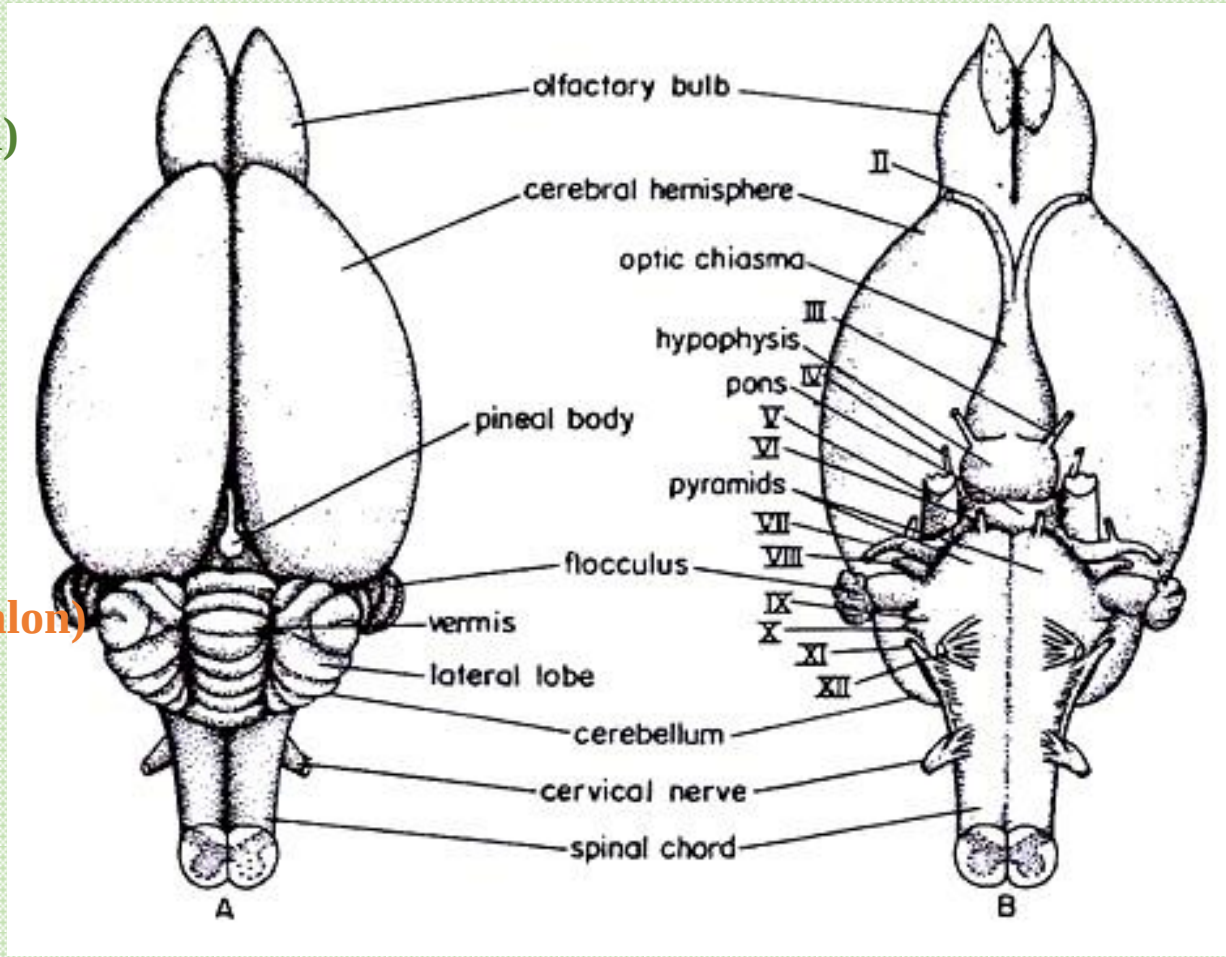
The brain is divided into three regions:

a. Fore brain (Prosencephalon)
b. Mid brain (Mesencephalon)
c. Hind brain (Rhombencephalon)

Fore brain (Prosencephalon)

Mid brain (Mesencephalon)

Hind brain (Rhombencephalon)



a. Fore brain (Prosencephalon): It is highly developed and comprises of ----

1. **Olfactory Lobes:**

- These are a pair of club shaped structures forming the anterior most part of the brain.
- Both the lobes are separate, not fused with each other.
- Each lobe has two parts, olfactory bulb and olfactory tract.
- Each olfactory lobe encloses a cavity called olfactory ventricle or rhinocoel.
- It opens into lateral ventricle of its side.

2. **Cerebral Hemispheres:**

- The cerebral hemispheres are well developed and occupy about 2/3 of the whole brain.
- These are tapering in front and broad behind.
- They cover the olfactory lobes partly in front.
- Dorsally, it has a median fissure which divided into two cerebral hemispheres.
- Laterally, sylvian fissure divide it into anterior frontal lobe, middle median lobe and posterior temporal lobe.
- Ventrally, two cerebral hemispheres are connected by a transverse band of white medullated fibres called corpus callosum.
- Each cerebral hemisphere contains a ventricle called paracoel or lateral ventricle.
- The two lateral ventricles communicate to each other and with third ventricle by foramen of Monro.

3. **Diencephalon:** It is comparatively small and is shadowed completely by backward growth of cerebrum. Its dorsal surface is raised into pineal stalk which bears rounded body called pineal body. The ventral surface of diencephalon has a funnel shaped depression called infundibulum bearing hypophysis. Hypophysis and infundibulum together constitute the pituitary body. The ventricle of diencephalon is called as diocoel which remains connected to the paracoel. The roof of diocoel is highly vascular and called anterior choroid plexus. The floor of diocoel is called hypothalamus which bears pituitary body.

b. Mid Brain (Mesencephalon): It consists of –

1. **Optic Lobes:** Four optic lobes are situated on the dorsal surface of mid brain. Most part of mid brain remains covered by cerebrum. Out of the four lobes, the anterior two lobes are larger and called superior colliculi. The other two are called inferior colliculi. The four optic lobes are together called corpora quadrigemina. The optic lobes are solid without Optocoel. A narrow passage called iter connects the 3^{rd} and 4^{th} ventricles.
2. **Crura Cerebri:** Below the optic lobes, two thick long bands of nerve fibres are present called crura cerebri. They are composed of white matter.

c. Hind Brain (Rhombencephalon): It consists of

1. **Cerebellum:** It is well developed. It consists of a large median central lobe called vermis, lateral lobes on the sides of vermis and two floccular lobes on the outer sides of lateral sides. The surface of cerebellum is thrown into numerous folds called gyri and grooves called sulci. The cerebellum is also solid and has no ventricle.
2. **Medulla Oblongata:** It is the posterior most part of the brain. It is broader in front but tapers posteriorly to form spinal cord. On the ventral side of anterior medulla oblongata, there is a transverse band of nerve fibres called pons varolli connecting the two lobes of cerebellum. The cavity of medulla is called myelocoel. Vascular folds of the roof from posterior choroid plexus. It is perforated by a small aperture called foramen of Magendie and two lateral foramen of Luschka.

B. Spinal Chord:

- The spinal chord is a whitish, tubular structure which runs through the neural canal of vertebral column.
- It is also covered by the three meninges – piamater, arachnoid mater and duramater.
- Posteriorly, the spinal cord forms a narrow, triangular cone, called conus terminalis, from which a bunch of nerves arises. These are called filum terminale.
- The spinal chord has a narrow cavity called central canal which is anteriorly connected to myelocoel but closed posteriorly.

Peripheral Nervous System:

- It includes nerves which are given out from brain and spinal cord.
- The nerves from the brain are called cranial nerves and those from the spinal cord are called spinal nerves.
- Twelve pairs of cranial nerves are present in Rat. Thirty two pairs of spinal nerves are present.

Autonomic Nervous System:

- The autonomic nervous system works without voluntary inputs.
- Its effectors are smooth and cardiac muscles and glands.
- The autonomic nervous system is of two types – sympathetic and parasympathetic.

Sense Organs:

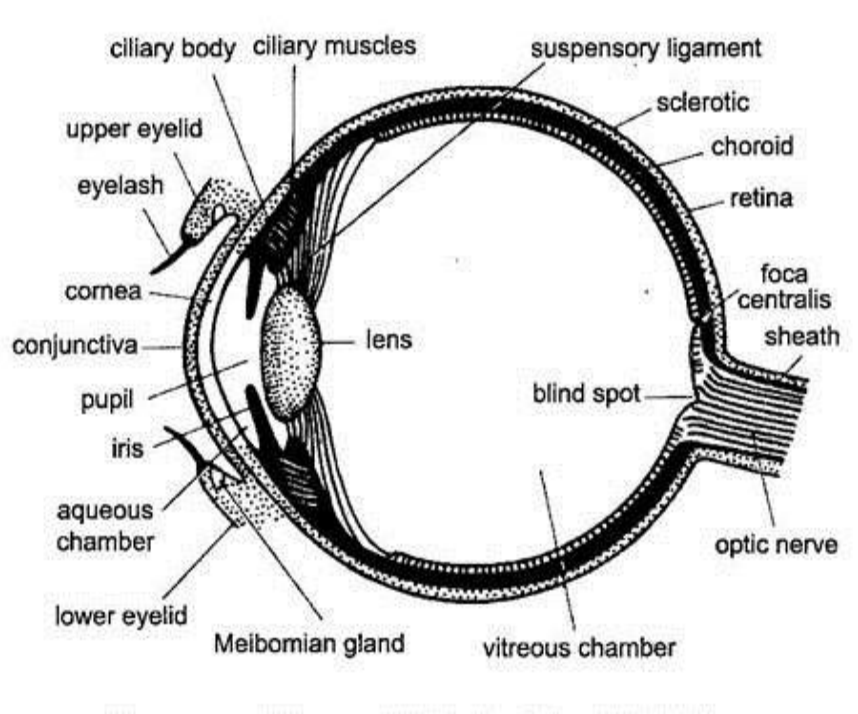
1. Structure of Eye:

The eye is photoreceptor organ. It is roughly spherical, lodged in a socket of the skull called orbit. The eye ball has three concentric coats – outer sclerotic coat, a middle choroid coat and inner retina.

A. **Sclerotic Layer:** It is outermost thick coat. It is opaque posteriorly and a small anterior part is transparent. The anterior transparent region is called cornea. The cornea is vascular and permits light to enter the eye. It is nourished by aqueous humor, and by lacrimal secretion. The cornea is externally covered by a thin transparent layer called conjunctiva. The conjunctiva is fused with cornea and is composed of stratified epithelium.

B. Choroid Layer:

- It is a vascular, pigmented coat just below the sclerotic layer and around retina.
- It is dark brown in colour to absorb the light and avoid internal reflection.
- The front part of choroid coat has an opening called pupil.
- The region of choroid visible through the cornea and surrounding the pupil is called iris.
- The iris contains two sets of muscles – sphincter and dilator muscles.
- These muscles regulate the amount of light entering the eye ball by varying the size of the pupil.
- The pupil is occupied by a biconvex lens.
- The lens is held in position by ciliary body which encircles the lens.
- The space between iris and cornea is called anterior chamber and that between iris and lens is called posterior chamber.
- Both the chambers are filled with aqueous humor containing 98% water. The space between lens and retina is filled with vitreous humor.



C. Retina:

- The inner most layer of eye where the image is formed is called retina.
- It lines two-third of choroid layer. It contains special photoreceptor cells called rods and cone.
- The rods are cylindrical and contain pigment rhodopsin. They perceive variety of light intensities.
- Therefore, they are also associated with vision in dim light and night.
- Cones are shorter and thicker as compared to rods.
- They contain the pigment iodeosin. The cones perceive the colours of objects.
- The region where optic nerve leaves the eye lack rods as well as cones. No image is formed in this region. This region is called blind spot.

D. Accessory Structures Associated with Eye:

1. **Eye Lids:** On the dorsal and ventral edge of orbit, the skin becomes folded to form upper and lower eyelid in front of eye. Both eyelids are movable. A third eyelid called nictitating membrane is also present. The free margins are provided with two rows of eye lashes.
2. **Glands:** The eye also contains lacrinal glands producing watery secretion called tears. Meibomian glands are pour out oily secretion at the edge of eyelid. Harderian glands secrete lipid rich material to lubricate the eyes and eye lids. Glands of Zeiss perform the same function.

3. **Eye–ball Muscles:** Each eyeball is provided with six sets of muscles which move the eyeball in the orbit. Out of the six sets, four sets are rectus muscles and two sets are oblique muscles. These muscles are attached on one side with the eyeball and on the other side with the orbit.

Function of Eye:

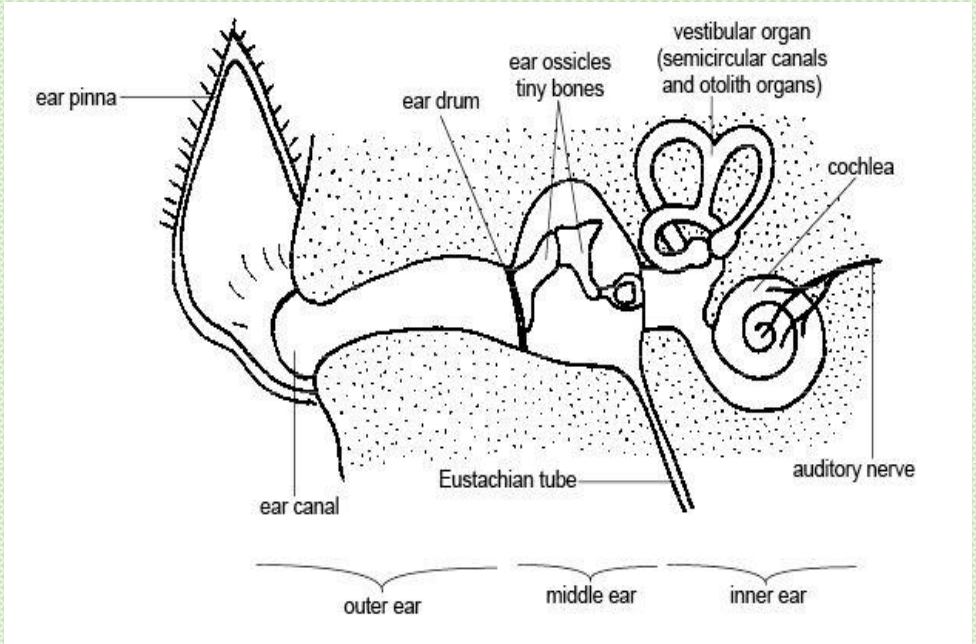
- The eye works on the principle similar to a photographic camera. The light rays from the object are refracted from the conjunctiva, cornea, lens and focused on the retina.
- Maximum refraction is caused by cornea. The retina receives the inverted image.
- This is carried to the optic lobes by optic nerve where the information is processed and animal sees an upright image.
- In normal condition, when the eye is at rest, the lens is flattened. While focusing on the near objects, the convexity of the lens increases.
- Convexity decreases while focusing on the distal objects. Since the eyes of rats are placed laterally on the head, they do not have binocular vision as great as humans.

Structure of Ear:

The ears are stato-ac0ustic organs of rat, performing the function of hearing and equilibrium or the ears are sensitive to the frequencies of sound waves and to changes in relation to gravity. The mammalian ear has three parts, an external, a middle and an internal. The internal ear transforms these sound vibrations into nerve impulses which are communicated to the brain through VIII cranial nerve.

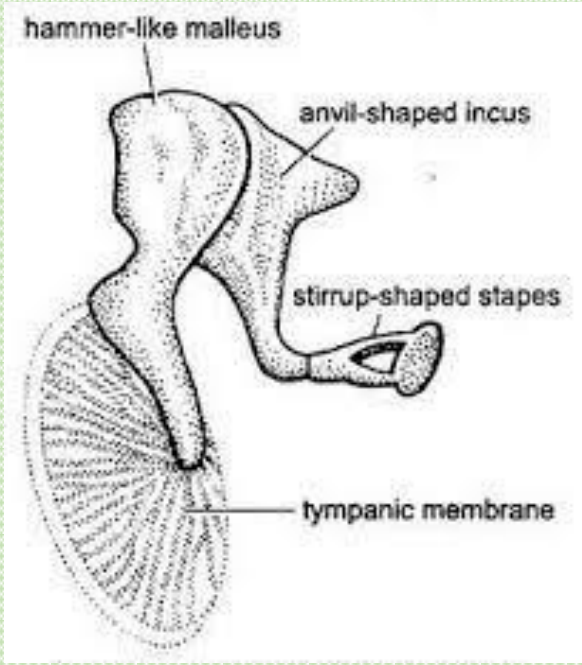
1. External Ear:

- A large external ear or pinna or auricle is found in rat which is movable.
- It is a skin covered elastic cartilaginous projection from the lateral sides of head.
- The pinna is a wide mouthed funnel capable of being moved or turned in different directions by its muscles.
- The opening of the funnel shaped pinna leads into a tubular passage called the external auditory meatus.
- It ends into a cone shaped membrane called the tympanum or ear drum.
- The walls of auditory meatus are covered by skin containing hairs, oil glands and wax glands.
- The hairs, oil and wax glands protect the ear drum from the harm caused due to dust and small insects.
- **The function of external ear** is to collect the sound vibrations and to detect the direction of sound vibrations and send them to middle ear.



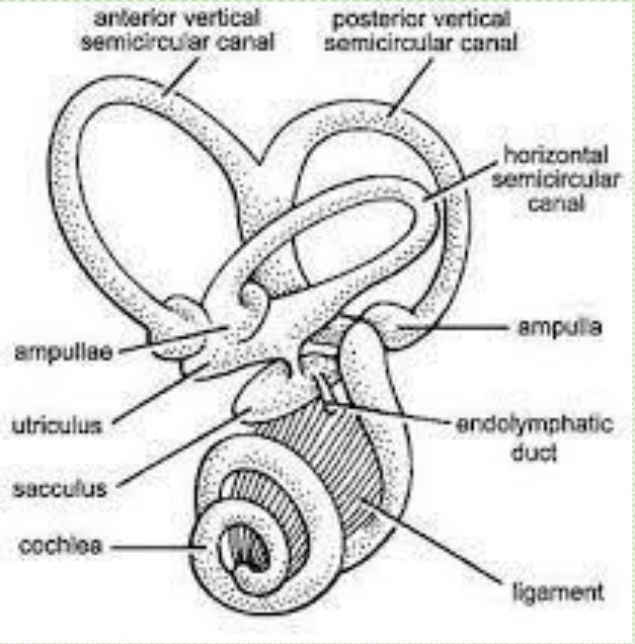
2. Middle Ear:

- It is the tympanic cavity which starts from the tympanic membrane or ear drum.
- It is an air filled cavity enclosed in the tympanic bone.
- The ear rum is exposed to the impact of sound vibrations caused due to the sound in air.
- The tympanic cavity is connected with the pharynx by a tubular passage, the Eustachian canal for equalizing the air pressure on both the sides of the ear drum.
- The tympanic cavity is closed internally by a wall which has two windows, opening into the internal ear.
- These are the upper oval fenestra ovalis and the lower rounded fenestra rotunda.
- There are three tiny bones called ear ossicles extending to the fenestra ovalis. These ossicles are hammer shaped malleus, anvil shaped incus and stirrup shaped stapes.
- These bones represent the articular, quadrate and hyomandibular bones of other vertebrates. The ear ossicles take up the sound vibrations from the tympanic membrane and convey them to the internal ear.



3. Internal Ear:

- It is well developed and complicated structure called the membranous labyrinth.
- It is enclosed in a bony auditory capsule of the same shape as the membranous labyrinth, formed by the periotic bone.
- The space between the bony capsule and the membranous labyrinth is filled with a liquid called perilymph.
- A similar fluid found within the membranous labyrinth called the endolymph having tiny calcareous particles called otoliths.
- The membranous labyrinth is formed of a larger dorsal utriculus and a smaller ventral sacculus forming the body proper and semi-circular canals and cochlea.



a. Utriculus and Sacculus: The utriculus and sacculus are connected by a small duct called sacculo-utricular canal. A small, narrow endolymphatic duct arises from the sacculus which ends blindly against the cranium into an endolymphatic sac. From the sacculus arises a spirally coiled tube called cochlear duct or lagena. Both the utriculus and sacculus have a special group of sensory cells called the macula. These cells bear five projecting hairs which are embedded in jelly containing otoliths. Macula of utriculus and sacculus are called machula utriculi and machula sacculi respectively. The bony labyrinth around the utriculus and sacculus is called the vestibule.

b. Semicircular Canals:

- Three semicircular canals connect at both the ends with utriculus.
- These are external, anterior and posterior semicircular canals situated at right angles to each other.
- The anterior and posterior semicircular canals arise from a common canal after their origin from utriculus are called crus commune.
- Each semicircular canal has a swollen ampulla at its lower end. Each ampulla has a sensory area known crista ampullaries which is formed by sensory hair cells and supporting cells.
- The hairs are embedded in a jelly cone having no otoliths.
- The VIII cranial or auditory nerve supporting to ear divides into two branches, vestibular branch supplying to the semicircular canals, utriculus and sacculus and a cochlear branch supplying to the cochlea.

c. Cochlea:

- The spirally coiled watch spring like cochlear or lagena arising from sacculus is enclosed within the similarly spirally coiled cochlear canal of the periotic bone, which together constitute the cochlea.
- It is organ of hearing. Cochlea is a bony tube lined with connective tissue.
- The cochlea shows three chambers or canals- middle chamber or scala media is the cochlear duct arising from the sacculus and is filled with endolymph.
- It terminates blindly at the apex of spiral or cochlea.
- The upper and lower canals of the cochlea are scala vestibuli and scala tympani respectively.

Working of Ear:

- Ear performs two functions – hearing and equilibrium.
- The cochlear duct of sacculus of the membranous labyrinth is responsible for hearing, while maculi of sacculus, utriculus and cristae of semicircular canals help in equilibrium.

Hearing:

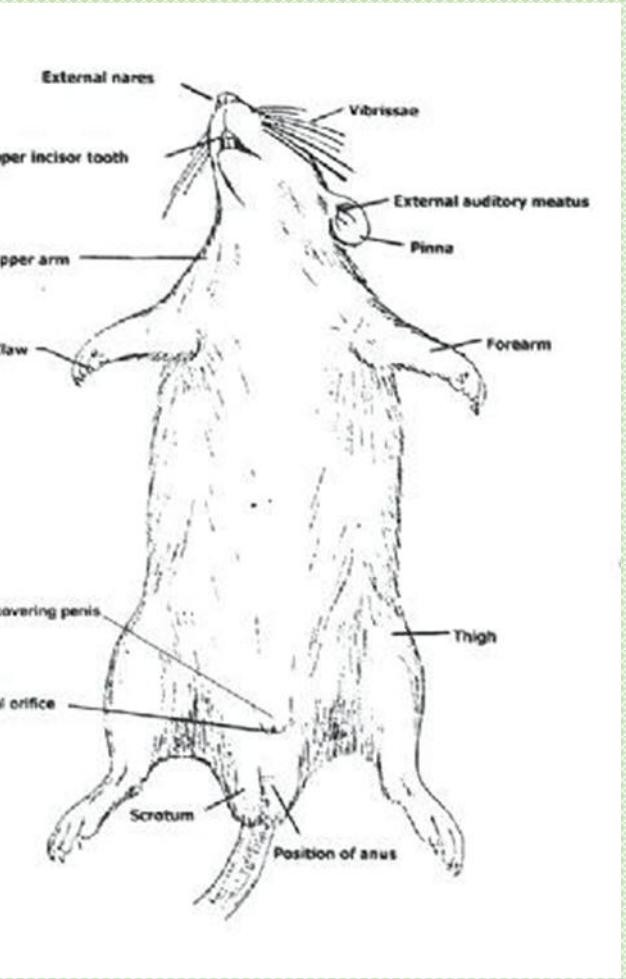
- The sound waves are collected by the movable pinna which travel through the external auditory meatus and cause the ear drum to vibrate.
- The vibrations are then transmitted through the ear-ossicles of the middle ear and fenestra ovalis into the perilymph of internal ear.
- The membrane of fenestra rotunda due to the pressure bulges out into the middle ear.
- Thus it act as a pressure relief valve.

Equilibrium:

- The sensory patches of the ampulla of semicircular canals called cristae and utriculus and sacculus are called maculae are responsible for maintaining equilibrium of the body.
- Any change in the equilibrium of the body stimulates the hair cells of the cristae and maculae due to movement in endolymph and otoliths in them.
- Maculae respond to the change in the posture of head and body.
- While the cristae respond to the changes in the direction or rotational movements of head. Cristae lack otoliths.

Reproductive System of Rat: In Rat the sexes are separate i.e., the male and female reproductive organs are present in different individuals. The male and the female can be identified by the sexual dimorphic characters, exhibited by individuals.

Male Reproductive System


External nares
Vibrissae
per incisor tooth
External auditory meatus
Pinna
pper arm
Forearm
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Thigh
orifice
Scrotum
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