The Heart
The Heart

- Structure and function
  - Electrical activity
  - The heart and exercise
  - Health and disease
  - Summary activities
What does the heart do?

The heart is a muscular organ located in the thorax. It pumps blood continuously around the body.

The blood supplies cells with oxygen and glucose, needed for respiration.

The blood also transports the waste products, such as carbon dioxide, the waste product of respiration, and urea.

Special arteries called coronary arteries carry blood to the heart to supply the heart muscle cells with oxygen and glucose for contraction.
A circulatory system consists of a group of organs that transport substances, such as oxygen, around the body.

Some organisms, such as insects, have an open circulatory system, where the fluid moves freely between cells.

Other organisms, including humans, have a closed circulatory system where blood is contained within vessels, where these factors can be controlled:

- the speed of blood flow
- the pressure of the blood
- the distribution of blood in the body.
One and two circuits

Closed circulatory systems

What are the different types of closed circulatory systems?
Press the two examples to find out.

one circuit
two circuits
Closed circulatory systems

A **single** circulatory system has a two-chambered heart so that blood can be returned to one chamber, and pumped back out of the heart from the second chamber. This ensures blood flow in one direction only.

The **double** circulatory system has a four-chambered heart so that blood can be pumped out to the lungs, returned to the heart, and be pumped out again to the rest of the body. This maintains a **high pressure** in the blood vessels and **faster blood flow** to the tissues.

This is essential for organisms with a large body, such as whales, elephants, and humans.
What are the structures in the human heart?

Press the buttons below to find out more about the parts of the heart.

- chambers
- vessels
- valves
How does the heart pump blood around the body?

The sequence of events that take place in one heartbeat is called the **cardiac cycle**. This involves contraction of the atria, contraction of the ventricles, and their subsequent relaxation.

Press "play" or the heart to find out what happens during each phase.
Can you label the structures of the heart?
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How is the contraction of the heart coordinated?

The heartbeat is controlled by electrical signals.

Press "play" to see how the electrical activity is coordinated.
What is an electrocardiogram?

The electrical activity of the heart can be monitored by using an **electrocardiograph**.

Several electrodes are attached to specific places on a person’s chest. These detect electrical changes in the heart by measuring current at the skin’s surface.

The leads are connected to a machine that draws an **electrocardiogram** (ECG). A normal ECG is shown below.
Interactive cardiac cycle – electrical activity

- atrial contraction
- ventricular contraction
- relaxation

ECG trace

Voltage (mV)

Time (ms)

- slow
- heart rate
- fast
What are the components of an ECG trace?

An ECG trace records the electrical activity of the heart (vertical axis) over time (horizontal axis).

Press a button to find out how an ECG trace relates to the cardiac cycle.

- P wave
- PR interval
- QRS complex
- ST segment
- T wave
- show all
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Heart rate and exercise

During exercise several changes occur:

- the heart rate increases
- the rate and depth of breathing increases
- the arteries supplying the muscles dilate.

These changes help to provide oxygen and glucose to muscles and remove carbon dioxide more quickly.

Heart rate can also be altered by hormones such as adrenaline. The presence of adrenaline causes the heart rate to increase, allowing a quick response to danger.
Regular exercise can strengthen the heart, causing:

- the heart to become bigger
- the amount of blood pumped by the heart to increase
- the walls of the heart to become thicker and stronger.

The result is that the heart becomes a more efficient pump.

The resting pulse rate gets slower as a person becomes fitter, because the heart needs fewer beats to pump blood round the body.
How does exercise affect heart rate?

- Person A
- Person B
- Person C

Pulse rate graph
Heart rate during exercise

What are the missing words about exercise?

1. During exercise the heart beats ? \( \downarrow \), breathing rate ? \( \downarrow \) and the arteries ? \( \downarrow \).

2. These changes help the body to deliver the substances needed for increased ? \( \downarrow \) to the muscle cells.

3. Pulse rate is expressed as beats per ? \( \downarrow \). Resting pulse rate is usually around ? \( \downarrow \), increasing up to a maximum of ? \( \downarrow \).
The heart rate and recovery rate of an individual can be measured before, during and after exercise such as running.

Changes in blood pressure can be measured over weeks due to the long-term effect of exercise.

Press "start" to interpret this data.
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What are the problems associated with the heart?

Press on each condition associated with the heart to find out more about it.

- Irregular heartbeat
- Hole in the heart
- Damaged valves
- Coronary heart disease
Heart disease and BMI

Obese people have a higher risk of developing heart disease.

An individual’s **body mass index**, or **BMI**, can indicate whether they are obese.

BMI measures the relative amounts of fat and muscle in the body.

**BMI** = \( \frac{\text{body mass (kg)}}{(\text{height})^2 (m)} \)

<table>
<thead>
<tr>
<th>BMI</th>
<th>Conclusion</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt;20</td>
<td>underweight</td>
</tr>
<tr>
<td>20–25</td>
<td>normal</td>
</tr>
<tr>
<td>25–30</td>
<td>overweight</td>
</tr>
<tr>
<td>&gt;30</td>
<td>obese</td>
</tr>
</tbody>
</table>

**Gloria:** 1.45 m and 66 kg
BMI = 31

**Zak:** 1.85 m and 66 kg
BMI = 19

Use the table to see who has a greater risk of developing heart disease.
Can you work out the BMI (to one decimal point)?

Matthew weighs 59 kg and is 156 cm tall.
Can you calculate his BMI?

Body Mass Index (BMI) = \( \frac{\text{Mass (kg)}}{\text{Height}^2 (m)} \)
ECG in diagnosis of irregular heartbeats

ECGs are used to diagnose problems with the heart, as variations in different components of the trace can indicate a disease or other abnormality.

An ECG may be taken while the patient is relaxed or it may be taken before, during and after exercise.

This is called a ‘stress test’ and usually involves the patient exercising on a treadmill while attached to an ECG machine.
Irregular heartbeats

Abnormal ECG traces

ECGs can help diagnose abnormalities, but there are a range of values that are considered normal, making interpretation difficult.

Press the images above to see examples of abnormal traces.
Diagnosing heart problems

An **echocardiogram** is a diagnostic test that uses sound waves which echo against structures to build up a detailed picture of the heart.

A transducer is placed on the chest of the patient. This emits sound waves and detects the reflected echoes.

Doctors use this test to help diagnose heart problems such as **coronary heart disease**, **weak valves** and heart defects, such as a **hole in the heart**.
Hole in the heart

A hole in the heart describes an opening in the wall of the heart that separates the right side from the left.

As deoxygenated blood is now able to mix with oxygenated blood, the amount of oxygen being carried to respiring tissues is less.

Unborn babies all have a hole in their hearts to allow blood flow between the ventricles. As the lungs are not used in the womb, this hole diverts blood flow away from the pulmonary circulation.

This hole closes after birth when the lungs are needed for gas exchange.
Some heart problems are caused by an impairment of the natural pacemaker cells in the heart. This can be treated by installing an **artificial pacemaker**.

This battery-powered device monitors the heart’s electrical activity and stimulates the ventricles or atria to contract at the right time.

Impulses are transmitted down electrodes implanted in the heart’s muscular walls.

A pacemaker can be installed using simple surgery. This can be a simpler and **safer alternative** to replacing the natural pacemaker cells by undergoing a heart transplant.
Scientists must understand how the heart functions normally so they can design suitable solutions for those with heart conditions and diseases.

Examples include the biomedical engineering of:

- **artificial pacemakers** to control the heart beat
- **replacement devices** for faulty heart valves
- **artificial hearts** to use in heart transplants.

What are the advantages and disadvantages of a heart pacemaker or artificial heart valves over a heart transplant?
Artificial pacemakers or heart valves over a heart transplant:

advantages

disadvantages

no need to wait for a donor heart
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Glossary of keywords: the heart

**adrenaline** – A hormone that can affect the heart rate.

**aorta** – The major artery that carries oxygenated blood from the heart to the rest of the body.

**artery** – A vessel that carries blood away from the heart.

**artificial pacemaker** – A small, battery-powered device that monitors the heart's electrical activity and stimulates the ventricles or atria to contract when necessary.

**atrium** – An upper chamber of the heart.
Can you pump your way through this quiz about the heart?

Press "start" to begin.

start