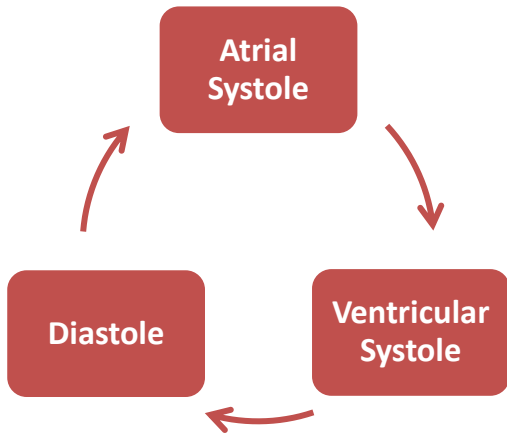


2.7

THE CARDIAC CYCLE

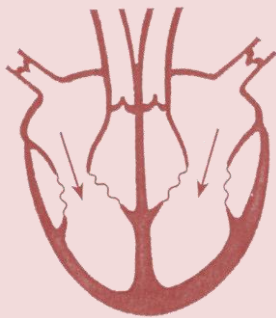
The cycle sequence of the heart beat and control of the cardiac cycle of the mammalian heart

The **cardiac cycle** refers to the sequence of events of a heartbeat. The pumping of the heart consists of alternate contractions (**systole**) and relaxations (**diastole**). During each complete cycle, each chamber of the heart undergoes a systole and a diastole.

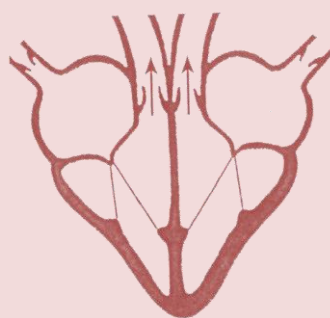


During **atrial systole** the atria contract, which pushes blood into the currently relaxed ventricles. The ventricles contract and push blood out through the arteries in **ventricular systole**. At this stage, the atrioventricular valves close to prevent blood flowing back into the atria.

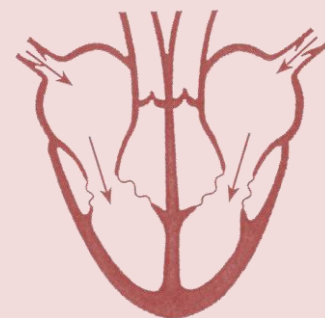
Atrial diastole happens whenever atrial systole is not happening, and similarly *ventricular diastole* happens whenever ventricular systole is not currently happening. When these two diastoles overlap, the period of the cycle is generally named **diastole**. Here, all chambers are relaxed and blood flows into the atria (and some into ventricles). The semilunar valves prevent the back flow of blood into the ventricles.



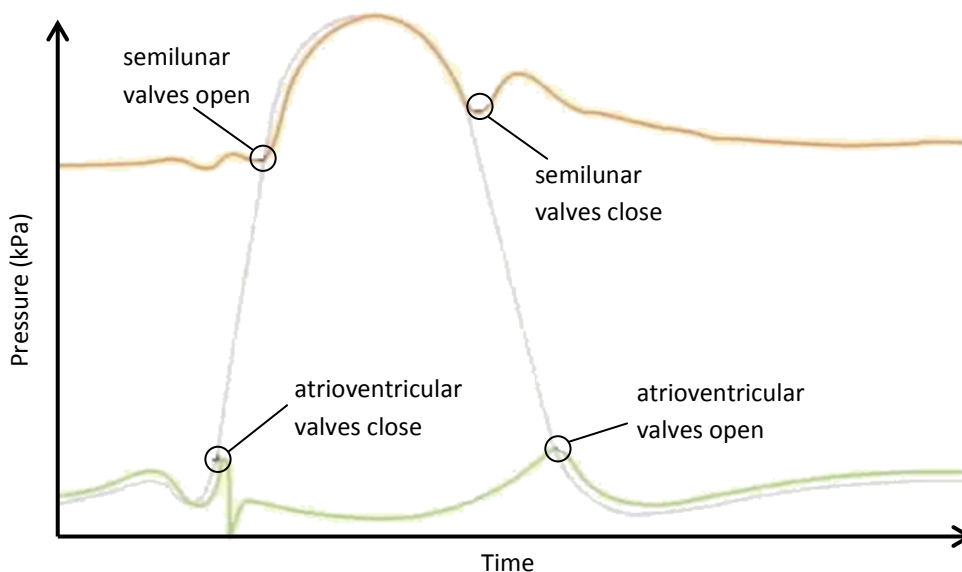
Atrial systole: Both atria contract. Blood flows from the atria into the ventricles. Backflow of blood into the vein is prevented by closure of the valves in the veins



Ventricular systole: Both ventricles contract. The atrio-ventricular valves are pushed shut by pressurised blood in the ventricles. Blood flows from the ventricles into the arteries



Diastole: Atria and ventricles relax. The semilunar valves have been pushed shut. Blood flows from the veins through the atria and into the ventricles



KEY:
 Left atrium
 Left ventricle
 Aorta

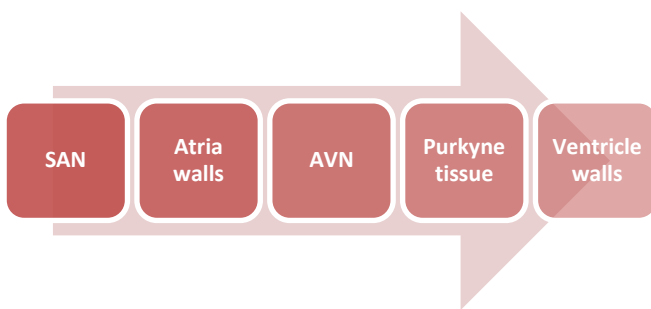
The graph on the previous page shows pressure changes in the heart throughout the various stages in the cardiac cycle. To understand whereabouts the three stages happen in the graph, note that:

- Atrial systole runs until the atrioventricular valves close
- Ventricular systole runs from when the atrioventricular valves close to when the semilunar valves close
- Diastole runs from when the semilunar valves close to the beginning of atrial systole

Heart muscle is very different from other muscles in the body. It is **myogenic**. This means that it *naturally* contracts and relaxes and does not need to receive nerve impulses to make it contract. **Cardiac muscle** can contract indefinitely without suffering fatigue. It is also **involuntary**, in that it does not have to (and indeed cannot be) controlled voluntarily.

Heart muscle will contract even in the absence of nervous signal. However, signals from the brain are used to control the rate at which these contractions occur. The cardiac cycle is initiated in a specialised patch of muscle in the wall of the right atrium, called the **sinoatrial node** or SAN (also known as a **pacemaker**). This is a small patch of tissue which generates electrical activity. The SAN initiates a wave of excitation at regular intervals. The wave quickly passes through the walls of both atria, travelling along the membranes of the muscle tissue, causing the atria to contract. This is what causes *atrial systole*.

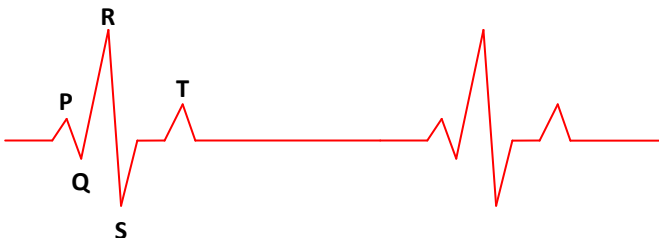
At the base of the atria lies a disc of tissue which cannot conduct the excitation, so it cannot spread directly to the ventricular walls. There is another node at the top of the *ventricular septum* (see 2.6 The Mammalian Heart) called the **atrioventricular node** or AVN. This is the only route through the disc of non-conducting tissue which the wave can take, although there is a slight delay for the wave of excitation at this second node. This time allows for the atria to finish contracting and for blood to fill the ventricles before they contract.



After the delay, the wave moves from the AVN and spreads down the specialised conducting tissue, this is called the **Purkyne tissue**. This tissue runs all the way down the septum. When the wave reaches the bottom of the septum it spreads all over the ventricular walls, starting from the base (apex) of the ventricles. This causes them to contract from the bottom upwards, which pushes the blood in the ventricles upwards towards the major arteries at the top of the heart.

ELECTROCARDIOGRAMS

An **electrocardiogram** (or **ECG**) is used to record the electrical activity within the heart. A typical ECG for a normal patient would identify a pattern of peaks and troughs which we give the letters P, Q, R, S and T.



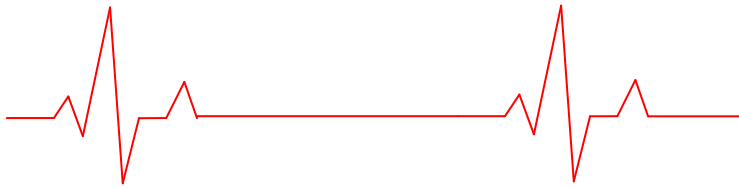
The **P wave** represents the contraction from the electrical excitation sweeping over the atria walls.

The **QRS complex** represents the wave of excitation spreading through the ventricles walls.

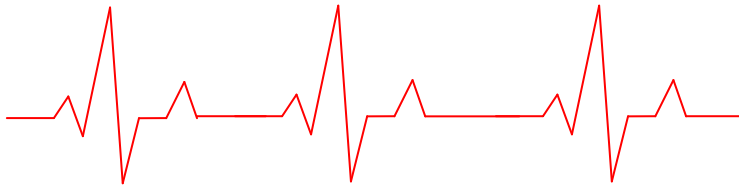
The **T wave** indicates diastole in the ventricles.

In order to obtain an ECG, a number of sensors are attached to the skin. Some of the electrical wave of excitation spread through the muscular walls of the heart are passed onto the skin, where the sensors pick up on them and record them as a trace like the one shown above.

The shape of an ECG can help to indicate when part of the heart muscle is not healthy. It can show if it has **arrhythmia** (irregular heartbeat), if it is in **fibrillation** (uncoordinated beating) or has suffered a **myocardial infarction** (heart attack).



This trace shows a normal PQRST trace. Such a trace might be used for measuring the relative lengths of the events involved in the cardiac cycle, for example, contracting time for Q - T, filling time for T - Q, calculating heart rate, etc...



Tachycardia – where heart rate is fast, such as during exercise, stress, etc. Depending on the cause, treatment may be stress management, giving up smoking or treatment with beta blockers to slow down heart rate



Bradycardia – pattern of activity is normal, but slow and the intervals between each heartbeat are long. Could be caused by beta blockers or tranquilisers, or may just be from an elite athlete. There is a risk of blood clot and stagnation



Fibrillation – the heart is contracting but in an uncoordinated and irregular way. When a strong electric current is passed through a heart experiencing fibrillation, it will stop the heart for a few seconds, hopefully returning it to its normal pace when the heart restarts

The heart muscle cells respire fatty acids and must have a continuous supply of oxygen because fat can only be respired aerobically. So a blood clot in the coronary artery starves part of the heart muscle of oxygen and those cells die. This is a heart attack.