

## B.SC 2<sup>nd</sup> Year, Paper IV

Dr. Medhavi Sudarshan  
Assist Prof  
Deapt of Zoology  
JNL College , Khagaul

### Comparative Anatomy – Vertebrate Respiratory System

Respiratory system is a system consisting of specific organs and structures used for the process of respiration in an organism. Respiration is the process of obtaining oxygen from the external environment & eliminating CO<sub>2</sub>.

External respiration - oxygen and carbon dioxide exchanged between the external environment & the body cells

Internal respiration - cells use oxygen for ATP production (& produce carbon dioxide in the process)

In vertebrates the skin may be respiratory (e.g., anurans), while in some fishes and aquatic turtles, the vascular rectum or cloaca is respiratory. But there are two main types of respiratory organs- gills for aquatic respiration and lungs for aerial respiration. Both gills and lungs may occur in the same animal. Accessory respiratory organs are also present in some vertebrates.

In both kinds of respiration two conditions are essential;

1. The respiratory organs must have a rich blood supply with very thin moist epithelium covering the blood vessels so that these blood vessels are through into close contact with the environment (water or air).
2. The organs of respiration the blood vessels should be reduced to thin capillaries which expose a large surface area to the environment, so that blood is brought into close contact with the water or air in the respiratory organs.

### Gills

#### ***Cartilaginous fishes: Septal gills.***

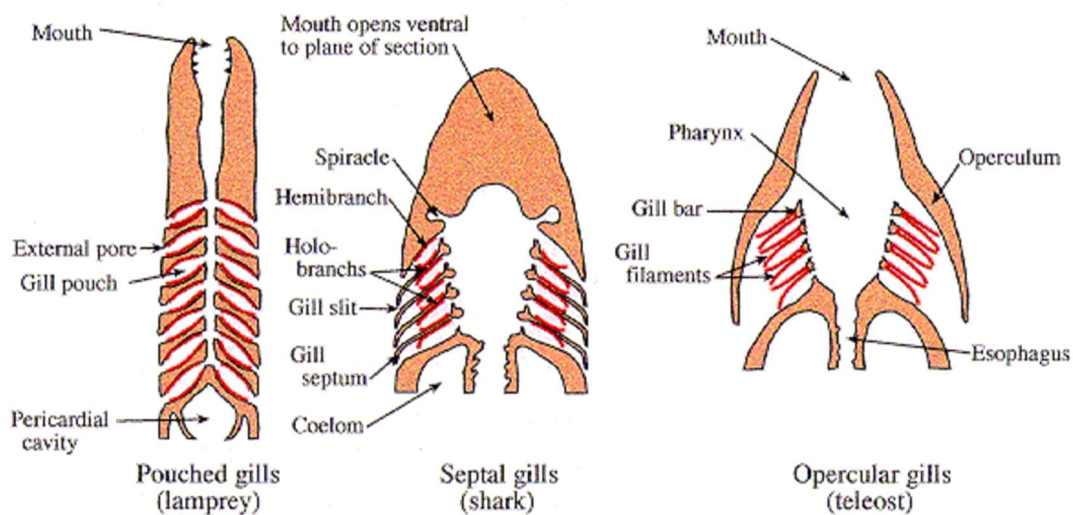
Cartilaginous fishes (*Sharks*) use gills to breathe rather than lungs. There is 5 to 7 gill arches, each bearing one gill slit and covered by the operculum, which acts as a lid over the gill. However, sharks do not have this covering. There is also a modified slit, called the spiracle, which lies immediately behind the eye on the shark's head. Anterior & posterior walls of the first 4 gill chambers have a gill surface (demibranch). Posterior wall of last (5th) chamber has no demibranch. Presence of interbranchial septum lies between 2 demibranchs of a gill arch. Sharks use these gill slits to oxygenate their blood. The spiracle assists in the process of taking water in. As the shark moves forwards, water is taken into the mouth and over the gills. This is called "ram ventilation".

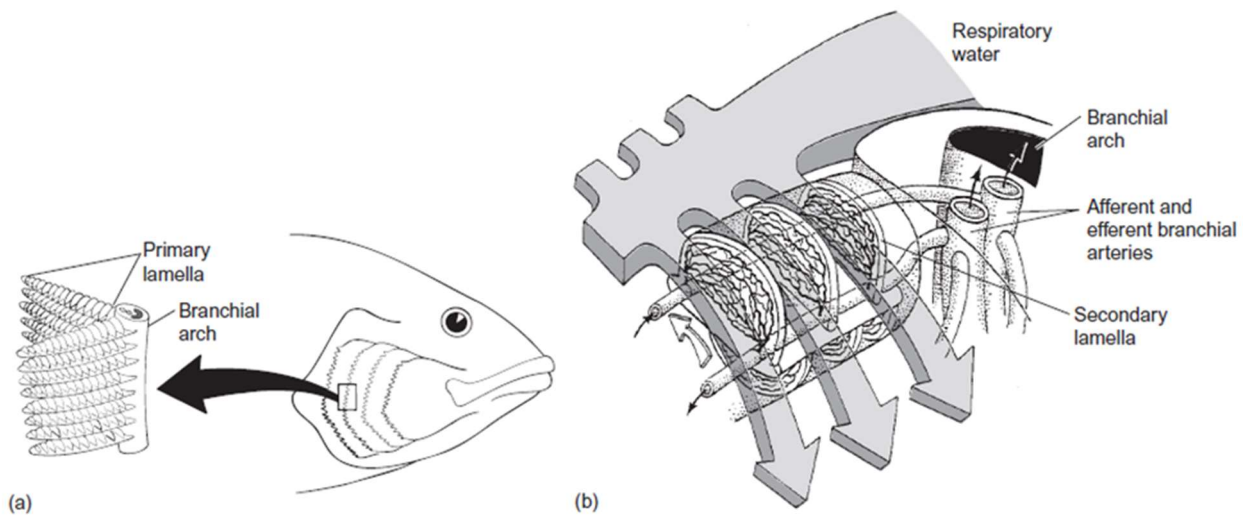
#### ***Bony fishes : Opercular gills***

Bony fishes (*teleosts*) usually have 5 gill slits. Operculum projects backward over gill chambers. It provides a protective cover over the branchial arches and gills they support. In addition, the operculum is part of the dual pump used to ventilate the gills. In cross section, each gill is V-shaped and composed of primary lamellae (gill filaments) that are subdivided into secondary lamellae and supported on a branchial arch. Tiny adductor muscles cross between filaments to control the arrangement of adjacent gills that govern the flow of water across the secondary lamellae. As in most other fish gills, the blood in the secondary lamellae flows one direction and water flows in the opposite direction to establish a countercurrent exchange. Interbranchial septa are very short or absent.

***Agnathans: Pouched gills***

Agnathans (lamprey & haffishes) has 6 - 15 pairs of gill pouches. Pouches connected to pharynx by afferent branchial (or gill) ducts & to exterior by efferent branchial (or gill) ducts. The pharynx is subdivided into the ventral part forming a respiratory tube that is isolated from the mouth by a valve called the velum.





Gill Ventillation in teleosts.

### ***Larval Gills:***

- (i) External gills: These are outgrowths from the external surface of 1 or more gill arches and are found in lungfish & amphibians
- (ii) Filamentous extensions of internal gills: These are project through gill slits and occur in early stages of development of elasmobranchs
- (iii) Internal gills – This is hidden behind larval operculum of late anuran tadpoles.

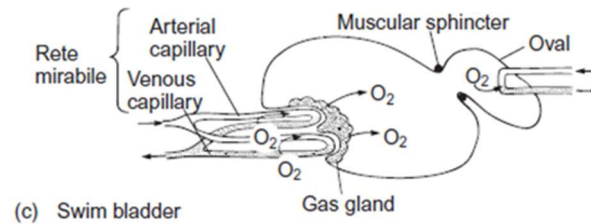
Most vertebrates develop an out pocketing of pharynx or esophagus that becomes one or a pair of sacs (swim bladders or lungs) filled with gases derived directly or indirectly from the atmosphere. Similarities between swim bladders & lungs indicate they are the same organs.

Vertebrates without swim bladders or lungs include cyclostomes, cartilaginous fish, and a few teleosts (e.g., flounders and other bottom-dwellers).

### **Swim bladder**

Swim bladder have, during development, a pneumatic duct that usually connects to the esophagus. The duct remains open (physostomous) in bowfins and lungfish, but closes off (physoclistous) in most teleosts. It serve primarily as a hydrostatic organ (regulating a fish's specific gravity)

Gas intake by way of a 'red body' (includes gas gland & rete mirabile) while gas is resorbed via the oval body on posterior part of bladder.



## **Lungs and associated organs:**

Most adult amphibians and all amniotes breathe by means of lungs, though lungs are also present in lung fishes. In an embryo a hollow outpushing, called lung primordium arises from the ventral wall of the pharynx. It grows backwards and divides into two, right and left lung buds. The undivided proximal portion develops into trachea and larynx, and opens into pharynx by glottis.

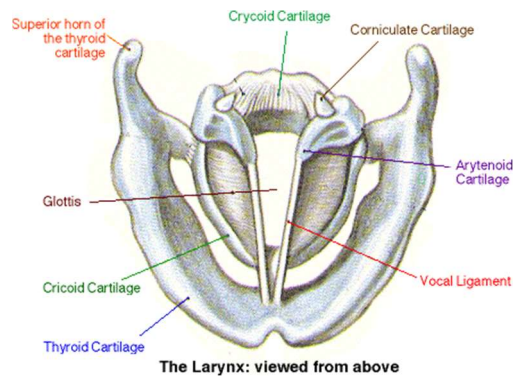
Later lung buds grow posteriorly into coelom and branch repeatedly and get covered by mesoderm. Thus, each lung has an endodermal lining and an outer visceral peritoneum and in between the two mesodermal mesenchyme having blood and lymph vessels, nerves, and smooth muscle fibres and connective tissue. Inner endodermal epithelium of lungs is raised into a network of ridges to increase the vascularised surface exposed to the action of air. In lower forms, the lungs are hollow bags, but in higher forms the ridges increase in number and unite with one another across the lumen of the lung to convert it into a solid but spongy structure with innumerable air spaces. The original duct of the lung sac connecting the pharynx to the lungs becomes a trachea in most. In many tetrapoda the anterior end of the trachea becomes modified into a larynx or sound box which opens into the pharynx by a glottis. At its lower end, the trachea divides into two bronchi, each of which enters a lung.

Lungs of Dipnoi (Choanichthys) are bilobed or paired as in Protopterus (African lung fish) and Lepidosiren (South American Lung fish) and are connected to oesophagus via a pneumatic duct. But the Australian lung fish (Neoceraodus) has a single lung that is used as hydrostatic organ.

In tetrapods, embryonic lungs arise from pharyngeal wall as a hollow mid-ventral evagination that subsequently bifurcates to form two lungs that carry an envelope of peritoneum.

### ***Larynx***

In tetrapods besides mammals there are 2 pair of cartilages: arytenoid & cricoid, while mammals have paired arytenoids, cricoid, thyroid and several other small cartilages including the epiglottis (closes glottis when swallowing). Amphibians, some lizards, & most mammals also have vocal cords stretched across the laryngeal chamber.



## *Trachea & syrinx*

Trachea is absent in anurans. It is usually about as long as a vertebrates neck (except in a few birds such as cranes) and is reinforced by cartilaginous rings (or c-rings). It splits into 2 primary bronchi &, in birds only, forms the syrinx at that point.



## Lungs

### *Amphibia*

Lungs of amphibians are two simple sacs, narrow and elongated in urodeles and bulbous in anurans enclosed in a single peritoneal membrane and supplied by pulmonary arteries and drained by pulmonary veins. Left lung in limbless amphibians is rudimentary. Lungs are vestigial in salamanders inhabiting hill streams where in fast flowing water buoyancy would not be a desirable trait.

Amphibians lack ribs and hence use floor of the buccal cavity to force air in and out of the lungs. Frogs and toads modify 2<sup>nd</sup>, 3<sup>rd</sup> and 4<sup>th</sup> visceral arches to produce a plate-like hyobranchial apparatus that lies in the floor of oral cavity and is connected to squamosal bone of skull by petrohyal muscle and to sternum by sternohyal muscle. One breathing cycle is completed in four steps in anurans that is affected by contraction of these two muscles. Breathing in frog requires much faster movement of hyoid plate as compared to lungs and considerable amount of gas exchange takes place in bucco-pharyngeal region too. Cutaneous respiration also contributes to major part of oxygen supply to the body of amphibians.

## ***Reptiles***

Lungs are narrow and elongated in snakes and lizards extending up to two-third of the body cavity but are more bulbous in turtles and crocodiles. The left lung is rudimentary in limbless lizards and snakes. There are well formed alveoli in lungs which are housed securely in a pair of pleuro-peritoneal cavities. Breathing in snakes and lizards is carried out by a combination of hyoid plate, nostril valves and ribs or only by the movement of rib cage, while tortoises and turtles make use of muscles surrounding peritoneal membranes. Crocodiles are the only living reptiles that possess a muscular diaphragm for breathing as do the mammals.

## ***Birds***

Lungs are secured into pleural cavities and extend into membranous air sacs that occupy all available space in the body cavity and also penetrate into bone marrow cavities. This makes the bones pneumatic in birds and help to reduce body weight which is so necessary in flight. Majority of birds have 5 pairs of air sacs, namely, cervical at the base of neck; interclavicular often united across midline; anterior thoracic placed lateral to the heart; posterior thoracic within the oblique septum and abdominal within the abdominal cavity. Sometimes there are also axillary air sacs near the pectoral muscles. The flight muscles inflate and deflate the air sacs like bellows with each stroke of wings.

Air duct system is unique in birds as there are no alveoli as found in reptiles and mammals. Trachea divides into two bronchi which enter the lungs and branch into mesobronchi that again divide to form parabronchi. From each parabronchus, bunches of air capillaries arise which loop back into their own lumen to form anastomosis that eventually leads into the air sacs. Air capillaries are minute and only one cellular layer thick and contain respiratory epithelium and rich network of blood capillaries.

## ***Mammals***

Multichambered & usually divided into lobes. Actually mammalian lungs increase efficiency by increasing the surface area of respiratory epithelium of alveoli whose number goes up to millions and lungs become almost like semisolid sponge with little empty lumen inside. Lungs are enclosed in double peritoneal membranes, the outer parietalpleura and inner visceral pleura that enclose the fluid-filled pleuro-peritoneal cavity in between.

Trachea which is commonly known as windpipe opens in pharynx by a slit-like glottis and posteriorly divides into two primary bronchi that enter lungs and branch off to secondary and tertiary bronchi which ultimately lead to fine capillaries called bronchioles. Each bronchiole is connected to several alveoli by alveolar ducts. The number of alveoli in human lungs is estimated to be about 750 million which collectively carry an enormous surface area of about 100 m<sup>2</sup> and if stretched.

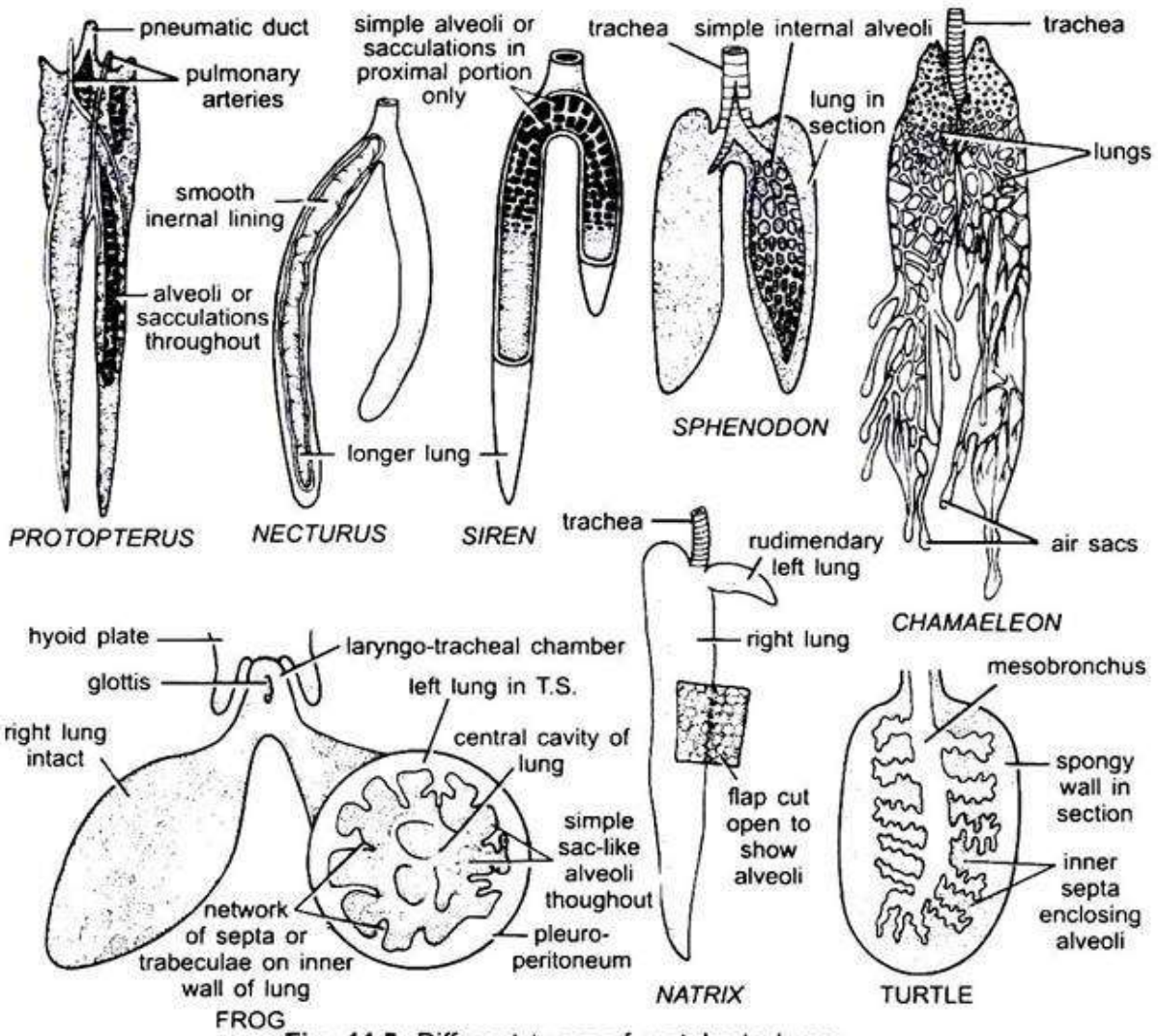
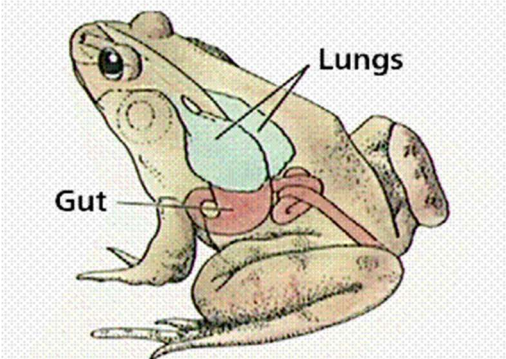


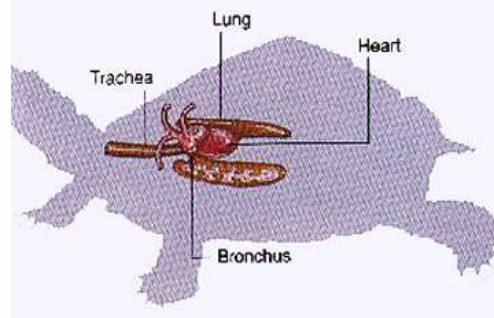
Fig. 44.5. Different types of vertebrate lungs.

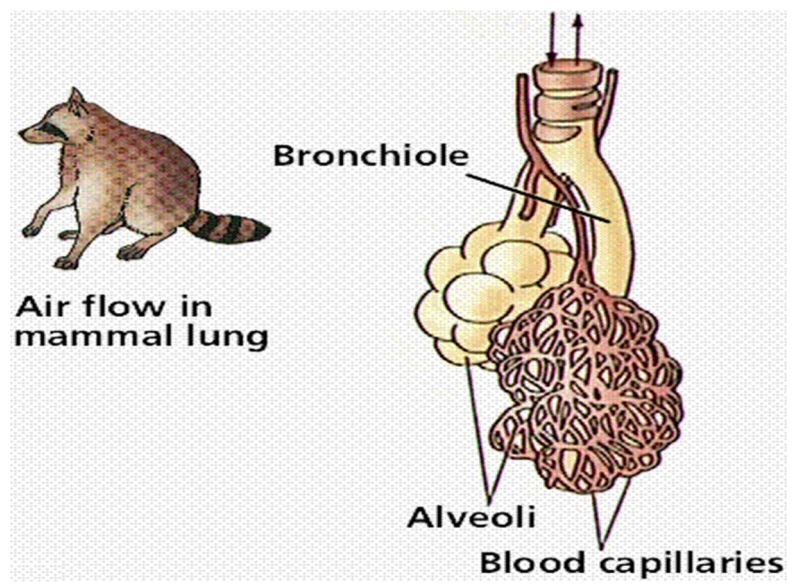
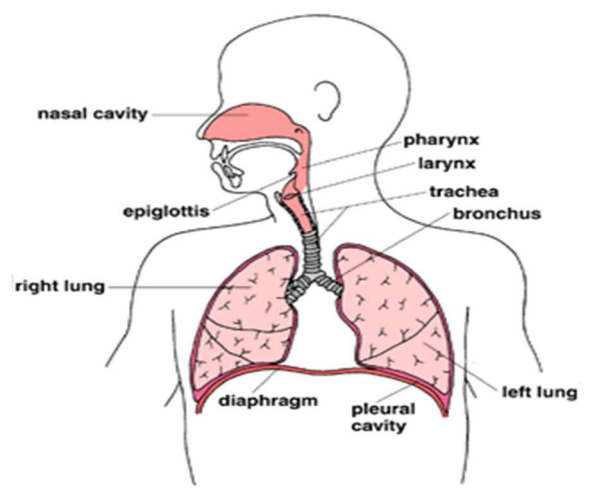
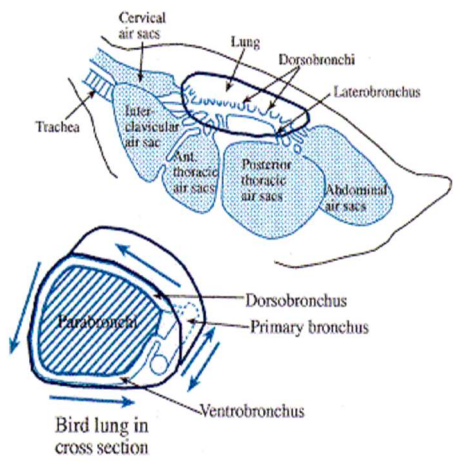
Amphibian lungs are ventral outpocketings of the gut, though they lie dorsal to it



### TURTLE

Phylum Chordata, Class Reptilia, Order Chelonia





Different pictorial forms : Lung of vertebrates