



Oxygen supply

Above: Coloured electron micrograph of red blood cells. One white blood cell can also be seen

Respiration goes on in all live cells, in all living things, all the time. Oxygen is essential for most respiration. This article explores how organisms get the oxygen they need from their surroundings and how it reaches cells. It also looks at how we can monitor oxygen transport, which is vitally important in medical care.

Respiration is the process that marks out life – it provides organisms with access to the energy stored in chemicals such as glucose, so that other life processes can be sustained. Under most circumstances the other key ingredient for respiration is oxygen. This is available from the environment, whether it be in the air above ground, in soil spaces or dissolved in water. All cells obtain oxygen from their surroundings, by diffusion down concentration gradients.

their immediate environment is then greater than that in the cell, so more oxygen enters by diffusion. In fact this is a continuous process – the organism uses up and is supplied with more oxygen all the time.

In larger multicellular organisms, cells still need oxygen from their surroundings. They acquire it in exactly the same way as a single-celled animal – by diffusion from the fluid in which they are bathed. This tissue fluid is formed from blood plasma at the start



Pulse oximetry is a simple method of monitoring the percentage of haemoglobin which is saturated with oxygen

GCSE key words

Aerobic respiration
Capillary
Haemoglobin
Oxygen

How are cells supplied with oxygen?

Single-celled organisms rely solely on diffusion to obtain oxygen. As they use it up in respiration their oxygen content falls. The concentration of oxygen in

Figure 1 How gas exchange occurs in the lungs and in the body tissues

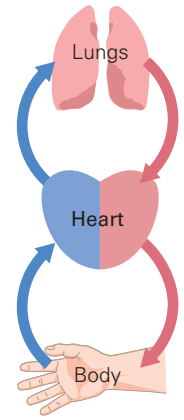
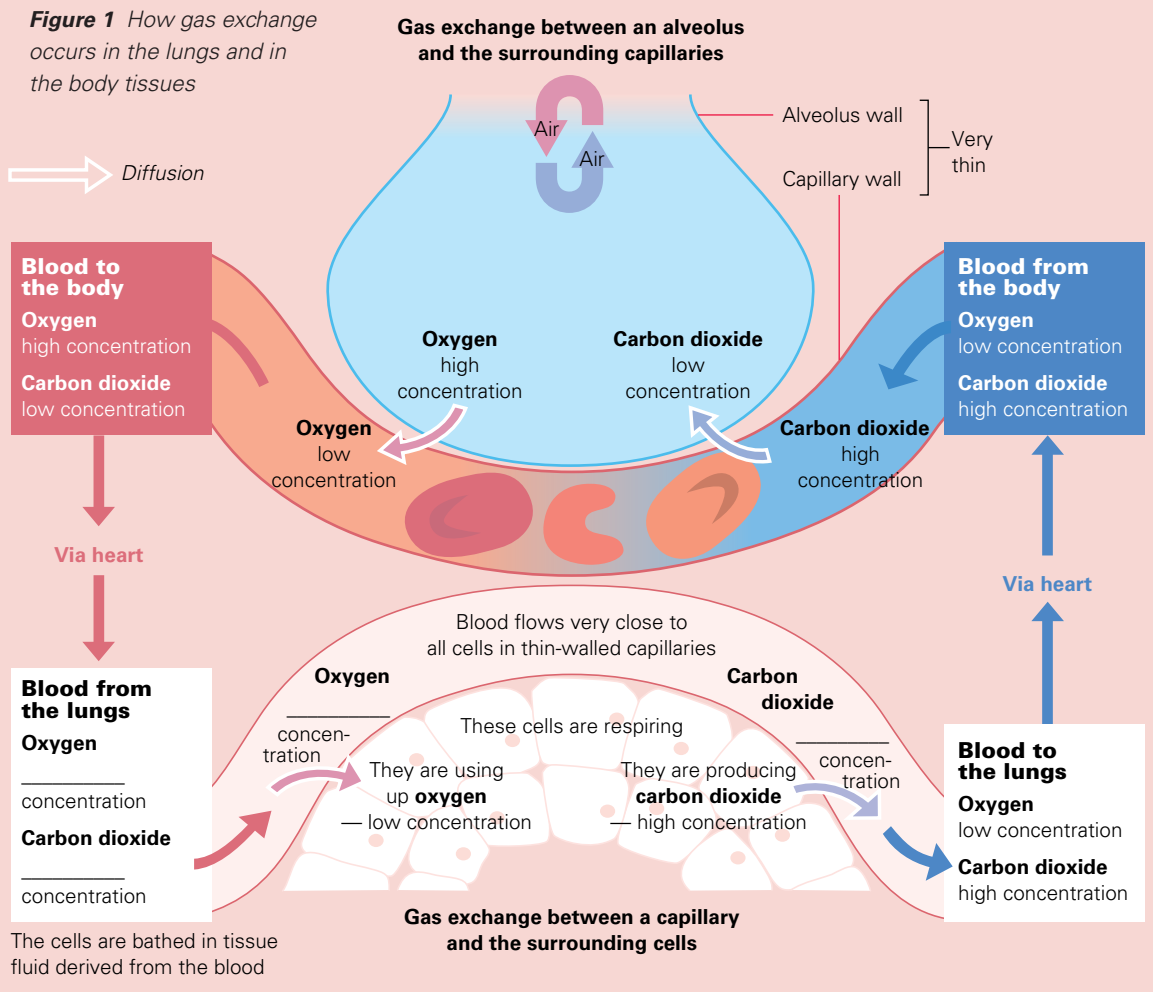


Figure 2 The basic circulatory system. Make sure you can identify major blood vessels on a full diagram of the circulatory system in your textbook

• Complete Figure 1 in the appropriate colours and add the missing words on the lines provided.

of capillaries. Oxygen passes out of red blood cells and diffuses through the tissue fluid to cells. No cell is more than three or four cell diameters away from a capillary.

Oxygen and blood

There is a highly efficient link between tissue fluid and the outside world. In humans this link is provided by:

- the lungs, where oxygen diffuses from the alveoli to the blood
- the circulatory system that carries oxygen very quickly to the cells of the body

Figure 1 summarises what happens in the lungs and part of what happens at the cells of the body – think hard and you should be able to complete the words that are missing from the diagram and add the appropriate colours.

Oxygen enters the blood in the lungs, and is carried round the circulatory system (Figure 2). Most of it is carried in red blood cells. These cells are packed with **haemoglobin**, a protein. Haemoglobin ‘grabs hold’ of oxygen molecules in places where there is a high concentration of oxygen, such as the lungs, forming **oxyhaemoglobin**. In places where there is a low oxygen concentration, such as respiring tissues, the oxyhaemoglobin molecule changes shape and ‘lets go’. Figure 3 shows how this happens. For medical

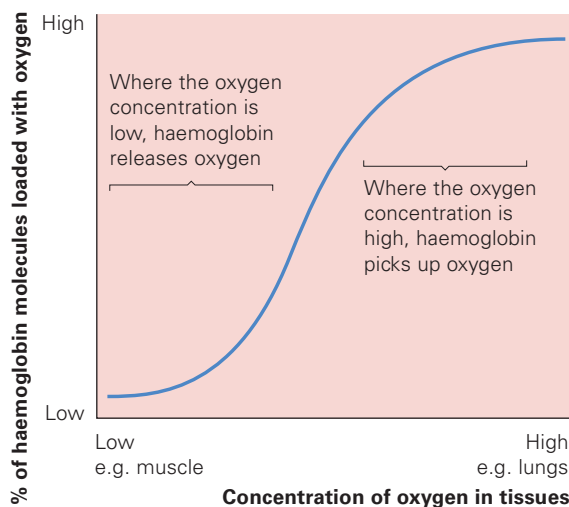


Figure 3

reasons it is often important to assess how much oxygen is being carried by the blood. This can be done using a pulse oximeter (see Box 1 on page 10). Blood leaving the lungs should be 99% saturated with oxygen.

Increased demands

When you exercise, there is an increased work rate in your body. More energy transformations take place

A small amount of oxygen (about 1–2%) is carried dissolved in plasma, the liquid part of the blood.

Box 1 Monitoring oxygen in the blood

A **pulse oximeter** is a probe, which is attached to a patient's finger or ear lobe, or to a baby's toe, and linked to a small unit containing a micro-processor. The unit displays the percentage of haemoglobin saturated with oxygen in arteries, and a calculated heart rate. It also emits an audible signal for each pulse beat; some models have a graphical display of the blood flow past the probe. An alarm is triggered when the pulse rate becomes too fast or slow, or if oxygen saturation falls below 90%.

The probe contains a dual light source and a photodetector, which are used to measure the amount of oxygen that is combined with haemoglobin in the blood (Figure 4). The light is at two wavelengths, red and infrared (650 nm and 805 nm). Each wavelength is absorbed differently by haemoglobin, depending on whether the haemoglobin is saturated with oxygen or not. By calculating the absorption at the two wavelengths the microprocessor can compute the proportion of haemoglobin which is oxygenated.

How does the pulse oximeter detect oxygen only in arteries and not in veins? The microprocessor is programmed to register blood flow coming in strong pulses, as happens in the arteries. It ignores flow in veins because the pulse is weaker. Under some circumstances a pulse may be weak in an artery and the pulse oximeter may not work.

Pulse oximeters are used:

- To monitor oxygenation and pulse rates in people under a general anaesthetic and while they are recovering from the anaesthetic. The

oxygen saturation of their blood should always be above 95%.

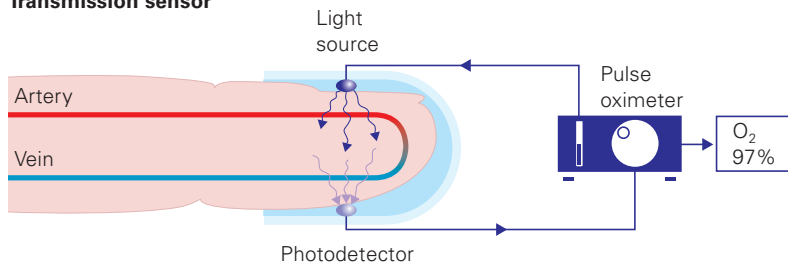
- To monitor patients in intensive care who cannot breathe without a mechanical ventilator. Oximeters detect problems with oxygenation before they are noticed clinically. They are used as a guide when weaning the patient from ventilation and also to help assess whether a patient's oxygen therapy is adequate.
- On hospital wards and in casualty departments. When patients are sedated for procedures such as endoscopy, oximetry has been shown to increase safety by alerting the staff to unexpected lack of oxygen (**hypoxia**).
- To monitor premature babies whose lungs are not fully developed. A premature baby cannot breathe at the same time as it is feeding. If it is linked to a pulse oximeter, the alarm warns when the blood oxygenation reading drops. The baby is then given a whiff of oxygen until the reading is high enough, when feeding can start again.

There are a number of reasons why doctors and nurses exercise great care when using a pulse oximeter. For example, a patient with anaemia may have the same percentage oxygen saturation levels as a patient with a normal haemoglobin value. Although all the haemoglobin molecules are carrying oxygen, the anaemic patient has fewer haemoglobin molecules. The total arterial oxygen content in this patient's blood is therefore lower, and less oxygen is reaching the cells. If oxygen demand increases or oxygen supply decreases an anaemic patient may be at risk.

- Find out more about pulse oximeters by putting this term in a search engine. A major supplier of the instruments is Nellcor, a US company.

- Find out the difference between hypoxemia and hypoxia.

Transmission sensor



Reflectance sensor

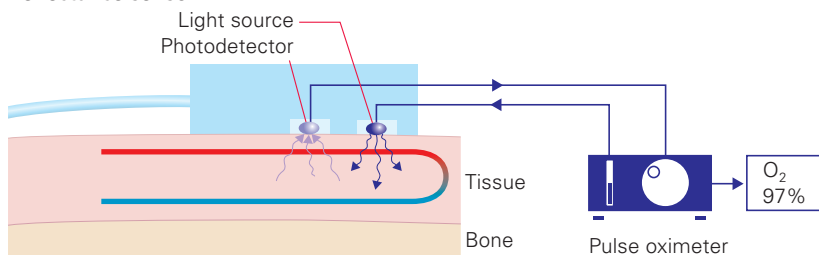


Figure 4 How two types of pulse oximeter work. They ignore reflections from blood in veins, where there is no significant pulse

and therefore more respiration must occur. This means that muscle cells need more sugar and oxygen and have to get rid of more carbon dioxide. Respiration is not 100% efficient — heat is produced and must be moved to the surface layers of the skin where it is lost to the surroundings. All of this means that:

- the heart beats faster and more strongly
- the rate and depth of breathing increases
- blood vessels near the skin surface dilate

The extent to which these happen depends upon the nature of the exercise. If it is at a sustained, steady rate, as in a long-distance race, the heart's output and ventilation of the lungs will settle to a new and higher level, matching oxygen supply to the needs of the body. If on the other hand you are running flat out, a point is reached at which the muscles cannot be supplied with oxygen fast enough, anaerobic respiration starts to occur, lactic acid builds up and you are forced to stop.

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