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# Circulation

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# Peristaltic pumps or Chamber pumps

Peristaltic pumps or Chamber pumps have contractive walls or the reduction in volume is achieved by external pressure from other body parts

Vertebrate blood is carried in a system of elastic tubes or pipes (arteries, capillaries, veins)  
vertebrate circulation as **closed circulation**



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# Major differences between closed and open circulation system

Sl.No.	Closed systems	Open systems
1.	Usually high pressure systems	Usually low pressure systems
2.	Blood conveyed directly to organs	Similar to closed systems
3.	Distribution to different organs can be regulated	Distribution of blood not ready regulated
4.	Blood returns to heart rapid	Blood returns to heart slow



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# Circulation pattern

Fish and mammals represent two extremes in vertebrate circulation



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Hag fish

# Cyclostomes

The circularly system of hag fish differs from that of all other vertebrates. It is partly an open system with a large **head sinus**, rather than a closed system as in other vertebrates



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# Shark

The heart consist of two chambers in series, on atrium and a vontride. Sinus venosus which helps assure a continous flow of blood to the heart



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# Lung fish

The major evolutionary change in lung fish is that, in addition to gills, they have lungs as respiratory organs

The caudal hearts of the hag fishes are particularly interesting because they differ in design from all other hearts, a longitudinal rod of cartilage separates



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# Cardiac output

The volume of blood pumped by the heart per unit time is usually called the cardiac output or the cardiac minute volume.





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# Crustaceans

The circulatory system of crustaceans is extremely variable small crustaceans have poorly developed circulatory systems, offer walkout any heart



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# Blood and Circulation

The blood vascular system in fishes consists of the following components

Blood

Heart

Arterial and venous system

Both RBC (erythrocytes) and WBC are formed from hemocytoblast precursor cells which may originate from a variety of organs but usually mature after they enter the bloodstream



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# Red Blood Cells (erythrocytes)

- RBC (erythrocytes) is usually the most abundant cells in fish blood (upto 3 million/cubic millimeter).
- They contain haemoglobin and largely function in carrying oxygen from the gills to the tissues
- Fish RBC's are nucleated contains hb. (Fig. 7.8) and shows a wide range of sizes among different species
- Elasmobranchs have larger red blood cells and fewer in number than teleosts



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# White Blood Cells (leucocytes)

The white blood cells varies between 20,000 to 1,50,000 per cubic millimeter of blood in different groups of fishes

**Granulocytes** are sub divided into neutrophils, acidophils and basophils based on their staining reactions

**Agranulocytes** are distinguished as lymphocytes and monocytes and are present in large numbers in blood



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There are several types of circulatory systems.

The open circulatory system

The closed circulatory system

All vertebrates possess a muscular chambered heart. Amphibians and the reptiles (except crocodiles) have a 3-chambered heart with two atria and a single ventricle, whereas crocodiles, birds and mammals possess a 4-chambered heart with two atria and two ventricles



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Fish heart is regarded as a 2 chambered structure owing to the presence of the true chambers viz

**Single Circulation**

**Incomplete Double Circulation**

**Complete Double Circulation**



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# Comparative anatomy of heart

## Elasmobranchs

The heart of *Scoliodon* consists of 4 chambers

The sinus is a thin walled chamber at the base of the pericardial cavity and receives blood through a sinu-auricular aperture guarded by a pair of membranous valves, which are so designed to prevent backward flow of blood

The ventricle has thick, muscular and spongy walls and continues into the tubular conus which extend upto the anterior end of the pericardial cavity



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# Teleosts

The heart in several cyprinids like *L. rohita*, *C. catla*, *C. mrigala* and *Tor* has the same general structure

The heart of mahseer is relatively large in size and consists of sinus venosus, atrium or auricle, ventricle and the bulbus arteriosus

The ventricle has thick muscular walls and a narrow lumen leading into the bulbus arteriosus





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# Shellfishes

The open circulatory system, examples of which are common to molluscs and arthropods

Blue blood, containing the pigment hemocyanin as its oxygen-capturing molecule instead of red hemoglobin, is pumped from the heart through blood vessels that lead to the various organs of the body

Arthropods and most mollusks (except cephalopods : nautilus, squid, octopus) have an open circulatory system



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# Function of plasma

- Transport of products of digestion from small intestine to various tissues
- Transport of excretory products from tissues to excretory organs
- Transport of hormones from endocrine glands to target organs
- Provides factors for clotting of blood (fibrinogen)
- Unlike hemoglobin, hemocyanin is not stored in a cell but flows freely in the blood



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hemocyanin blood is a beautiful blue in the arteries  
and as clear and colorless as water in the veins



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# Circulatory system of cephalopods - Heart

- The *Nautilus* sp. has a heart with four auricle, while the decapoda and octopoda, has a heart with only two auricles
- This difference is connected with the difference in the number of the ctenidia, four in *Nautilus* (tetrabranchia), two in the *Decapoda* and *Octopoda* (Dibranchia)
- The strongly muscular ventricle of the *Dibranchia* is almost always elongated into a tube



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# Circulatory system of crustaceans - Introduction

In lobster the blood is called as hemolymph and the circulating system involving cells are called as hemocytes

Although there is an elaborate system of vessels carrying hemolymph from the heart to the tissues, the vessels eventually terminate



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# Circulation - Hemolymph flow

In crustaceans, hemolymph flows from the heart to the body, then to the gills and back to the heart

Contraction of the heart pumps hemolymph through seven arteries include the ophthalmic (cephalic, median, anterior aorta), the paired antennal, and the paired hepatic arteries