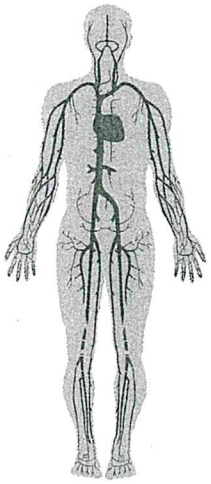
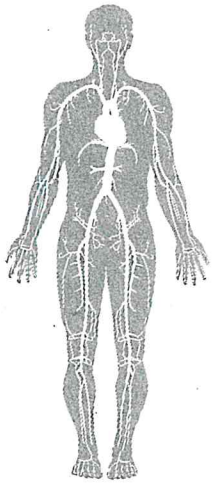
The Human Transport System

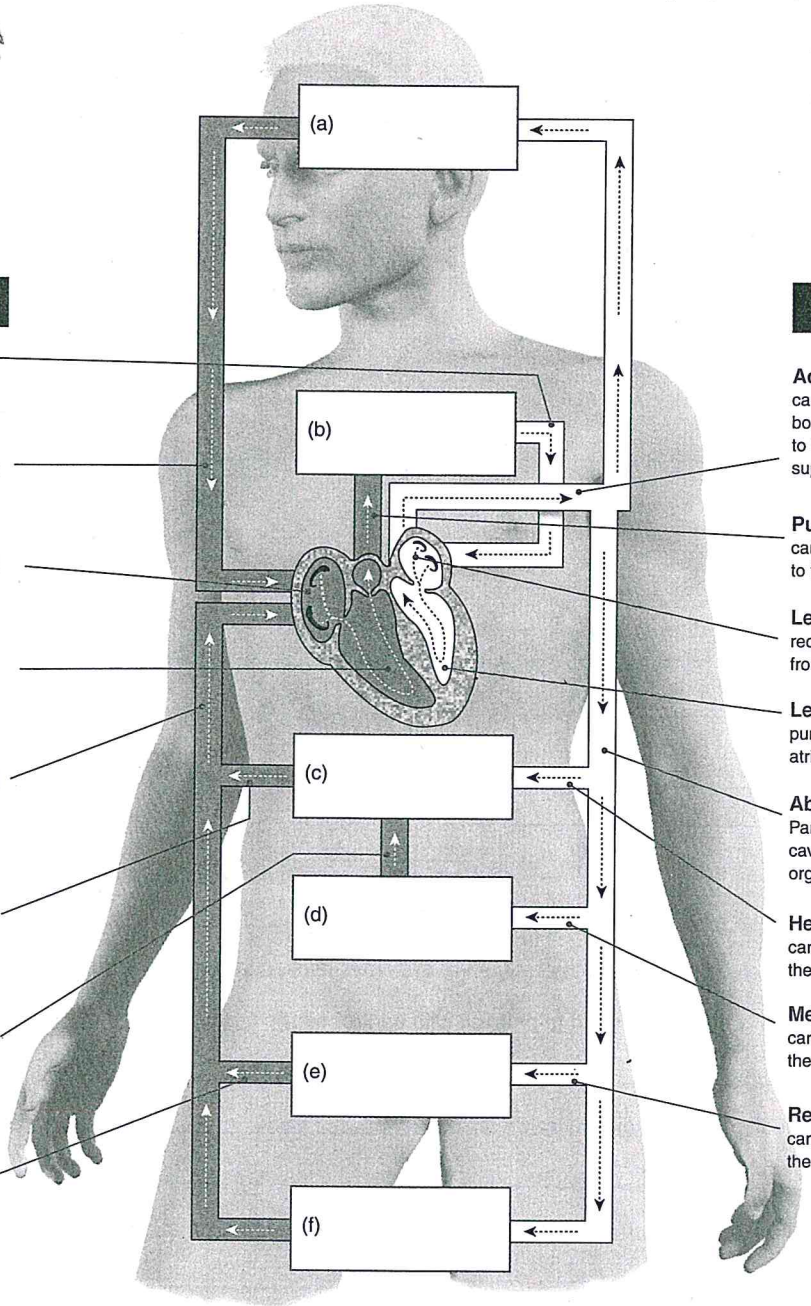
The blood vessels of the circulatory system form a vast network of tubes that carry blood away from the heart, transport it to the tissues of the body, and then return it to the heart. The arteries, arterioles, capillaries, venules, and veins are organized into specific routes to circulate the blood throughout the body. The figure below shows a number of the basic **circulatory routes** through which the blood travels. Mammals have a **double circulatory system**: a **pulmonary system** (or circulation), which carries blood between the heart and lungs, and a **systemic system** (circulation), which carries blood between the heart and the rest of the body. The systemic circulation has many subdivisions. Two important subdivisions are the coronary (cardiac) circulation, which supplies the heart muscle, and the **hepatic portal circulation**, which runs from the gut to the liver.



Schematic Overview of the Human Circulatory System

Deoxygenated blood (coloured grey below) travels to the right side of the heart via the vena cavae. The heart pumps the deoxygenated blood to the lungs where it releases carbon dioxide and receives oxygen. The oxygenated blood (coloured white below) travels via the pulmonary vein back to the heart from where it is pumped to all parts of the body. The **venous system** (figure, left) returns blood from the capillaries to the heart. The **arterial system** (figure right) carries blood from the heart to the capillaries. **Portal systems** carry blood between two capillary beds.





VENOUS SYSTEM

Pulmonary vein
carries oxygenated blood back to the heart.

Superior vena cava
receives deoxygenated blood from the head and body.

Right atrium
receives deoxygenated blood via the superior and inferior vena cavae.

Right ventricle
pumps deoxygenated blood to the lungs.

Inferior vena cava
receives deoxygenated blood from the lower body and organs.

Hepatic vein
carries deoxygenated blood from the liver.

Hepatic portal vein
carries deoxygenated, nutrient rich blood from the gut for processing.

Renal vein
carries deoxygenated blood from the kidneys.

ARTERIAL SYSTEM

Aorta
carries oxygenated blood to the body. Anteriorly, it branches to form the carotid arteries supplying the head and neck.

Pulmonary artery
carries deoxygenated blood to the lungs.

Left atrium
receives oxygenated blood from the lungs.

Left ventricle
pumps blood from the left atrium to the aorta.

Abdominal aorta
Parallel to the inferior vena cava, branching to supply the organs of the abdominal cavity.

Hepatic artery
carries oxygenated blood to the liver.

Mesenteric artery
carries oxygenated blood to the gut.

Renal artery
carries oxygenated blood to the kidneys.

1. Complete the diagram above by labeling the boxes with the organs or structures they represent.

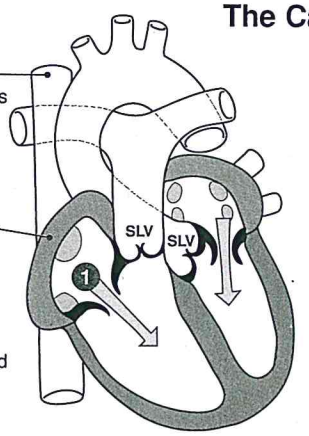
The Cardiac Cycle

The heart pumps with alternate contractions (**systole**) and relaxations (**diastole**). The **cardiac cycle** refers to the sequence of events of a heartbeat and involves three main stages: atrial systole, ventricular systole, and complete cardiac diastole. Pressure changes within the heart's chambers generated by the cycle of contraction and relaxation are responsible for blood movement and cause the heart valves to open and close, preventing the backflow of blood. The noise of the blood when the valves open and close produces the heartbeat sound (**lubb-dupp**). The heart beat occurs in response to electrical impulses, which can be recorded as a trace, called an **electrocardiogram** or **ECG**. The ECG pattern is the result of the different impulses produced at each phase of the cardiac cycle, and each part is identified with a letter code. An ECG provides a useful method of monitoring changes in heart rate and activity and detection of heart disorders. The electrical trace is accompanied by volume and pressure changes (below).

The Cardiac Cycle

The **pulse** results from the rhythmic expansion of the arteries as the blood spurts from the left ventricle. Pulse rate therefore corresponds to heart rate.

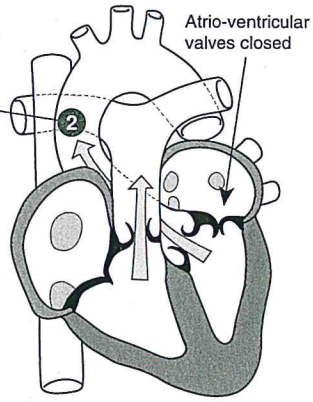
Stage 1: Atrial contraction and ventricular filling
The ventricles relax and blood flows into them from the atria. Note that 70% of the blood from the atria flows passively into the ventricles. It is during the last third of ventricular filling that the atria contract.



Heart during ventricular filling

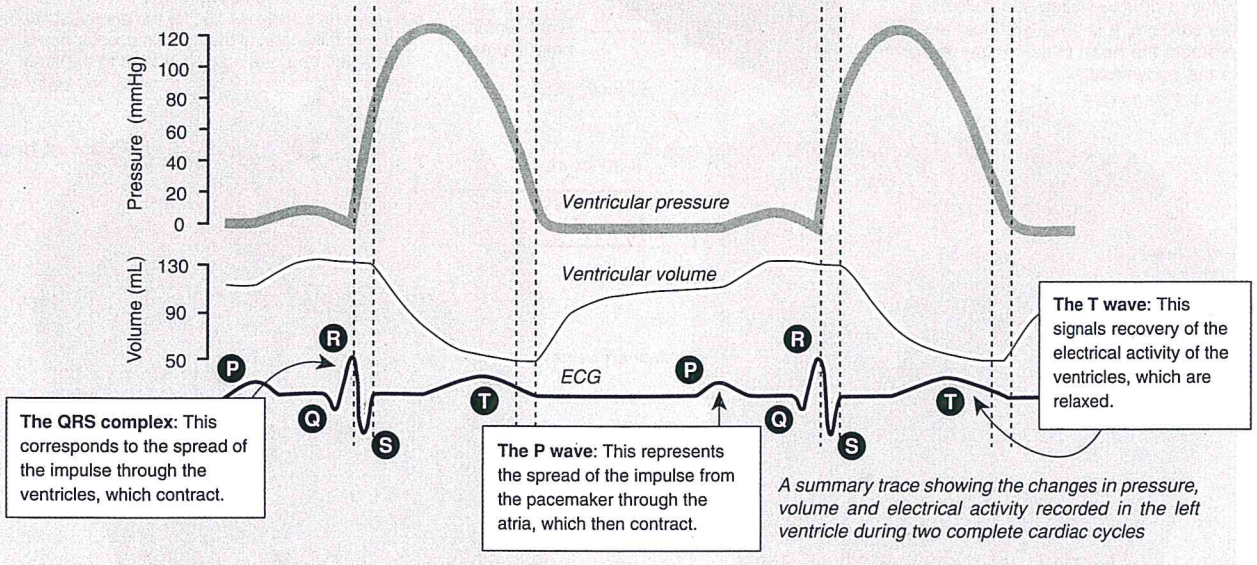
Stage 2: Ventricular contraction
The atria relax, the ventricles contract, and blood is pumped from the ventricles into the aorta and the pulmonary artery. The start of ventricular contraction coincides with the first heart sound.

Stage 3: (not shown) There is a short period of atrial and ventricular relaxation. Semilunar valves (**SLV**) close to prevent backflow into the ventricles (see diagram, left). The cycle begins again. For a heart beating at 75 beats per minute, one cardiac cycle lasts about 0.8 seconds.



Heart during ventricular contraction

Cardiac Cycle Events in the Left Ventricle



A summary trace showing the changes in pressure, volume and electrical activity recorded in the left ventricle during two complete cardiac cycles

1. Identify each of the following phases of an ECG by its international code:

   (a) Excitation of the ventricles and ventricular systole: _____

   (b) Electrical recovery of the ventricles and ventricular diastole: _____

   (c) Excitation of the atria and atrial systole: _____

2. Suggest the physiological reason for the period of electrical recovery experienced each cycle (the T wave):

   _____

3. Using the letters indicated, mark the points on trace above corresponding to each of the following:

   (a) E: Ejection of blood from the ventricle

   (b) AVC: Closing of the atrioventricular valve

   (c) FV: Filling of the ventricle

   (d) AVO: Opening of the atrioventricular valve