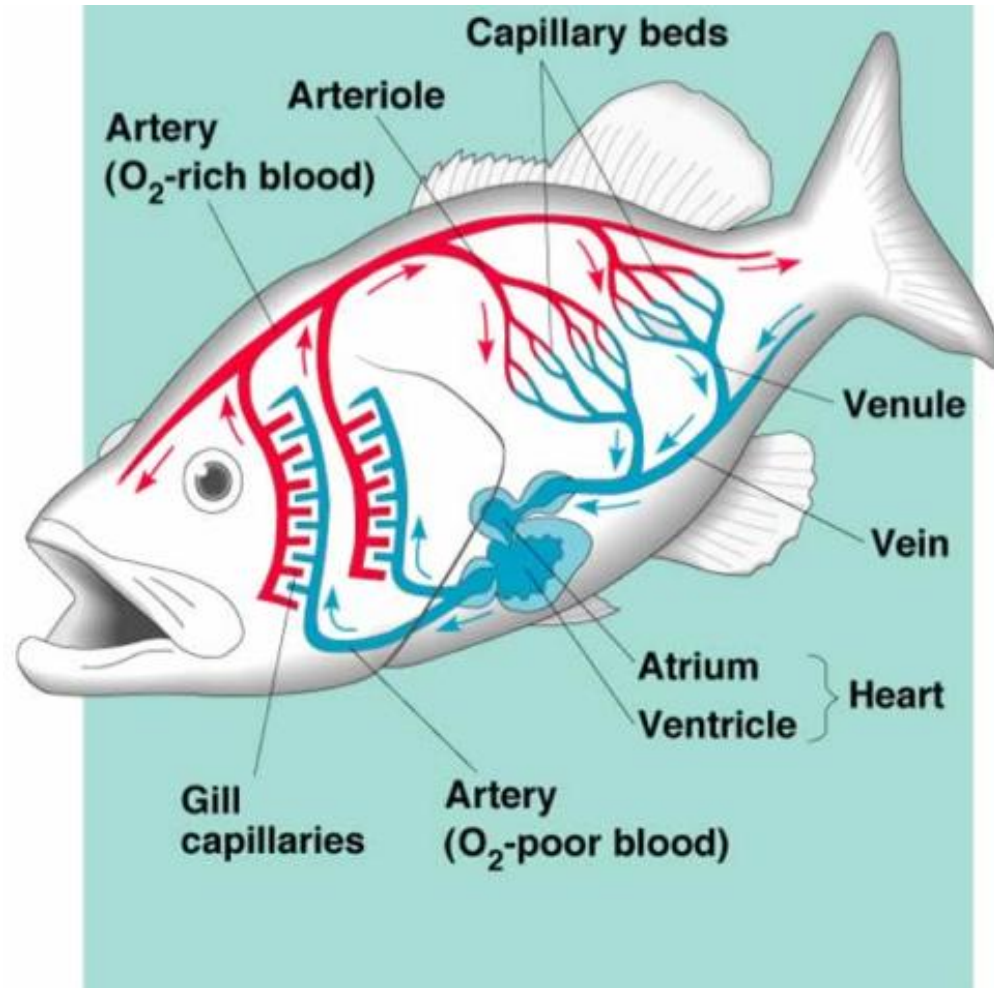
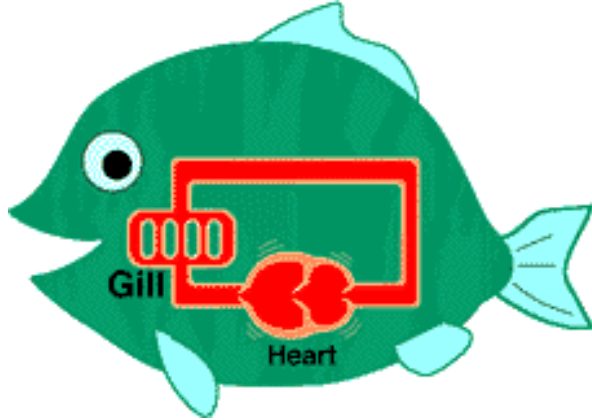


Circulatory System in Finfish



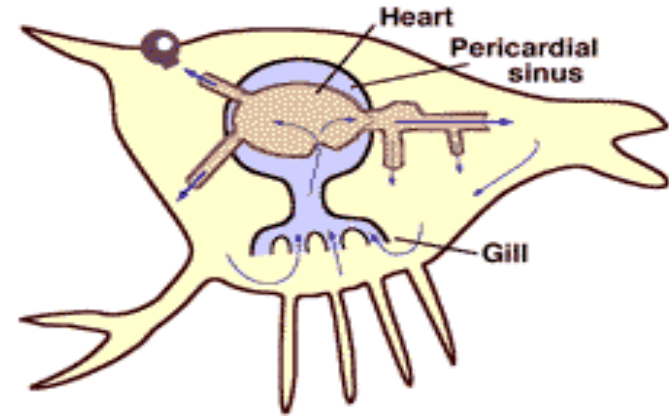
Two type of circulatory system found in animal

Closed circulatory system



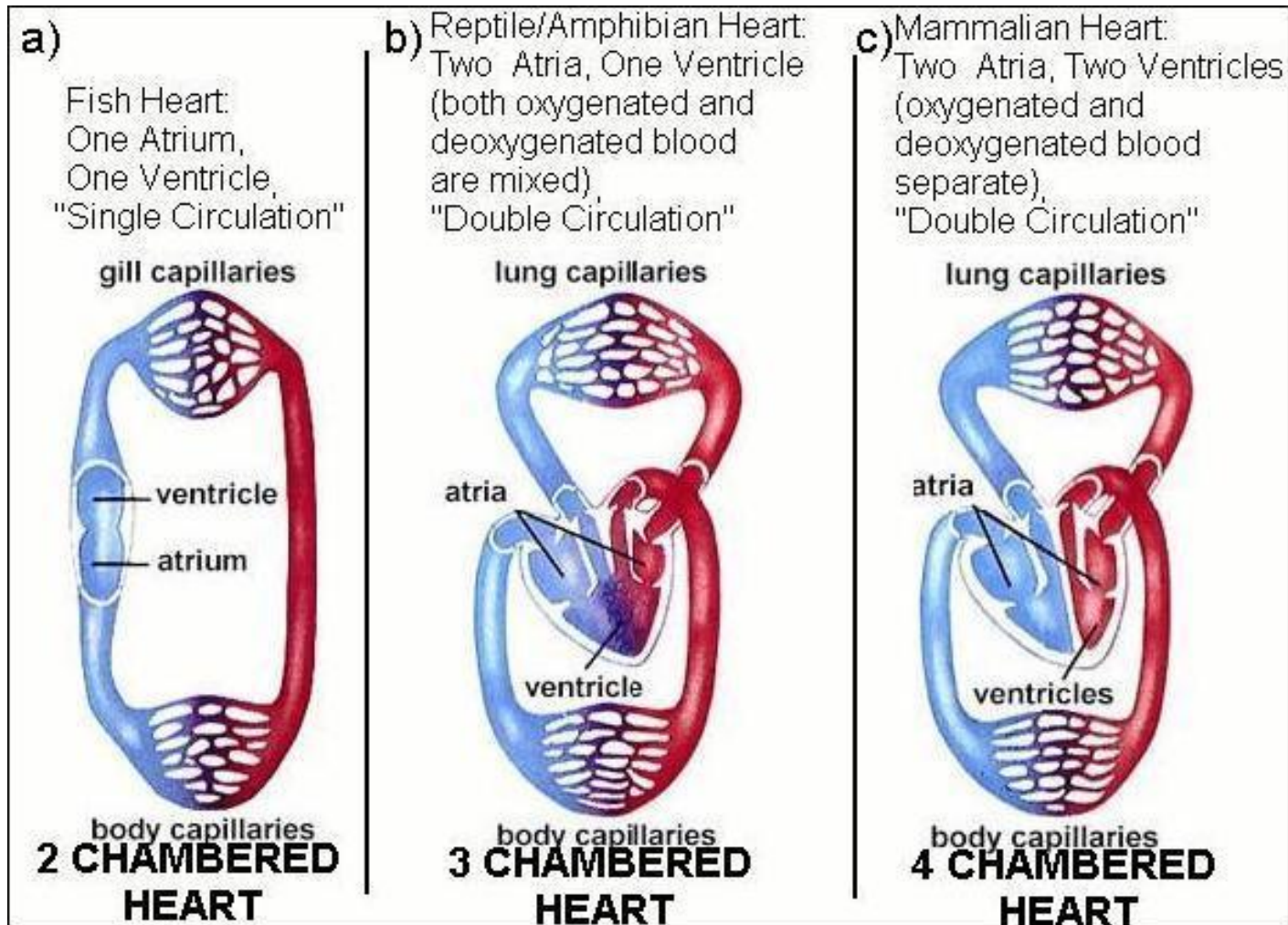
Vertebrates, and a few invertebrates, have a closed circulatory system. Closed circulatory systems have the blood closed at all times within vessels of different size and wall thickness. In this type of system, blood is pumped by a heart through vessels, and does not normally fill body cavities.

Open circulatory system



The open circulatory system is common to **molluscs** and **arthropods**. Open circulatory systems (evolved in crustaceans, insects, mollusks & other invertebrates) heart pump blood into a hemocoel with the blood diffusing back to the circulatory system between cells. Blood is pumped by a heart into the body cavities, where tissues are surrounded by the blood.

There are 3 basic type of heart found in vertebrates: a **2 chambered** heart, a **3 chambered** heart, and a **4 chambered** heart. **Fish have 2 chambers, one atrium and one ventricle.** Amphibians and reptiles have 3 chambers: 2 atria and a ventricle. Crocodiles are the one reptilian exception, as they have 4 chambers (2 atria, 2 ventricles). Birds and mammals have 4 chambers (2 atria and 2 ventricles).



Single vs. Double Circulation

Single Circulation

- Blood flows only once through the heart during one cycle of passage through the body.
- **Fish have a single circulation system.**
- Only venous blood passes through the heart

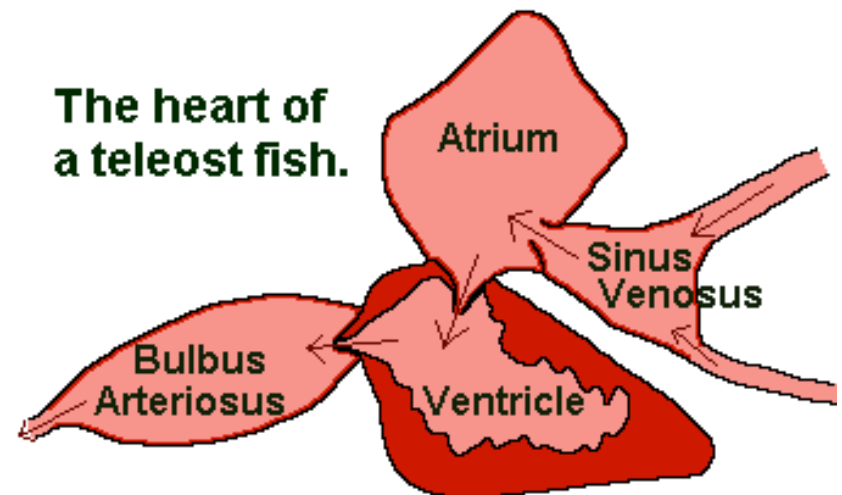
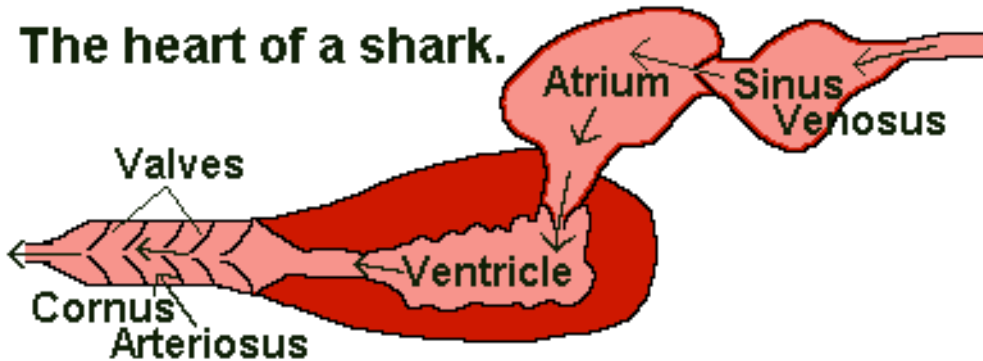
Double Circulation

- Blood flows twice through the heart during one cycle of passage through the body.
- The **double circulatory system** of blood flow refers to the separate systems of pulmonary circulation and the systemic circulation in **amphibians, birds and mammals.**
- Mixed or oxygenated or venous blood passes through the heart.

Circulatory system in fishes

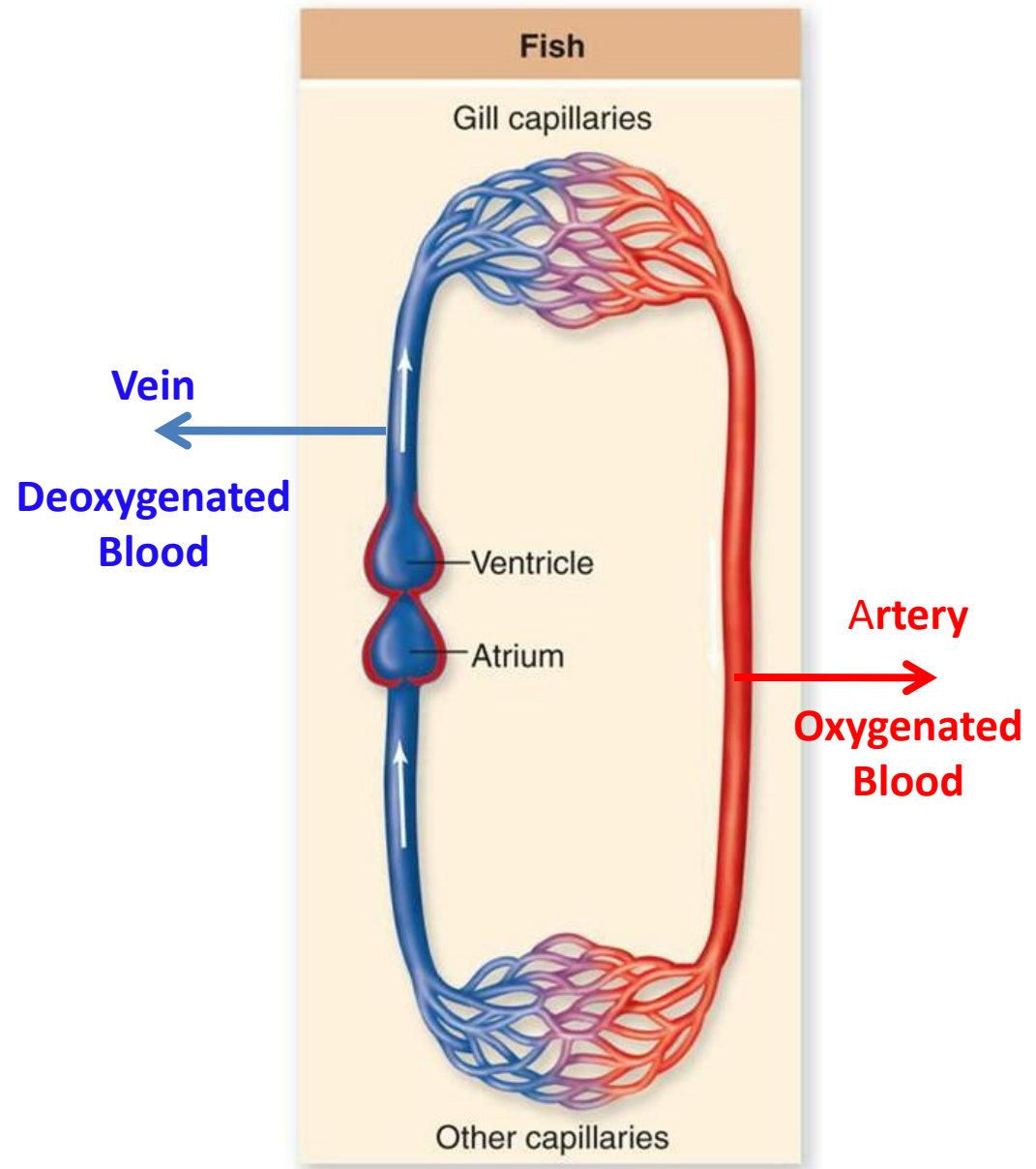
Fishes are cold-blooded aquatic vertebrates and can be found in both saline and fresh water. The circulatory system of fishes is responsible for transporting blood and nutrients throughout the body. It has a closed circulatory system, i.e. blood travels across the body through the network of blood vessels.

Fish heart carry only deoxygenated blood that is why it is called as **Venous heart**.



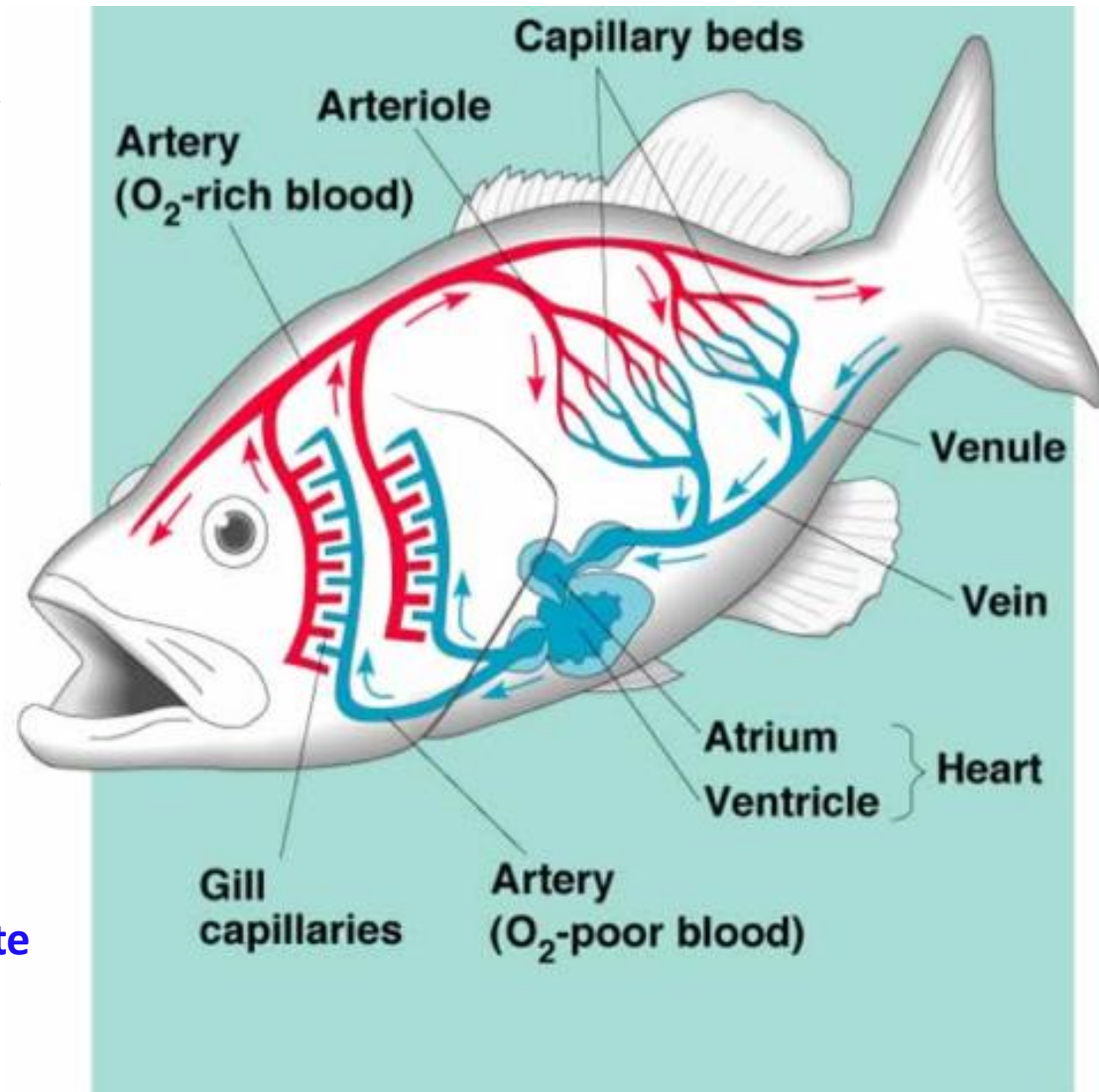
Blood vessels

The blood vessels are of two types, arteries and veins. The arteries are responsible for carrying oxygenated blood from the heart to the rest of the body, while the veins return deoxygenated blood from the different parts of the body to the heart.



Circulatory system in fish

Fish have a closed circulatory system with a heart that pumps blood around the body in a single loop—from the heart to the gills, from the gills to the rest of the body, and then back to the heart. The fish's heart consists of four parts: the sinus venosus, atrium, ventricle, and the bulbus arteriosus.



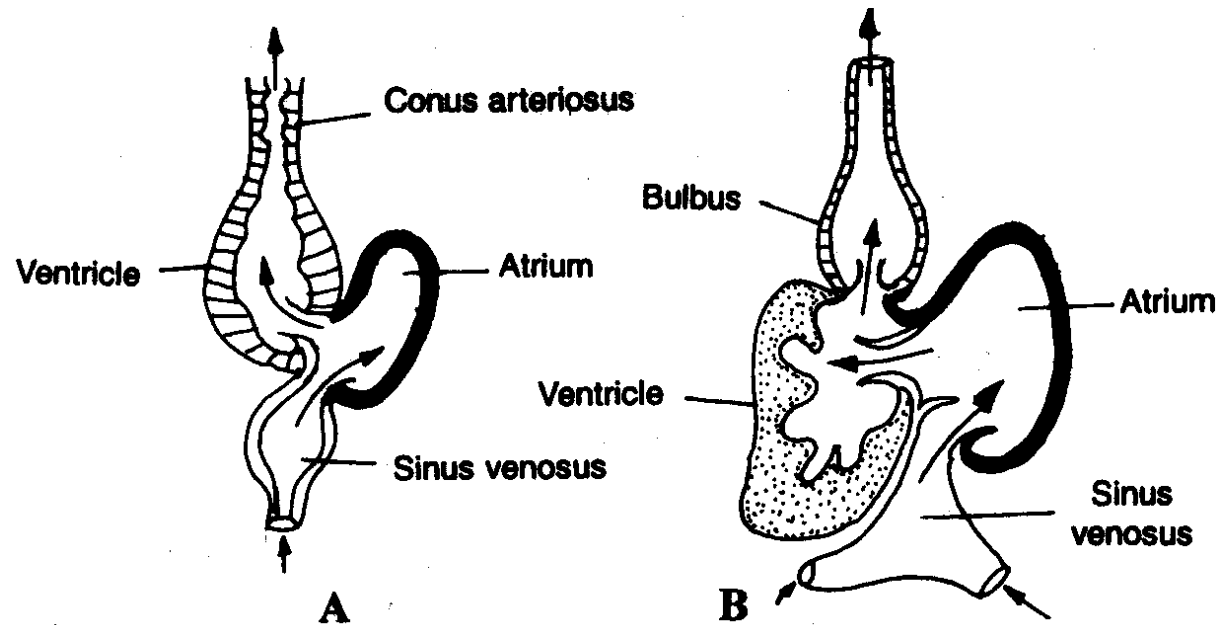
The circulatory system of fish is quite simple and consists of

- Heart
- Blood
- Blood Vessels

The Heart

□ In fishes, heart is a simple, two chambered, muscular structure that is located below the pharynx and immediately behind the gills. It is enclosed by the pericardial membrane or pericardium.

□ In most of the fishes, the heart consists of an atrium, a ventricle, a sac-like thin walled structure known as sinus venosus and a tube, known as bulbus arteriosus.



Heart of A Chondrichthyes, and B Teleost.

Sinus venosus: The first chamber is called the sinus venosus, it is the preliminary collecting chamber. In teleosts it is filled from two major veins called the hepatic veins and the left and right branches of the Curvierian ducts which in turn collect blood from the paired (left and right) lateral veins the inferior jugulars, the anterior cardinals and the posterior cardinals. However in the elasmobranchs only one hepatic vein leads into it.

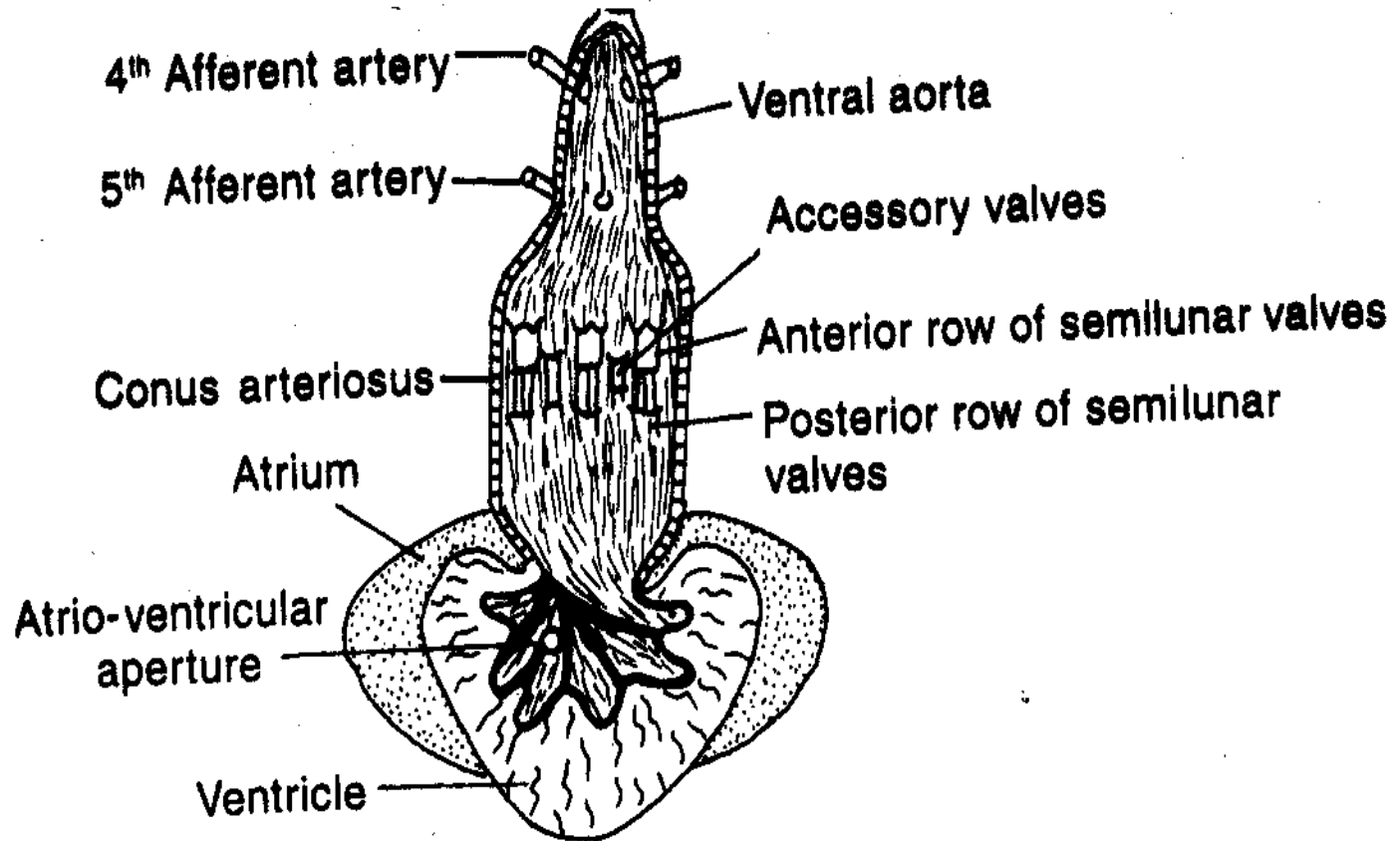
Atrium. From the sinus venosus the blood flows into the atrium. the atrium is the largest of the chambers and weakly muscular. It pushes the blood, with weak contractions in the ventricle.

Ventricle. The ventricle is the only well muscled chamber, nearly as large as the atrium it is the work horse of the heart, its contractions drive the blood around the body.

Bulbus arteriosus

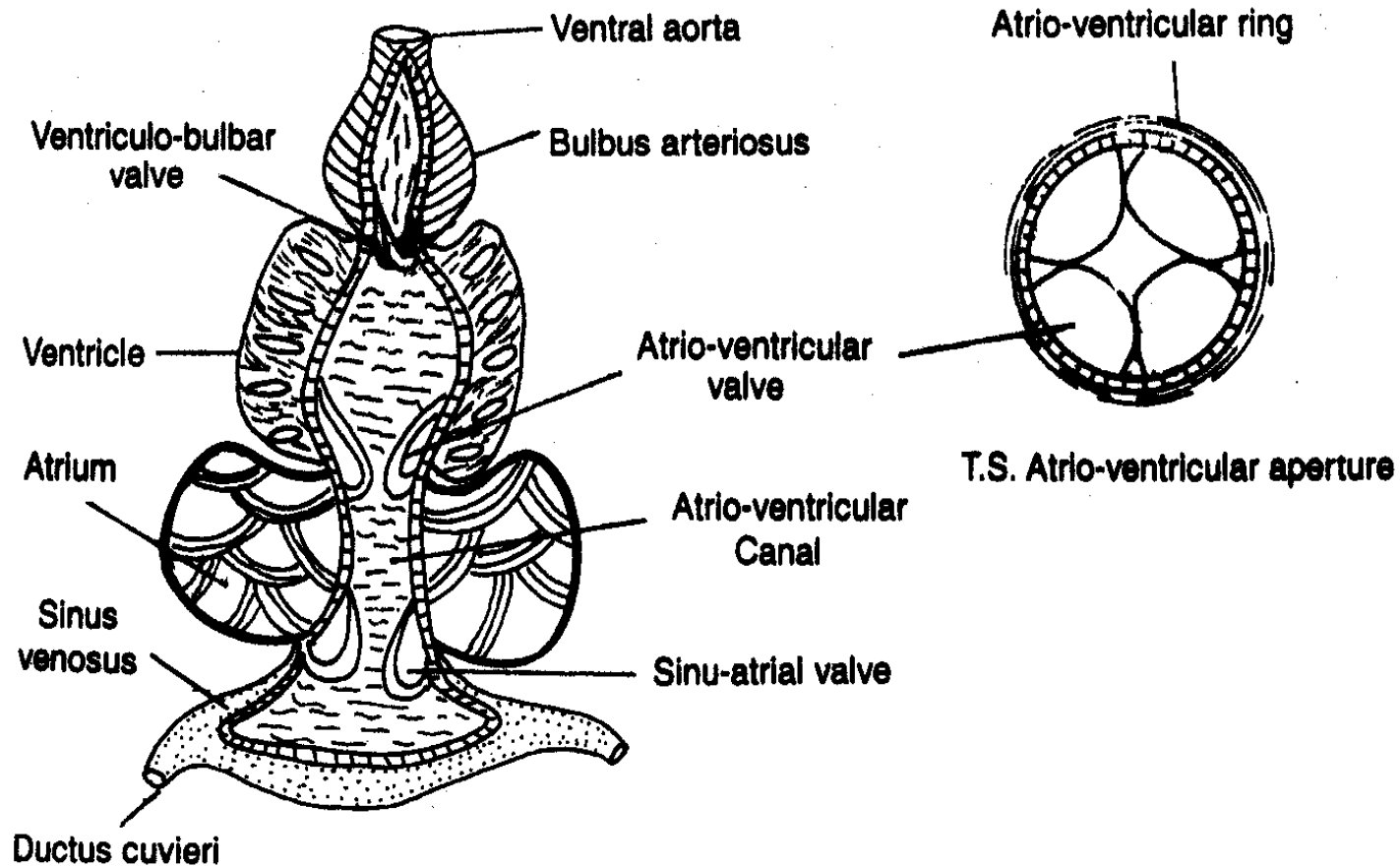
The last chamber of the fish heart is called the bulbus arteriosus in the teleosts, but the conus arteriosus in the elasmobranchs. The difference between these chambers is that the conus arteriosus of sharks and rays contains many valves while the bulbus arteriosus of bony fish contains none. Both are alike in being primarily elastic and work to reduce the pulsed nature of the blood leaving the ventricle giving it a more even, constant flow.

Internal Structure of chondrichthys heart



Heart of *Scoliodon* dissected to show the internal structure.

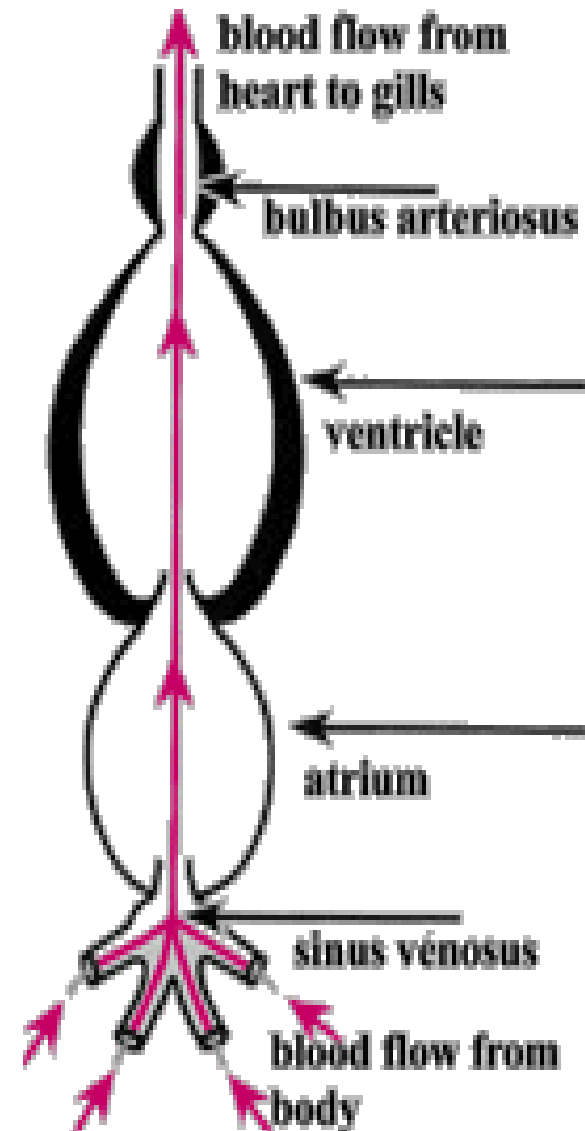
Internal Structure of bony fish heart



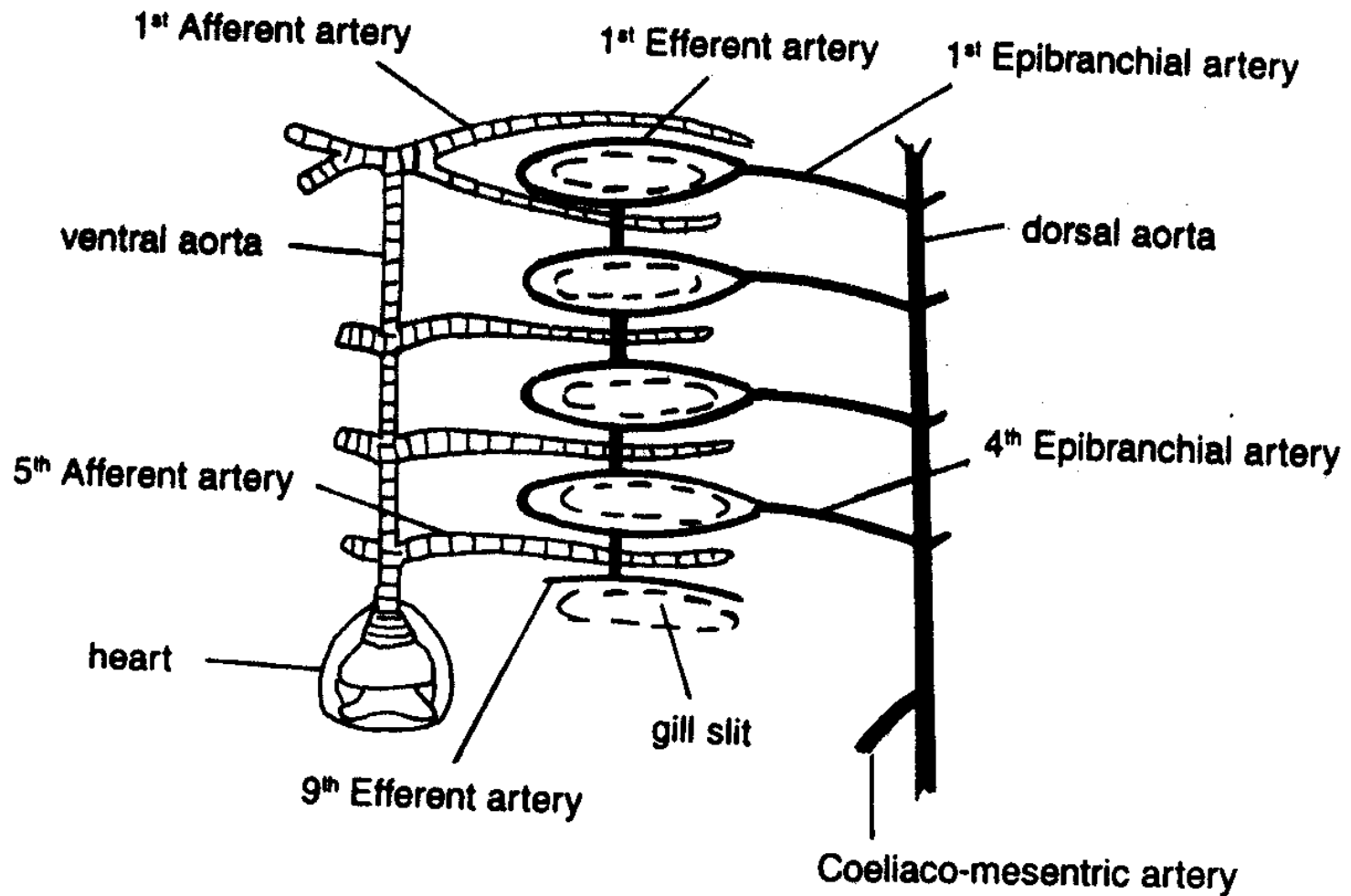
Heart of *Tor tor* dissected to show internal structure.

Circulatory mechanism

The deoxygenated blood collected by the veins accumulates in the sinus venosus, before entering the heart. Blood first enters the atrium of the heart, which is a large chamber. Then it enters the ventricle, from where it is pumped into the tube, bulbus arteriosus. Through bulbus arteriosus, the blood reaches the aorta and then the gills. They facilitate the exchange of gases, i.e. absorption of oxygen from water and elimination of carbon dioxide. Then the oxygenated blood is transported throughout the body with the help of blood vessels. Blood facilitates the transport of oxygen and nutrients. It also collects carbon dioxide which is again transported to the heart and then to the gills, to be removed from the body.

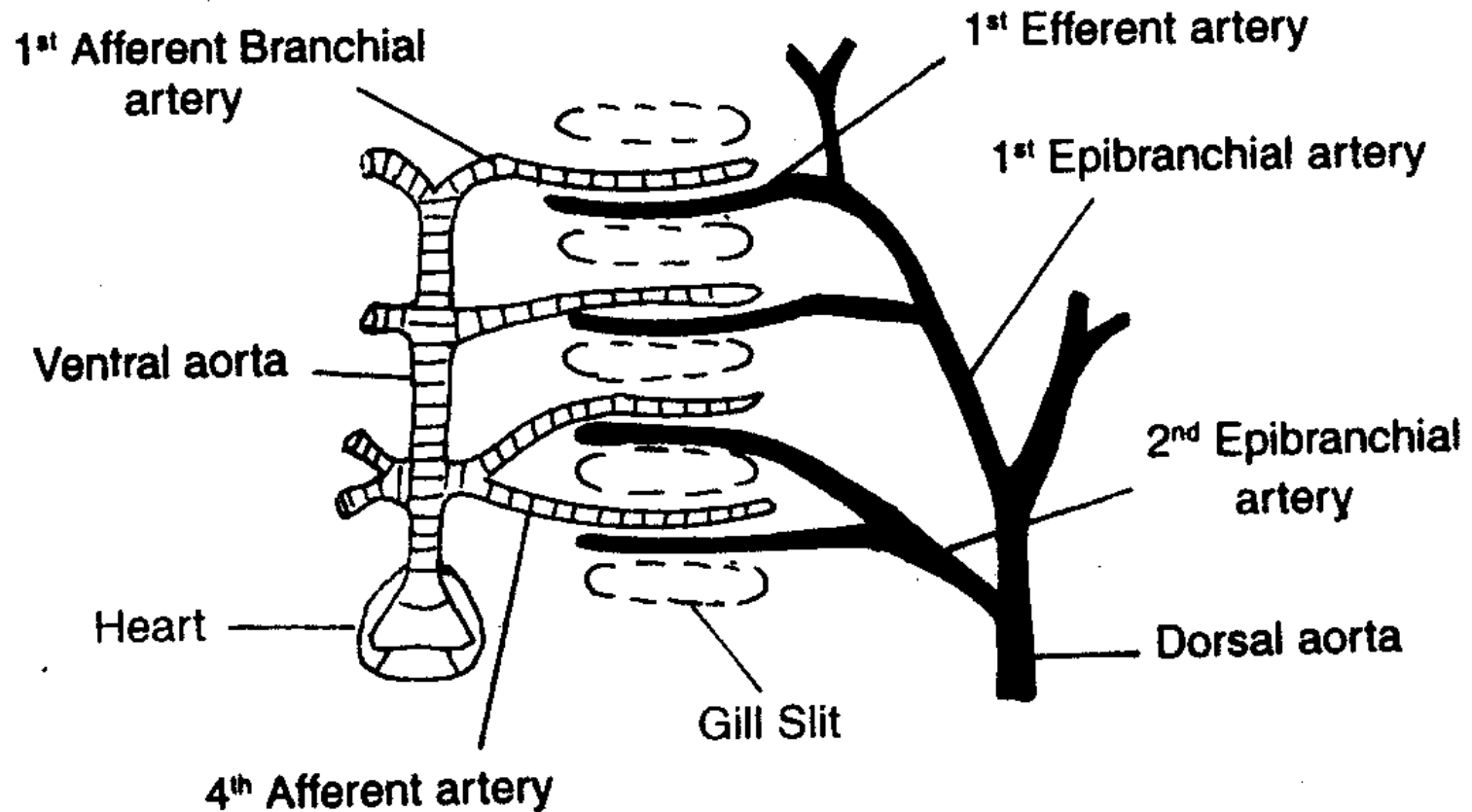


Artery system in Elasmobranchs



Afferent and Efferent branchial arteries of *Scoliodon*.

Artery system in Bony fish



Afferent and efferent branchial arteries of Mahseer (*Tor putitora*).

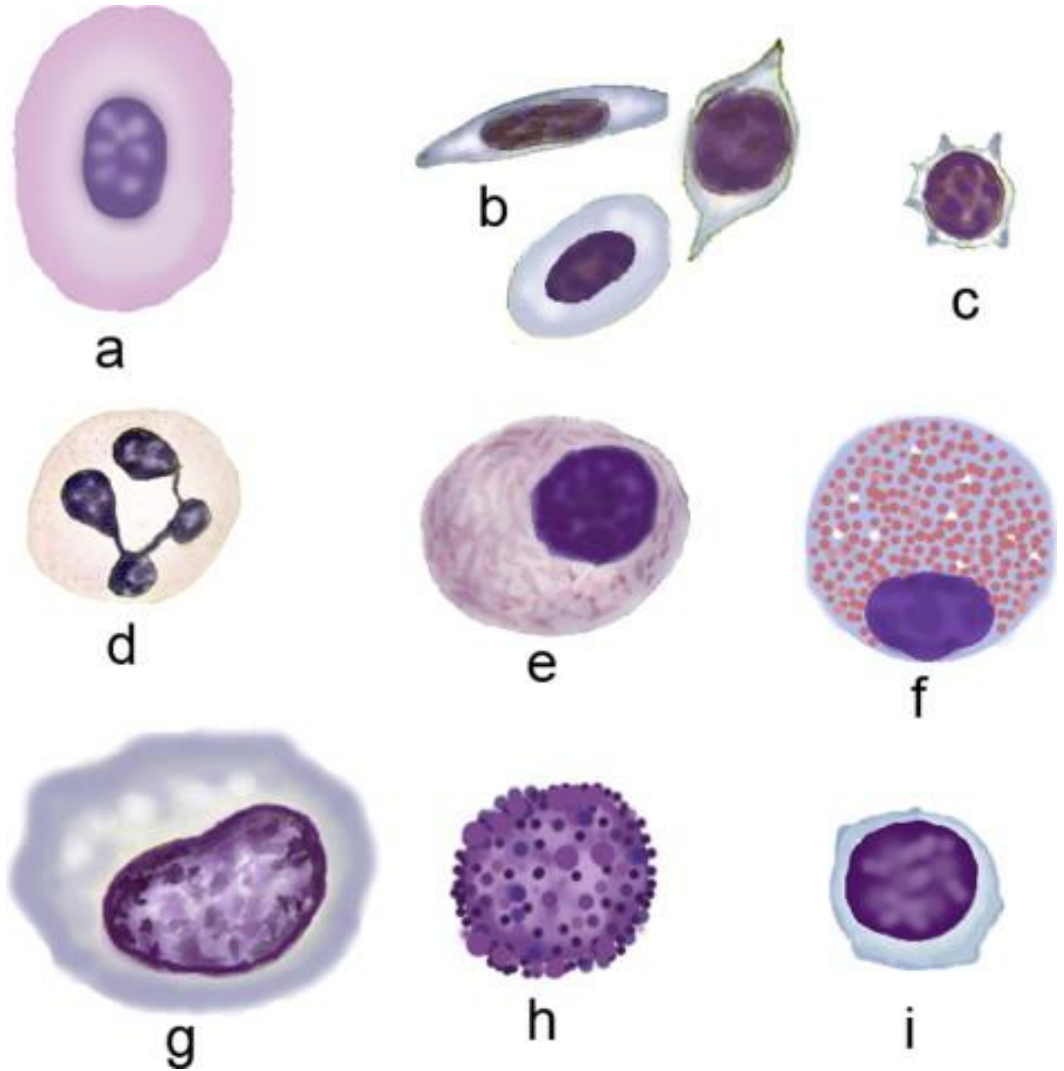
Blood cells of fishes

The blood in fishes is red in color and consist of fluid plasma and blood cells. Red Blood cells, White Blood Cells and Thrombocytes are present in plasma

RBC (erythrocytes) are nucleated, oval and contain haemoglobin

The WBCs may be grannular or agranular. They are called basophils, acidophils, neutrophils, monocytes and lymphocytes

Thrombocytes (responsible for blood coagulation)



Erythrocyte (a), normal (b) and activated (c) thrombocytes, neutrophil of trout (d), heterophil of shark (e), eosinophil (f), monocyte (g), basophil (h), and lymphocyte (i).

Hemoglobin

- ✓ Hemoglobin is a **tetrameric** molecule in most teleost fishes
- ✓ Agnathans (lampreys & Hag fishes) possess **monomeric** hemoglobin
- ✓ Antarctic fishes (Ice fish) **do not have hemoglobin**



Teleost



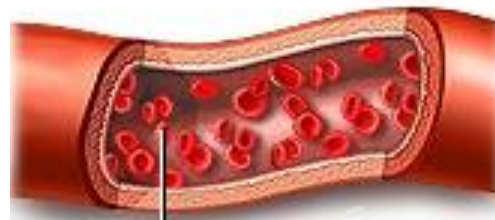
Hag Fish



Ice Fish

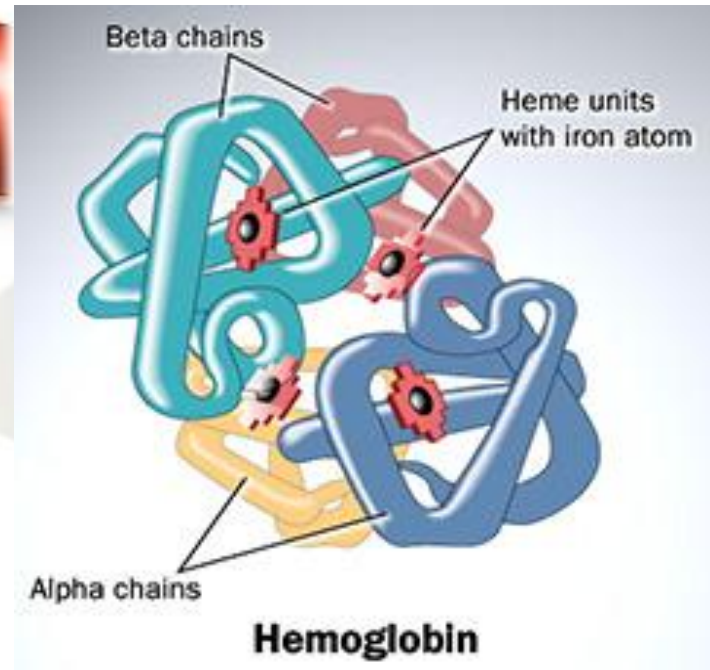
Respiratory Pigment in Fishes: Hemoglobin

- ✓ Tetrameric hemoglobin has two α and two β chain
- ✓ O_2 bind in reversible and cooperative fashion to four heme group while H^+ and CO_2 bind to specific amino acid residues in the globin chains
- ✓ But in fishes, due to acetylation of α amino group only β chain available in bind to CO_2



Red blood cell

Red blood cells contain several hundred thousand hemoglobin molecules, which transport oxygen



Oxygen binds to heme on the hemoglobin molecule