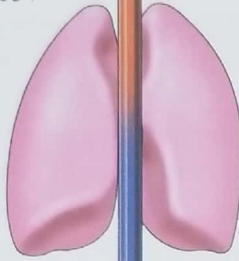


## How do our red cells carry oxygen?

Our red blood cells contain an iron-based substance called haemoglobin. When the blood travels to our lungs the oxygen in the air joins up with the haemoglobin in the blood to form oxyhaemoglobin.



Our blood is now oxygenated and bright red. In this way the oxygen is carried by our blood around our body.

When blood arrives at our capillaries, the oxyhaemoglobin breaks down, setting the oxygen free to pass out to our body cells.



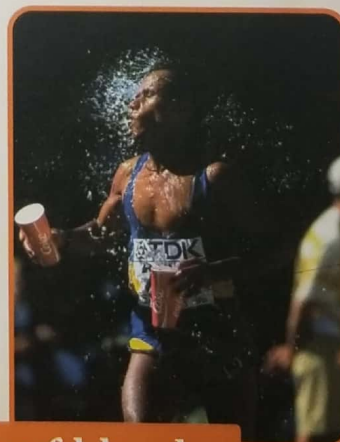
Our blood is now deoxygenated and dull red in colour. It is pumped back first to our heart then to our lungs to pick up more oxygen.

## What does our blood do?

Our blood links all the tissues and organs of our body together. It has four main functions.

### Transportation

- Carries nutrients from our digestive system to all our body cells
- Takes oxygen from our lungs to our working muscles
- Removes carbon dioxide from our body in our lungs
- Removes waste products and excess water in our kidneys
- Takes hormones to where they are needed



### Temperature regulation

- Carries heat away from working muscles to skin
- Carries heat away from centre of body to skin
- Maintains temperature within the body

### Functions of blood

### Protection

- Carries white cells to sites of infection
- Carries **antibodies** to destroy germs
- Carries platelets to damaged areas to form clots



### Maintaining body's equilibrium

- Reduces the effect of lactic acid produced in the working muscles
- Regulates fluid balance
- Enables hormones and **enzymes** to work

## How well does our heart pump?

The heart is made up of cardiac muscle and we cannot control its action. Fortunately cardiac muscle never tires. The speed and force of each heartbeat is controlled by the brain. Our brain is affected by what we are doing. If we start running, our brain tells our heart to pump more blood to supply our working leg muscles with more oxygen.

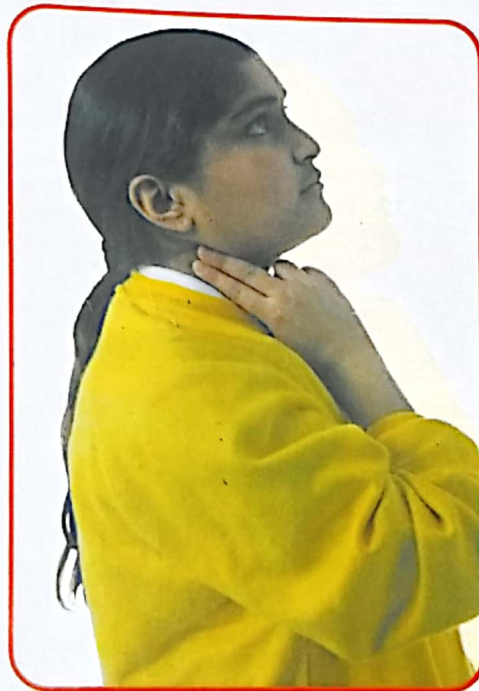
Heart muscle can get stronger when exercised, like any other muscle.

The amount of blood pumped by the heart depends on heart rate and stroke volume.

## Heart rate

Heart rate is the number of times the heart beats per minute. At each heartbeat, blood is pumped out of the heart into the arteries. Our arteries are forced to expand and then contract, which is called our pulse. The number of pulses in one minute is the heart rate. For a normal adult when resting this will be about 70 beats per minute.

A pulse can be felt at points in the body where arteries are near to the skin.



Carotid – in the neck, in the groove beside the windpipe

Radial – at the wrist, below the thumb



## Our heart rate and sport

Resting heart rates can vary between people, due to factors such as sex, age and health. For a healthy, resting adult it is about 70 beats per minute. Endurance sportspeople will have a much lower rate, perhaps as low as 30 beats per minute. This is because their hearts are stronger and are able to pump more blood in fewer beats than an unfit person. Their stroke volume is therefore greater.

Resting heart rate can be one way to show fitness level. The speed at which heart rate returns to normal after exercise is called the recovery rate. This rate can also be used to measure fitness.

## Stroke volume

Stroke volume is the amount of blood pumped by the heart in each beat.

Whenever we exercise stroke volume increases for a number of reasons. Working muscles squeeze blood in our veins, forcing more blood back to the heart. The heart stretches as it fills up with the extra blood and in turn it contracts more strongly. This results in more blood being pumped out of the heart for each beat.

## Cardiac output

Cardiac output is the amount of blood pumped out of the heart per minute.

It is controlled by both heart rate and stroke volume:

$$\text{heart rate} \times \text{stroke volume} = \text{cardiac output}$$

In sport we usually want to increase the amount of blood going to the working muscles – that is, our cardiac output. We can do this by increasing stroke volume, heart rate or both.

## What is blood pressure?

Blood pressure is the force of the blood against the walls of the blood vessels. It is different in different blood vessels. It depends on how much blood is flowing into the blood vessels and how easily it can flow out.

In our arteries the blood pressure is high because the arteries are narrow and a lot of blood is being forced into them from the heart. Blood flows only slowly in the wider veins, which are a long way from the heart. Here blood pressure is low and so valves are needed to prevent blood from flowing backwards.

## How do we measure blood pressure?

We use a special instrument to measure the pressure needed to stop the blood flowing through an artery. It is always measured in our upper arm and two readings are taken. Blood pressure should be taken when we are relaxed and resting. It will therefore be at its lowest.



## What will affect blood pressure? \*

- Age: blood pressure increases as we grow older because our arteries are less elastic.
- Exercise: blood pressure increases when we exercise but returns to normal after exercise. Regular exercise helps to lower resting blood pressure and prevent cardiovascular disease.
- Stress: stress causes hormones to be released into the blood, which increases blood pressure.



Exercise affects blood pressure

- Smoking: smoking increases blood pressure because nicotine reduces the efficiency of our capillaries.
- Diet: a diet high in fat or salt may lead to increased blood pressure. This is because fatty deposits may block up or harden arteries. Excess salt intake may lead to an imbalance in the body's chemistry.
- Weight: being overweight puts an extra strain on the circulatory system and so raises blood pressure.

## What does high blood pressure mean?

A person has high blood pressure (called hypertension) if readings stay high over a long period of time. Hypertension may be caused by blockages in the smaller blood vessels, which means that the heart has to work harder to force blood around the body. Arteries taking blood to the heart muscle can also become blocked. Sudden activity can cause a sharp pain (called angina) or even a heart attack.

## Our blood pressure and sport

During sport the heart beats faster and pumps out more blood. Blood pressure rises. This is quite normal. Regular sensible exercise linked with a healthy diet and lifestyle will actually lower resting blood pressure. In sport, illegal blood doping raises blood pressure. Recently some drugs such as erythropoietin (EPO), which has been taken by some cyclists, have reduced blood pressure to dangerously low levels.

## What happens to our circulatory system when we exercise?

- The hormone adrenaline is released even before we start to exercise. It prepares the body for action.
- Adrenaline in the bloodstream causes the heart to beat more quickly – heart rate increases.

- The heart contracts more powerfully. It sends out a greater amount of blood with each contraction. Stroke volume increases.

- Blood circulation speeds up and greater amounts of oxygen-carrying blood reach the working muscles. Cardiac output increases.



- The pumping action of muscles forces more deoxygenated blood back to the heart more quickly.
- Blood flow to the areas of the body not in urgent need of oxygen, for example our digestive system, is reduced.
- Blood flow to the areas in greatest need of oxygen, for example our skeletal muscles, is increased.

- Blood vessels to skin areas become enlarged. This allows excess heat from muscles and organs to be lost more easily from the skin.
- During very hard exercise even these blood vessels will be reduced in size. Body temperature will then rise very quickly. It can cause overheating and **fatigue**.

- The oxygen going to the muscles can be up to three times the resting amount.
- Blood flow can be increased up to 30 times. Therefore, the working muscles can receive up to 90 times the amount of oxygen they receive at rest.

## Examination-type questions: Our circulatory system

There are 12 marks for each question.

- 1 (a) Name two of the major components of blood. (2 marks)
- (b) Where is blood carried to in  
(i) the aorta  
(ii) the vena cava? (2 marks)
- (c) Describe two differences between arteries and veins. (2 marks)
- (d) Explain how the heart, lungs and circulatory system work together to get blood to working muscles. (6 marks)
- 2 (a) Name two functions of the circulatory system. (2 marks)
- (b) Give two factors that might affect blood pressure. (2 marks)
- (c) Blood arrives at the working muscles in the capillaries. Explain what happens to it then. (2 marks)
- (d) Our circulatory system responds to exercise. Describe six changes that occur when we exercise. (6 marks)
- 3 (a) Name the components of blood which:  
(i) help clotting  
(ii) carry oxygen. (2 marks)
- (b) What is meant by:  
(i) heart rate  
(ii) stroke volume? (2 marks)
- (c) Explain why our pulse increases when we exercise. (2 marks)
- (d) Name three functions of blood and give one example to illustrate each function. (6 marks)
- 4 (a) The heart has four chambers, called the upper and lower ventricles and atria. Where does blood go when it leaves  
(i) the right ventricle  
(ii) the left ventricle? (2 marks)
- (b) Suggest two ways in which the pulse can be used to show our level of fitness. (2 marks)
- (c) Describe the difference between the systemic and pulmonary circulation systems. (2 marks)
- (d) Explain why an efficient circulatory system is important for sportspeople. (6 marks)