Unit 4.4 The respiratory system

context

The cells in the human body carry out aerobic respiration to obtain the energy they need. Aerobic respiration uses oxygen and produces carbon dioxide. Hence, staying alive depends on a constant supply of oxygen and a way of removing the waste, carbon dioxide. This is the function of the respiratory system.

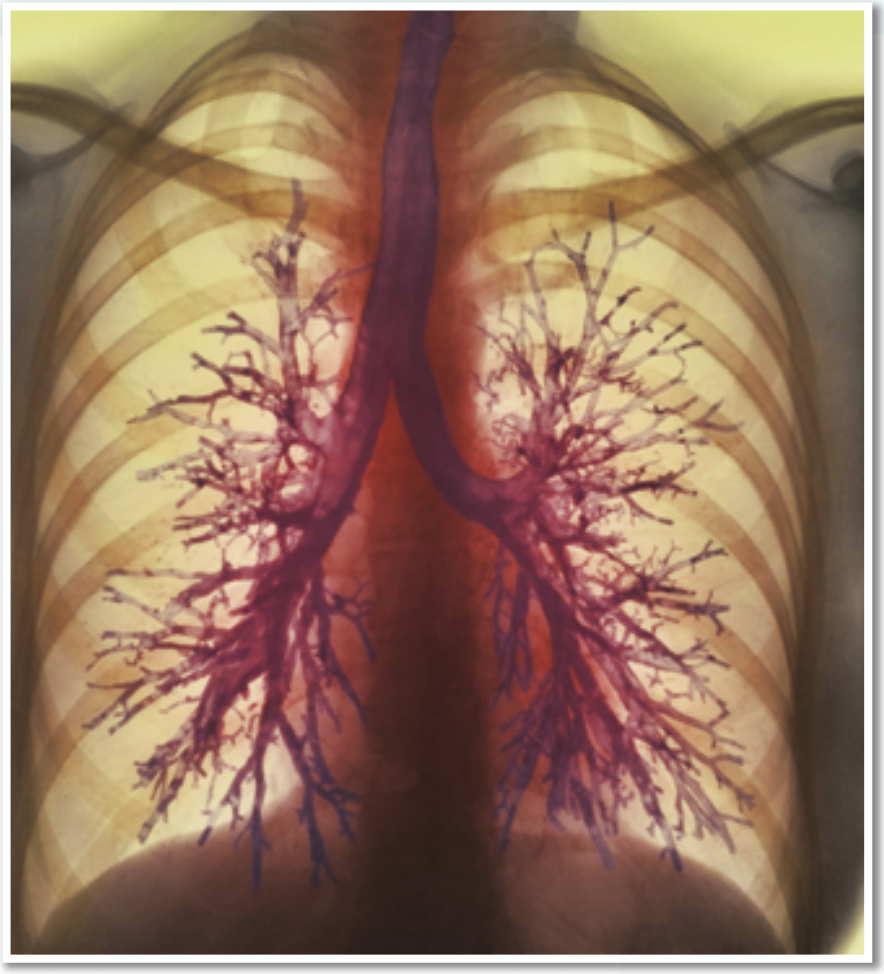

Fig 4.4.1 The tree-like airways that feed the lungs

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Breathing

Breathing allows your body to take in the oxygen that its cells need and to expel the carbon dioxide the cells produce as waste. When breathing in (i.e. inhaling), your ribs move up and out. This occurs due to the action of muscles in the chest (known as the **intercostals**) and the **diaphragm**. The diaphragm is a sheet of muscular tissue that separates your chest from your abdomen. The larger space in the chest causes the pressure inside to decrease, causing air to rush into the lungs. When breathing out (i.e. exhaling), your chest returns to its normal size and the air inside is forced out.

The percentage composition of inhaled and exhaled air varies because gases are exchanged between the lungs and the bloodstream.

Gas	Percentage in inhaled air	Percentage in exhaled air
Nitrogen	79.0	79.5
Oxygen	21.0	14.0
Carbon dioxide	0.04	5.6
Water vapour	Varies with location	100 (i.e. fully saturated)

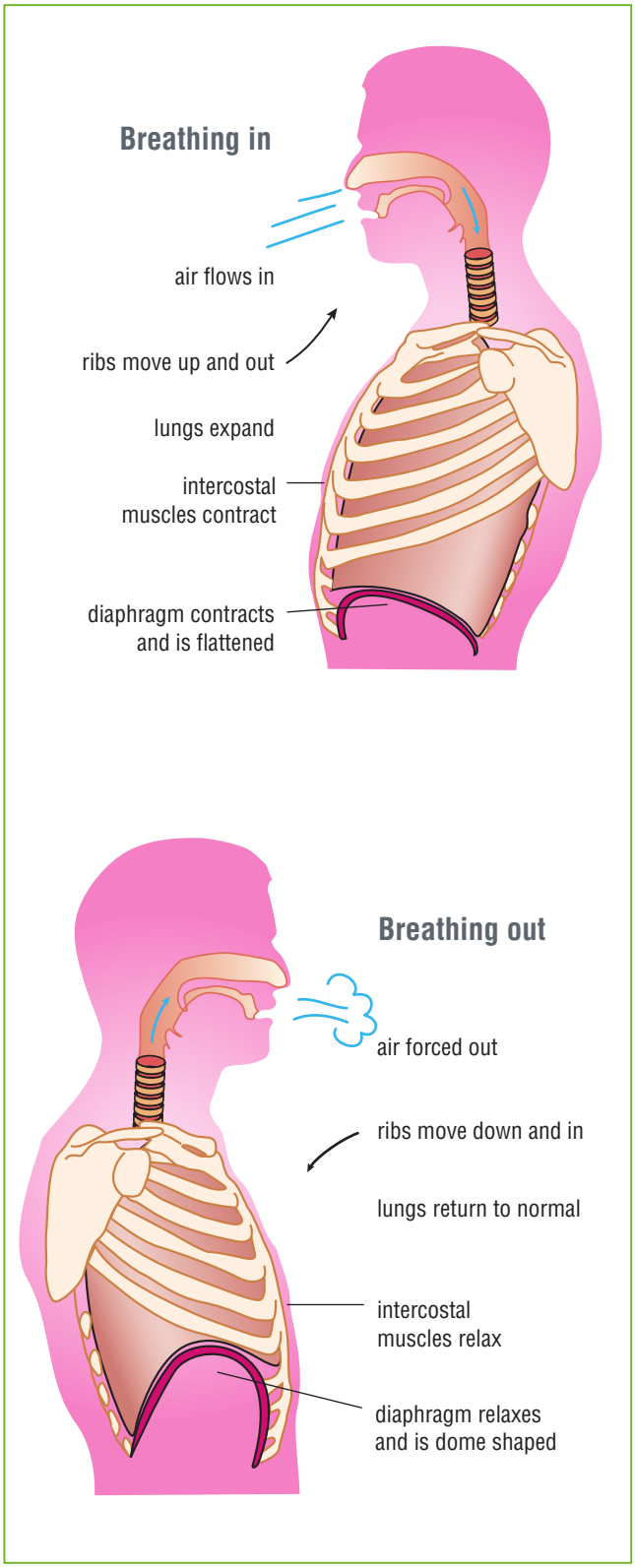


Fig 4.4.2 How the body breathes

Science Clip

Bubbles in the blood

Around 78 per cent of air is nitrogen gas. Normally it does no harm—you breathe it in but you breathe it straight back out. However, during deep-sea diving the increased pressure causes some of this nitrogen to dissolve in the blood. If the diver returns to the surface too quickly, the reduced pressure causes the dissolved nitrogen to form bubbles in the blood. This is similar to the way bubbles form when the lid is taken off a soft drink bottle. The bubbles rupture tissues, block blood vessels and cause extreme pains in the joints, known as the 'bends'. The condition is relieved by returning the diver to high pressure and then slowly lowering the pressure. This breaks up the bubbles so that the nitrogen can then be removed by the lungs.

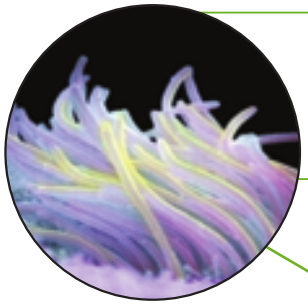
Breathing rate varies with age, physical activity and mood. Each breath exchanges around 500 millilitres of air. The vital capacity of the lungs is the maximum amount of air than can be exhaled after taking a deep breath. Vital capacity is normally around 4500 millilitres, but may be as high as 6500 millilitres in a well-trained athlete.

The human respiratory system

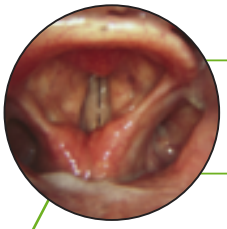
Most inhaled air enters via your nose. Here it is warmed, moistened and filtered. Nostril hairs filter out larger dust particles while tiny hair-like **cilia** trap finer particles. Even more particles get stuck in sticky mucus produced by mucous glands that line the inside of the nose. The mucus and trapped particles move to the back of the nose, into the **pharynx** and are eventually swallowed. You swallow around 600 millilitres of this mucus per day without being aware of it!

The inhaled air then passes into the **trachea** or windpipe. Parallel to it is the **oesophagus** (foodpipe), which sends food to the stomach. Nearby lies a flap of tissue called the **epiglottis**, which closes over the trachea, making sure that food and drink does not go down it and into the lungs. The vocal cords of the **larynx** provide some protection for the trachea, as do the reflex reactions of coughing and sneezing. You might also cough because of dust. Cilia line the entire respiratory system, constantly beating upwards and sending any dust that gets in back to the pharynx, to be coughed out or swallowed.

The trachea divides into two branches called **bronchi**, which in turn divide into smaller and smaller branches. These smallest branches are known as **bronchioles**, off which sprout clusters of tiny sacs called **alveoli**.



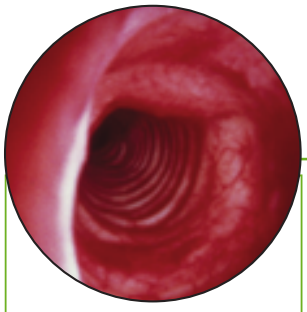
Nasal cavity
Inhaled air is warmed, moistened and filtered by nostril hairs, tiny hair-like cilia and a sticky mucous lining.



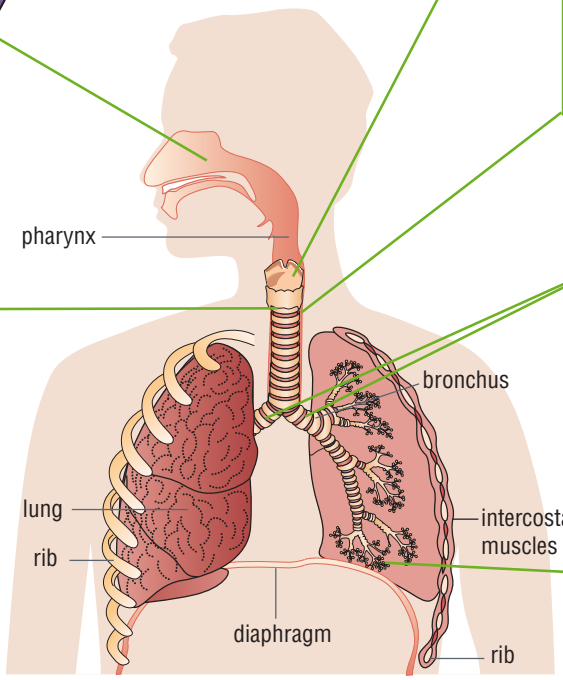
Larynx (voice box)
Flaps of skin that vibrate as air is forced across them, making sound.

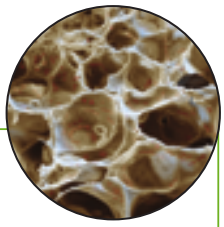
Oesophagus (foodpipe)
Runs parallel to the trachea and carries food to the stomach.

Bronchi
The trachea branches into two bronchi, which then branch into smaller and smaller tubes. Bronchioles are the smallest of these tubes and are located at the end of all these branches.



Trachea (windpipe)
a thin-walled tube about the diameter of a garden hose. The epiglottis is a flap of skin that blocks the trachea whenever food or drink is heading towards it, making it go into the foodpipe instead.





Alveoli
Tiny sacs in which oxygen and carbon dioxide are exchanged, passing in and out of the blood vessels that surround them.

Fig 4.4.3 The human respiratory system

Gas exchange in the alveoli

Gas exchange occurs in the alveoli. The oxygen that you breathe in passes into the bloodstream through the alveoli, as does the carbon dioxide that you breathe out. There are around 500 million alveoli in the lungs, giving a total surface of about 80 square metres.

The walls of alveoli are only one cell thick. Each alveolus lies close to the wall of a capillary. **Capillaries** are the smallest blood vessels of all. Their walls are only one cell thick and are so thin that gases pass easily through them from the lungs and the bloodstream. Gases cross between the alveoli and the capillaries by **diffusion**, a process during which substances naturally move from areas of high concentration to areas of lower concentration. Oxygen is more concentrated in the alveoli than in the blood of the capillaries, and so it diffuses from the alveoli into the blood. Carbon dioxide diffuses from the blood (high concentration) into the alveoli (low concentration).

Worksheet 4.6 Asthma

Science Clip

Smoking
Tobacco smoke immediately inhibits the action of the cilia that remove mucus, allowing it to accumulate and making infection more likely. Tobacco smoke also coats the alveoli in tar, leading to shortness of breath.

PP Drag-and-drop

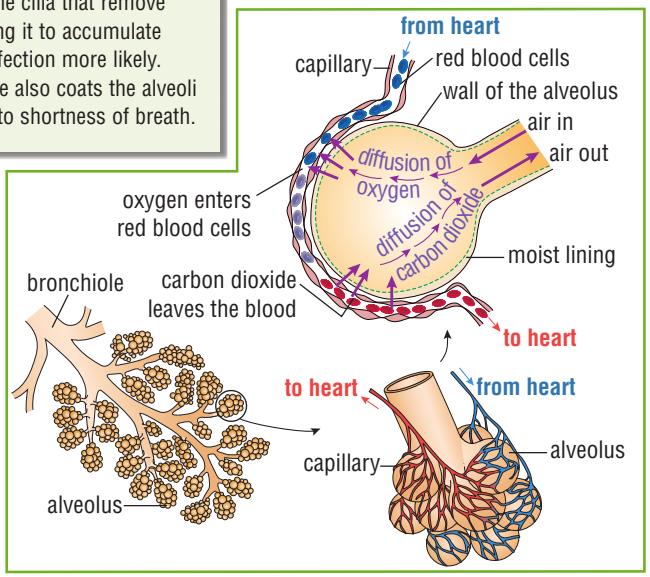


Fig 4.4.4 The airways branch and branch, ending in the alveoli, where gas exchange takes place.