CARDIAC SYSTEM

Content Statements:

B3.2.14 Differences between the single circulation of bony fish and the double circulation of mammals

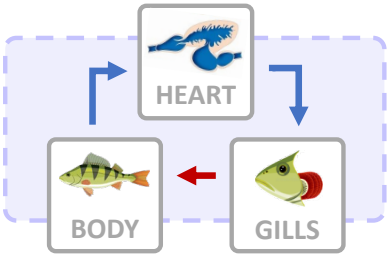
B3.2.15 Adaptations of the mammalian heart for delivering pressurised blood to the arteries

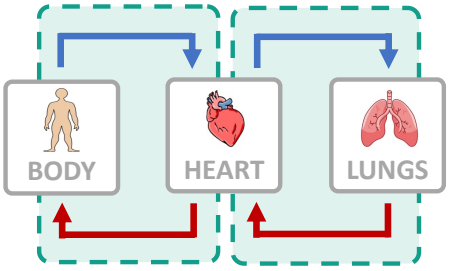
B3.2.16 Stages in the cardiac cycle

D3.3.11 Changes in blood supply to organs in response to changes in activity

CIRCULATION

All vertebrate animals possess a circulatory system to transport materials between cells in the body. This is a closed system consisting of a continuous network of vessels (arteries → capillaries → veins). A **heart** acts as a muscular pump that moves the blood via rhythmical contractions. Certain animals (such as bony fish) have a single circulation system, whereby blood flows through a two-chambered heart only once per cycle. Mammals have a double circulation system, whereby a four-chambered heart moves blood twice per cycle.





Circulation Systems:

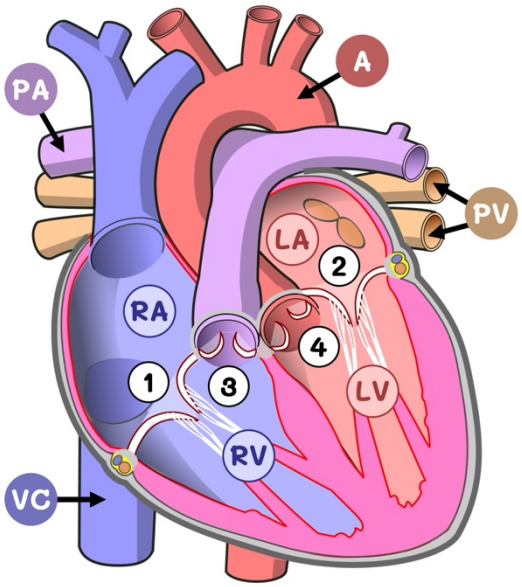
Single circulation systems (left) are less efficient but require less energy than double circulation (right)

HEART STRUCTURE

Mammalian hearts are muscular organs that have two sides (left and right) separated by a central **septum**.

- The left side acts to transport deoxygenated blood from the body to the lungs (pulmonary circulation)
- The right side will transport oxygenated blood from the lungs to the body tissues (systemic circulation)

Each side contains two chambers – small *atria* collect blood, while *ventricles* pump blood from the heart. **Heart valves** prevent backflow and the heart is nourished by **coronary arteries** that surround its surface.



Chambers:

RA = Right Atrium
LA = Left Atrium
RV = Right Ventricle
LV = Left Ventricle

Vessels:

VC = Vena Cava
PV = Pulmonary Vein
PA = Pulmonary Artery
A = Aorta

Heart Valves:

1 = Tricuspid (AV)
3 = Pulmonary (semilunar)
2 = Bicuspid (AV)
4 = Aortic (semilunar)

Note: Heart is drawn as is seen in the chest (left = right)

HEART BEAT

The contraction of the heart is **myogenic** – meaning that the signal for compression arises within the heart. Within the wall of the right atrium is a pacemaker called the **sinoatrial node**, which will initiate contraction. The SA node sends out electrical impulses that causes the atria to contract and also stimulate another node located at the junction between the atria and ventricles (**atrioventricular node**). The AV node sends signals down the septum via the **bundle of His** and innervate **Purkinje fibres** in the ventricles, causing contraction. The delay between atrial and ventricular contractions allows time for the ventricles to fill with atrial blood.

CARDIAC CYCLE

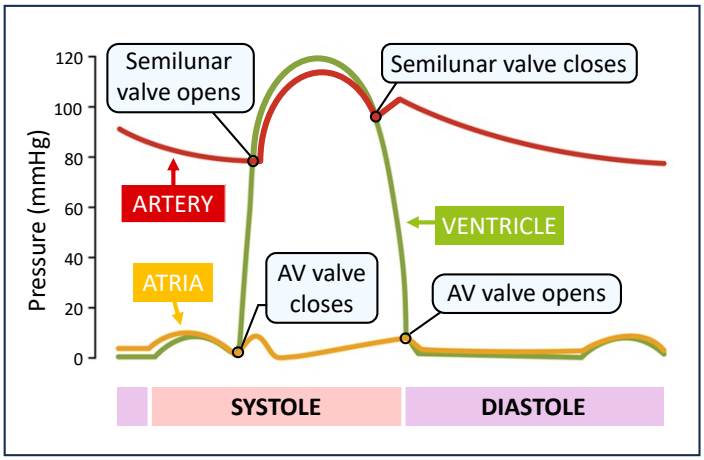
The series of events that take place over the duration of a single heart beat is called the cardiac cycle. It is comprised of two connected stages – a period of contraction (**systole**) and a period of relaxation (**diastole**).

Systole:

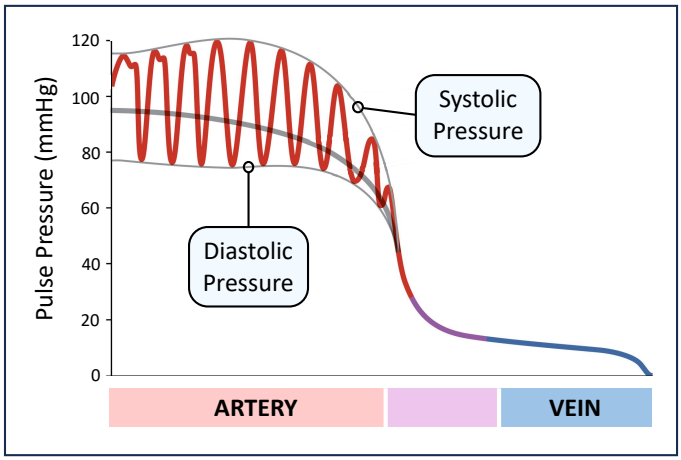
Blood returning to the heart will flow in the atria and ventricles as the pressure inside them is lower (due to low blood volume). As the heart chambers fill with blood, atria contract and force blood into the ventricles. As the ventricles contract, ventricular pressure builds and the **atrioventricular valves** close to prevent the backflow of blood into the atria. This creates the first heart sound. When ventricular pressure exceeds the blood pressure in the arteries, blood is pumped from the heart (pulmonary artery → lungs, aorta → body).

Diastole:

As blood exits the heart and the ventricles relax, the pressure starts to fall. When ventricular pressure falls below arterial pressure, the **semilunar valves** will close to prevent the backflow of blood into the ventricles. This creates the second heart sound. When the ventricular pressure drops below the atrial pressure, the AV valves will open and allow blood to flow once more from atria to ventricles (beginning a new cardiac cycle). Throughout the cardiac cycle, arterial pressure remains high as the elastic fibres within the artery wall will expand and then recoil in response the flow of a pulse through the vessel. This maintains a steady pressure.



Blood pressure changes within the **heart**



Blood pressure changes within the **vessels**

BLOOD SUPPLY

The blood pumped by the heart is not made equally available to all body tissues but is distributed according to need. Blood flow can be regulated by changing the diameter of arteries (vasoconstriction / vasodilation), while **precapillary sphincters** can open or close to control the amount of blood that enters a capillary bed.

- **Sleeping** – Blood flow to skeletal muscles is reduced, but blood flow to brain may increase (REM sleep)
- **Exercise** – Blood flow to skeletal muscles is greatly increased, while blood to kidneys and gut is reduced
- **Wakeful Rest** – There is moderate blood flow to the kidneys and gut but blood flow to muscles will vary