



Pacemakers



Syllabus References

9.3.2 e

Identify the types of materials used to make pacemakers and the properties that make these suitable for implanting in the body

9.3.2 i

Identify data sources, gather, process and analyse information to outline the historical development of pacemakers and use available evidence to identify types of technological advances that have made their development possible.

What you need to do



Identify Data Sources

Research the following and answer the following questions using either the library resources or the internet. Your research should be printed **HANDED INTO YOUR TEACHER** for marking (this is a non-assessable task). Please be aware of the cost of printing, or if you would like to print at home you will need a thumb drive / data stick to transfer your research.

- Describe the structure of the pacemaker.
- Explain how and where a pacemaker is implanted.
- Explain the functions of a pacemaker.
- Explain how a pacemaker can be adjusted without surgery.
- List the materials pacemakers are made from and the properties of the materials that make them suitable for implanting. A table may be suitable to answer this question.
- Develop and collate a timeline about the history and advancement of pacemakers using information on the internet, in books or in the information sheets supplied by your teacher.

Process Information

Analyse Information



3 Heart and Pacemakers

Palpitations occur when the heart beats too fast or too slow or beats in an irregular manner. This happens when there is a malfunction in some part of the heart's electrical system. Palpitations can be felt in different ways, including skipping a heartbeat, occasional extra heartbeats, rapid heartbeat or pounding in the chest. Some palpitations are not serious and may occur in healthy hearts. Other palpitations may need medical treatment. Three of the most common problems are:

- the heart beats too quickly, usually more than 100 beats per minute
- the heart beats too slowly, usually less than 50 beats per minute
- the heart beats in an irregular manner, usually when there are disorganised electrical impulses moving through the heart.

Treatment

Many cases of heart palpitations are temporary and harmless, and may disappear with exercise, stress reduction, stopping smoking, and reducing caffeine and alcohol consumption or changing medications. If the unusual rate of heartbeat interferes with the supply of blood to the body, the matter is serious. Table 3.1 lists a range of treatments for people with unusual heartbeats.

Natural Pacemakers

The pumping of our heart depends on bundles of nerves called **natural pacemakers** (Figure 3.1). The SA node controls contractions of the atria and sends coordinating

signals to the AV node. It tends to beat faster than is normally needed and is slowed down by nerve impulses from the body. The AV node controls contraction of the ventricles and tends to beat slower than necessary. If blood was pumped at the AV node's natural rate of contraction, the body and brain would not receive enough oxygen. Thus the SA node sends signals to speed up the signals produced by the AV node.

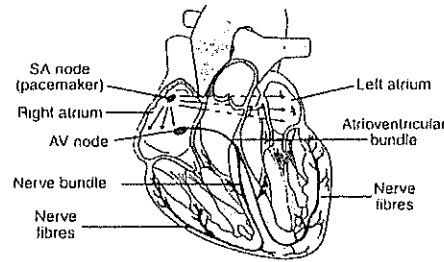


Figure 3.1 Natural pacemakers The beating of the heart is controlled by two natural pacemakers

As we can see, there needs to be some coordination between the SA node and the AV node. Normally a heartbeat starts when the SA node sends a signal that spreads along nerves through the atria to the AV node. The AV node then connects to a group of nerve fibres in the ventricles that conduct the electric signal. The impulse travels down these nerve fibres to all parts of the ventricles. The electrical signal must follow this exact route for the heart to pump properly. The heart contracts (beats) as this electrical impulse travels through it. This normally occurs 60 to 100 times a minute. The atria contract a split-second before the ventricles. This lets the

atria empty their blood into the ventricles before the ventricles contract.

Abnormal heartbeats can occur for a number of reasons:

- when the heart's natural pacemaker develops an abnormal rate or rhythm
- when the normal conduction pathway is interrupted
- when another part of the heart takes over as pacemaker.

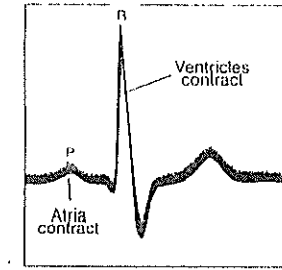


Figure 3.3 Heart ECG Electrical signals from the heart

Artificial Pacemakers

When the natural pacemaker fails to work properly, doctors can implant a small, battery-operated device called an **artificial pacemaker** to help the heart beat in a regular rhythm. One of the first artificial pacemakers was developed around 1930 by Sydney doctor Mark Lidwill and physicist Edgar Booth. Their rather large portable device attached one electrode to the skin and a second to the heart through the skin. In contrast a modern artificial pacemaker is a small, battery-operated device (Figure 3.2). Some are permanent (internal) and some are temporary (external). They can replace a defective natural pacemaker or blocked pathway.

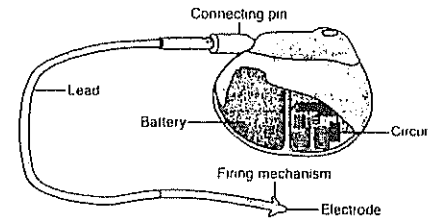


Figure 3.2 Artificial pacemaker Battery-operated devices help the heart beat in a regular rhythm

Attached to the battery are two electrodes that connect it with the heart. Under local anaesthesia, the pacemaker is implanted under the skin of the chest wall, and the electrodes are threaded through a vein near the collarbone and guided to the heart muscle. The artificial cardiac pacemaker regulates heartbeats by sending electrical impulses to the heart muscle. When the muscle is stimulated, it contracts or beats.

- Abnormally slow heartbeat can be due to no electrical impulses reaching the ventricles from an AV node. The ventricles beat at their natural rate which is too slow for adequate blood supply. If the heart does not respond in any way to the nerves or hormones, then a **fixed-rate pacemaker** can sometimes be used to send electrical impulses at a higher constant rate to maintain adequate blood supply

- Even when no signals can reach the ventricles, the atria of the heart may sometimes change their rate of contraction in response to nervous or hormonal signals. In this case a **demand pacemaker** connected to the ventricle can be set off by the P-wave produced when the atria contract (Figure 3.3). This will allow the amount of blood pumped to change depending on the type of activity.
- Abnormally slow heartbeat can be due to only some electrical impulses reaching the ventricles from an AV node. Most **demand pacemakers** are designed to be triggered by the R-wave produced by the contraction of the ventricles. They have a sensing device that turns the pacemaker off when signals are getting through and the rate of heartbeat is above a certain level. It turns back on when the heartbeat is too slow. Since a signal is not sent every heartbeat, it uses less electrical energy and the batteries last much longer.

Early pacemakers required external powering which meant wires passing through the skin. Wires such as these allowed bacteria to gain access and cause infection. The first really practical internal pacemakers were not implanted in humans until around 1960. This removed the need for wires passing through the skin. This could only happen with the development and miniaturisation of the transistor. It also required the development of suitable batteries. For some years the mercury battery was used, but due to short battery-life, this has been replaced by various types of lithium battery. Today the lithium-iodine battery is often used as it produces no gases during operation.

The other design consideration for pacemakers is the casing and electrical leads. They have to survive in a warm and salty environment under the skin. The leads that pass along the veins to the heart have to cope with the flow of blood and continual flexing as the heart pumps and the body is moving about. Nor can the materials used inside the veins cause blood clotting. Modern pacemakers are encased in sophisticated titanium alloys while the leads are enclosed in low

Table 3.1 Treating palpitations

Group	Name	Treatment
Non-surgical	Lifestyle management	Some palpitations may disappear if a person abstains from drinking coffee or alcohol, or ceases smoking. Other palpitations may go away once a person learns to manage stress.
	Medications	Some palpitations respond very well to a wide range of medicines. Some medicines can speed up slow hearts while other medicines can slow them down.
Surgical	Radiofrequency ablation	If an area of cardiac tissue causing the abnormal rhythm is located, a minute amount of electrical energy is delivered through a catheter passed along blood vessels to the site, permanently interrupting the abnormal pathway.
	Pacemaker	Depending upon the success of non-surgical options, as well as lifestyle changes, a person may require a pacemaker to prevent slow heart rhythms.
	Defibrillator implantation	Depending upon the success of non-surgical options, as well as lifestyle changes, a person may need a defibrillator implant. The defibrillator attempts to correct the rapid twitching of the heart and re-establish a normal heart rhythm by delivering an electric shock to the heart.
	Endocardial resection	In many patients, especially those with abnormally fast heartbeat after a heart attack, the damaged portion of the heart can be removed.