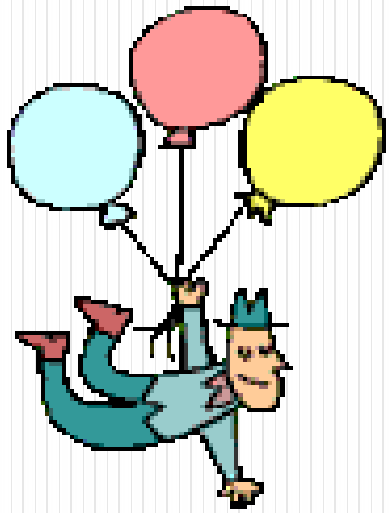
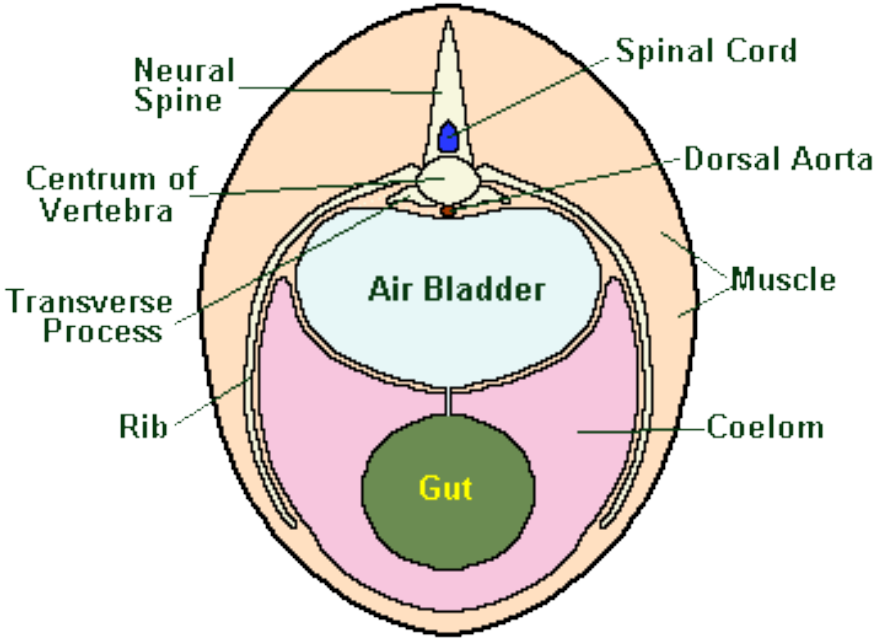
Swim Bladder and its modifications

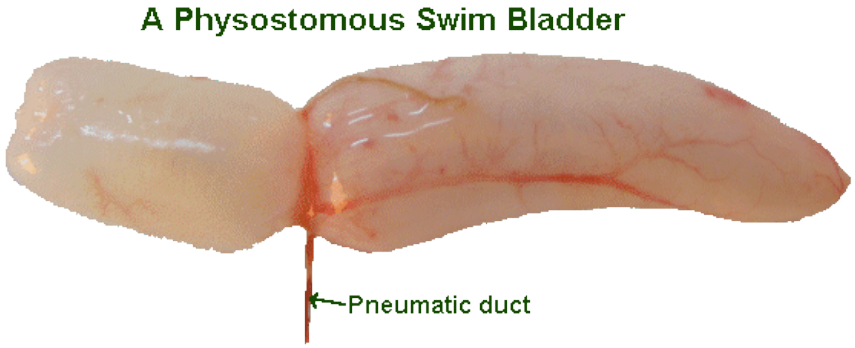


Swim Bladder

- Swim bladder also known as air bladder or gas bladder is a characteristic structure in most of the osteichthyes
- It situated between the alimentary canal and kidneys and sac like in appearance
- It contain air and develop as a small outgrowth from wall of the gut



Transverse Section of a Teleost Fish Body



Structural Modification

- **In primitive bony fish, *Polypterus* it is in the form of bilobed sac having smooth wall. The right lobe is larger than the left and the two are joined at the proximal ends before opening into the pharynx by an aperture (glottis) provided with muscular sphincter**

- **In *Lepidosteus* (Holostei) the bladder is single elongated sac which open into gut by glottis. The wall of sac is not smooth but shows alveoli arranged in two rows**

- **In Dipnoi, *Neoceratodus, Protopterus* and *Lepidosiren* the bladder resembles the lung of an amphibian. The wall of bladder is highly vascular and shows numerous alveoli that are further divided into the smaller sacculi. Their bladder is modified for aerial respiration**

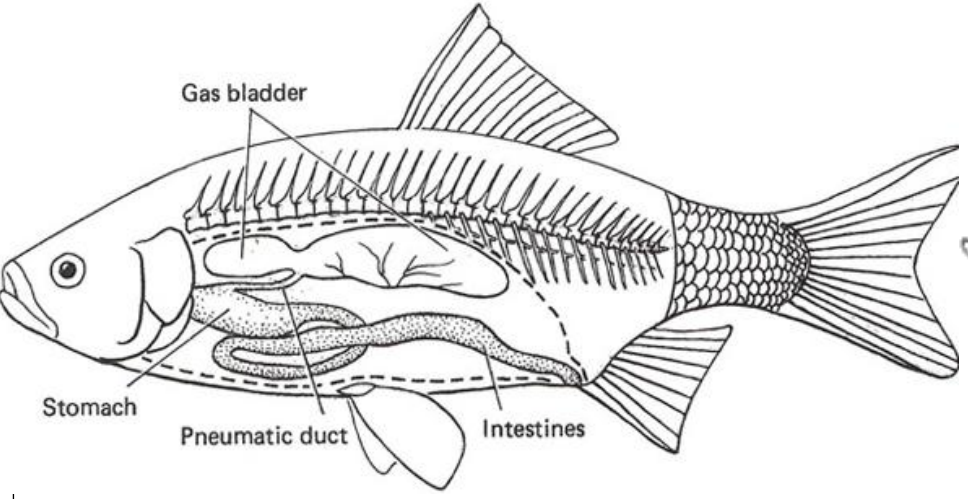
Structural Modification in teleost

- Gas bladder is present in most teleost but it is absent in several order of fishes such as Pleuronectiformes, Echeneiformes, Giganturiformes, Saccopharyngiformes, Pegasifformes and Symbranchiformes
- Teleost species in which bladder is present , it may be oval, tubular fusiform, heart shaped, horse-shoe shaped or dumb bell shaped
- In Cyprinidae (*Labeo, Cirrhinus, Catla*) the air bladder is divided into two inter connecting chambers
- In several sound producing fishes, the air bladder has finger like caecal outgrouth. In *Gadus* a pair of such caeca extend into the head region of the fish. In *Otolithus,* pair of short tubular caeca develop from the antero-lateral wall of the bladder and each further divides into two. One of which grows forwards and the other backwards. In *Corvina lobata*, several tubular appendages develop from lateral walls of the air bladder

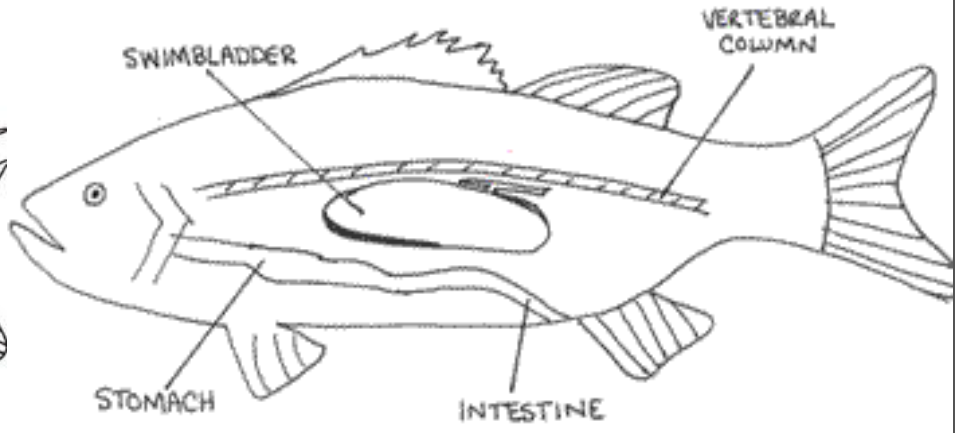
Physostomous and Physoclist bladder in Teleost

- In **physostomi telesost** bladder open into gut by the mean of long pneumatic duct (open type swim bladder) eg: fishes belong to order Cypriniformes, Clupeiformes, Anguilliformes and Esociformes

- In **physoclisti teleost** the pneumatic duct is absent (closed type swim bladder) eg: fishes belongs to order Gasterosteiformes, Mugilifomes, Notacathiformes and Acanthopterygii. Gas reabsorption structure called oval is present in physoclists only



Physostomous Bladder

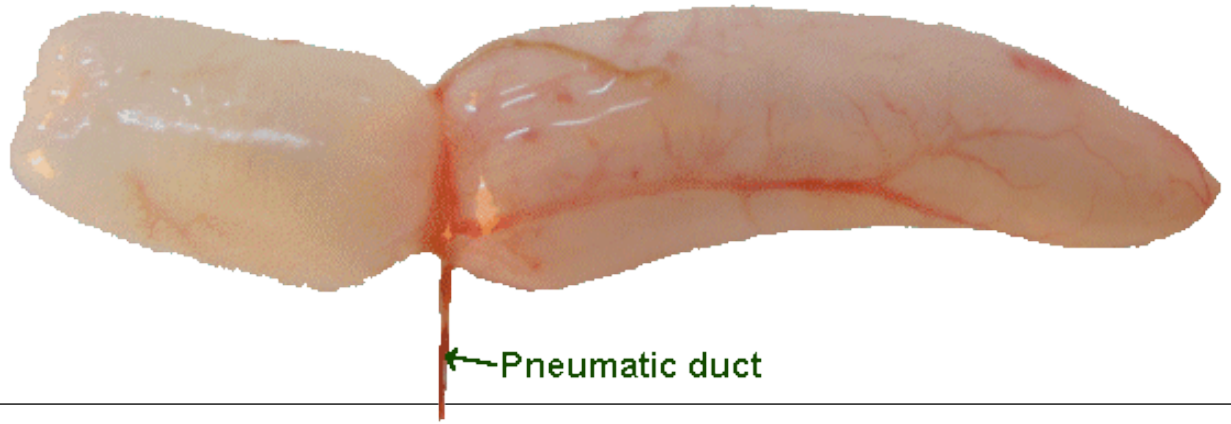


Physoclist Bladder

Blood supply in physostomus swim bladder

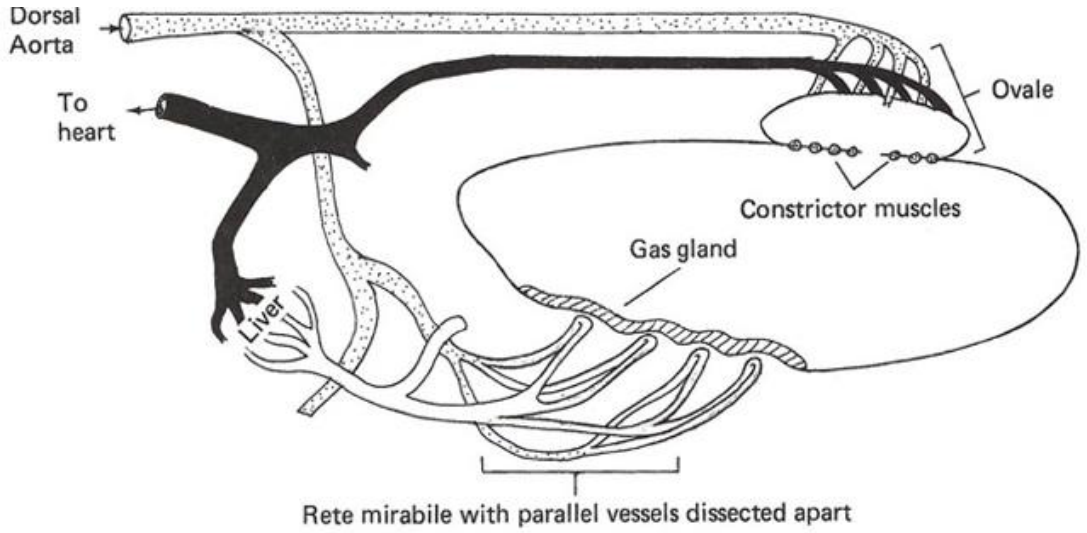
- Air bladder is supplied with blood from dorsal aorta or from the branch of coeliaco-mesenteric artery. The deoxygenated blood is drained into the hepatic portal system or into posterior cardinal vein.
- In species belonging to Cluppeidae or Salmonidae, there is uniform distribution of blood capillaries over the bladder wall and red bodies or red glands are not formed.
- In cyprinidae blood capillaries are concentrated at one or more points on inner surface of bladder and formed red bodies of various shape
- In physostomous fishes, the capillaries are covered by simple epithilium and the structure called red body

A Physostomous Swim Bladder



Blood supply in physoclists swim bladder

- Inner epithelium of the swim bladder is mostly composed of metabolically active cuboidal cells, but the areas involved in reabsorbing gas from the swim bladder have squamous epithelium. The specialized secretory epithelium of the swim bladder is often called the "gas gland"
- Capillaries transporting blood to and from the bladder forms dense bundle of capillary network where arterioles and veinuoles are in close diffusion contact is called rete mirable
- Distance between arterial and venous blood streams is about the same as the distance between air and blood in the human lung
- In simplified terms, the rete mirable is responsible for gas secretion into the swim bladder and the resorbent capillary network is responsible for removing gas from the swim bladder



Function of Swim Bladder

- **Respiratory**: In primitive bony fishes and Dipnoi, its act as main respiratory organ
- **Sound production**: Act as a resonator for the sound produced by other organ as in Ballistidae and Triglidae
- **Auditory**: In several fishes air bladder is connected with membranous labyrinth and serves to transmit sound waves to the ear
- **Sensory**: Works as a pressure receptor like a barometer
- **Hydrostatic organ**: Volume of gas in bladder increase or decrease to adjust the density of fish when it swim from one depth to another.

  In physostomous species, excess gas passed out to gut through pneumatic duct. If increase in a volume is desired air can be gulped in at surface and forced into the bladder through pneumatic duct.

  In physoclists, gas is secreted or absorbed from blood through bladder wall. Gas secreting complex consist of rete mirable and gas gland and reabsorption of gas is through oval

Gas secretion mechanism in Physoclist

An unique property of the hemoglobin in fish with swim bladders enables the fish to fill or empty its swim bladder

The hemoglobin of fish with bladders is extremely sensitive to acidic conditions, releasing about half of bound oxygen even at high oxygen concentrations. This property is called the **Root effect**

When the blood surrounding the bladder becomes slightly **acidic** the hemoglobin releases oxygen into the bladder. If the blood becomes less acidic the oxygen is reads orbed by hemoglobin

Make up the wall of the swim bladder convert glucose to lactic acid. The lactic acid diffuses into blood circulating over the outer surface of the bladder.

Gas secretion mechanism in Physoclist contd.....

- Blood entering the rete has the same pH and partial pressure of oxygen (P02) as arterial blood elsewhere in the fish's body.
- Venous blood in the rete is acidic and has high PO2. As the arterial blood encounters the venous blood in the rete, oxygen diffuses across its pressure gradient into the arterial blood causing the PO2 in the arterial blood to increase.
- As blood circulates through the swim bladder, the PO2 is further increased by lactic acid secretion from swim bladder epithelium ("gas gland") into the blood which acidifies the blood and causes gas to be less soluble. As PO2 increases in the blood circulating through the swim bladder, oxygen is secreted into the swim bladder lumen
- This is a **counter-current exchange system**, in which acid and free oxygen in the blood leaving the bladder diffuses back into the less acidic blood entering the bladder.

- Gas can be removed from the swim bladder by reabsorption into the blood. In reabosrptive areas, the swim bladder epithelium becomes squamous and gas can diffuse according to partial pressure differences