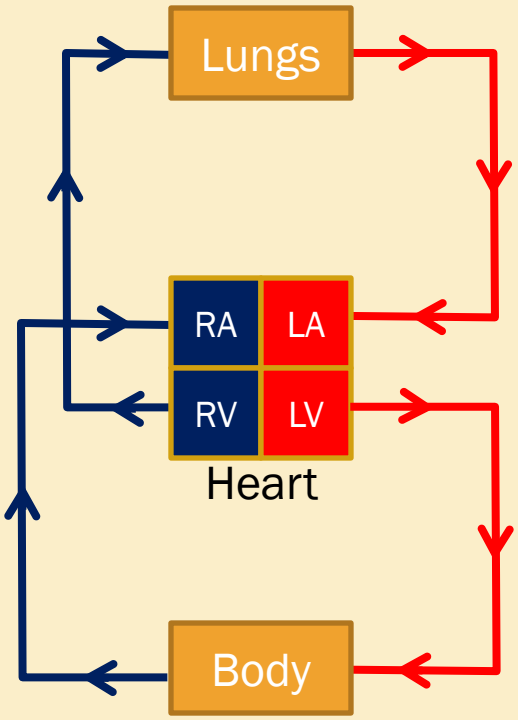
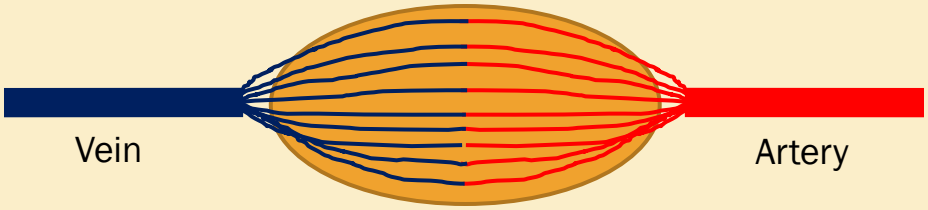
The Circulatory System





Capillaries passing through an organ

The heart pumps blood around the body. Blood flows from the heart to the organs through arteries and returns through veins. In the organs, blood flows through capillaries.

Substances needed by cells in the body tissues pass out of the blood, and substances produced by the cells pass into the blood through the walls of the capillaries.

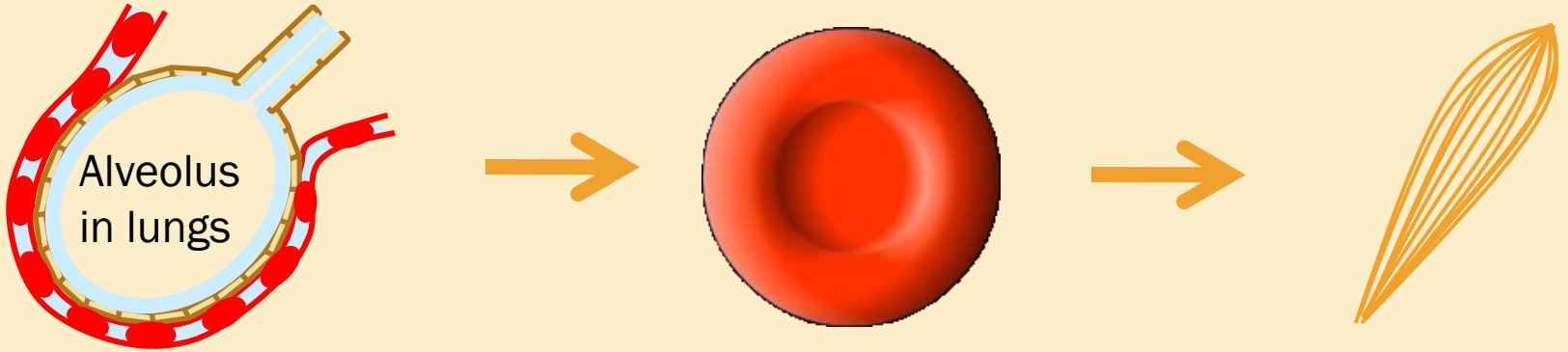
There are two separate circulation systems, one to the lungs and one to all the other organs of the body.

In the diagram blood returning to the heart from the body enters through the right atrium (RA). It is then pumped to the lungs through the right ventricle (RV). After passing through the lungs blood enters the heart through the left atrium (LA) and is pumped around the body through the left ventricle (LV)

Note: You do not need to know the names of heart valves and the names of blood vessels connected to the heart. You also do not need to know the structure of arteries and veins.

Transport in the Blood

Red blood cells transport oxygen from the lungs to the organs.
Red blood cells have no nucleus. They are packed with a red pigment called **haemoglobin**. In the lungs haemoglobin combines with oxygen to form oxyhaemoglobin. In other organs **oxyhaemoglobin** splits up into haemoglobin and oxygen.



Oxygen diffuses from the alveoli in the lungs into blood. It combines with haemoglobin in red blood cells to form oxyhaemoglobin. Oxygen diffuses down a concentration gradient from a high concentration in the lungs to a lower concentration in the blood.

Oxygen binds to **haemoglobin** in red blood cells to form **oxyhaemoglobin**. Red blood cells are biconcave discs. This helps to increase their surface area.

In organs such as muscle, the oxyhaemoglobin splits up and oxygen diffuses down a concentration gradient from the blood where it is at a higher concentration into the tissues where it is at a lower concentration.

Blood **plasma** (the liquid part of the blood) transports:
– carbon dioxide from the organs to the lungs. Carbon dioxide diffuses down a concentration gradient from the tissues into the plasma. In the lungs carbon dioxide passes from the plasma into the alveoli and is removed when you exhale.
– soluble products of digestion (these include **glucose, amino acids and fatty acids**) from the small intestine to other organs
– **urea** from the liver to the kidneys.

The effect of exercise on the body

- During exercise a number of changes take place:
  – the heart rate increases
  – rate and depth of breathing increases
  – the arteries supplying the muscles dilate (i.e. the cross sectional area increases to allow more blood to flow through).

- These changes increase the blood flow to the muscles and so increase the supply of sugar and oxygen and increase the rate of removal of carbon dioxide.

- **Glycogen** stores in the muscle are used during exercise. Glycogen is a carbohydrate that is rapidly broken down into glucose.

- If muscles are subjected to long periods of vigorous activity they become fatigued, ie they stop contracting efficiently. If insufficient oxygen is reaching the muscles they use **anaerobic respiration** to obtain energy.

The effect of exercise on the body

Colour changes (blood moved to the surface of the skin for heat regulation)

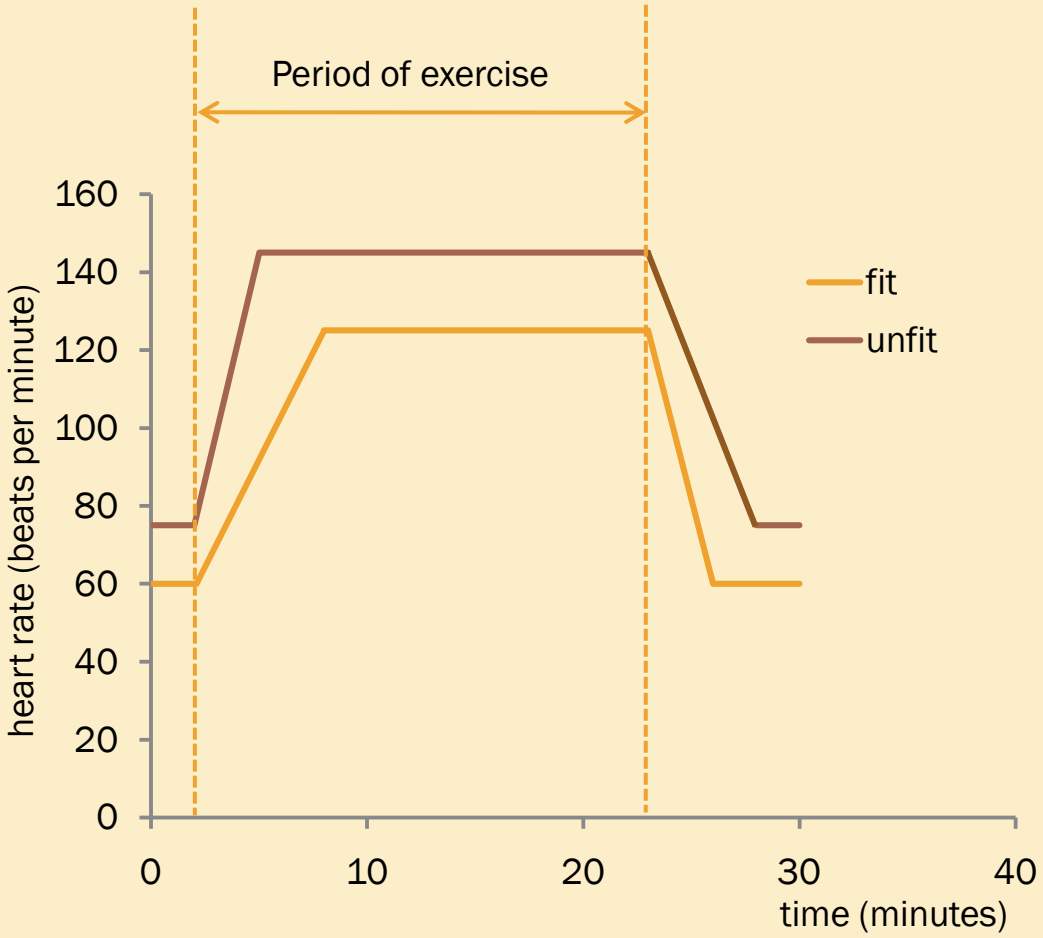
Heart rate increases and stroke volume increases

Sweating to cool body leads to salt and water loss

Breathing rate and depth increases

More blood flows to muscles

The benefits of exercise



Regular exercise benefits the muscles, heart and lungs. If you exercise regularly both your heart and lungs become larger. Fitter people have a lower resting heart rate and a lower breathing rate (as each beat of the heart pumps more blood around the body). The graph shows how the heart rate changes for a fit and unfit person before, during and after exercise. During exercise the fit person has a lower heart rate as heart can pump more blood around the body with each beat. The time taken for the heart rate to return to the resting value after exercise is also much shorter for the fit person than the unfit person.

Aerobic and Anaerobic Respiration (Higher Tier Only)

Normally your muscles respire using **aerobic respiration**:

Glucose + Oxygen → Carbon Dioxide + Water + Energy

However, during vigorous exercise, your heart and lungs may not be able to supply oxygen at a sufficiently high rate. In this situation, the muscle cells obtain energy from glucose through **anaerobic respiration:**

Glucose → Lactic Acid + energy

Anaerobic respiration is the incomplete breakdown of glucose and produces lactic acid. As the breakdown of glucose is incomplete, much less energy is released than during aerobic respiration.

Anaerobic respiration results in an oxygen debt that has to be repaid in order to oxidise lactic acid to carbon dioxide and water. After exercise your heart rate and breathing rate stay high to repay this oxygen debt. Lactic acid is broken down as follows:

Lactic Acid + Oxygen → Carbon Dioxide + Water

Fit people are able to repay this oxygen debt more quickly than unfit people (see graph on previous slide).