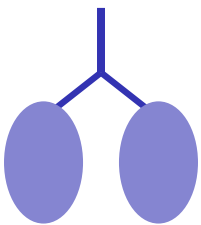
Gas Exchange in Humans

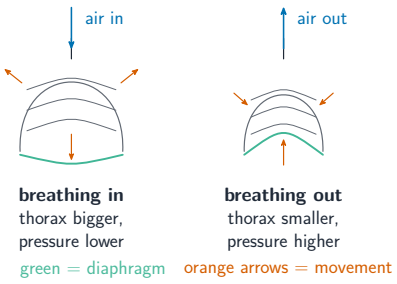
IGCSE Biology ▪ Topic 11

IGCSE Biology



What we will cover

1. A good gas-exchange surface
2. The breathing system
3. The alveolus
4. How you breathe
5. Inspired vs expired air
6. Exercise & clean airways



how you breathe

1 Surfaces and airways

A good gas-exchange surface

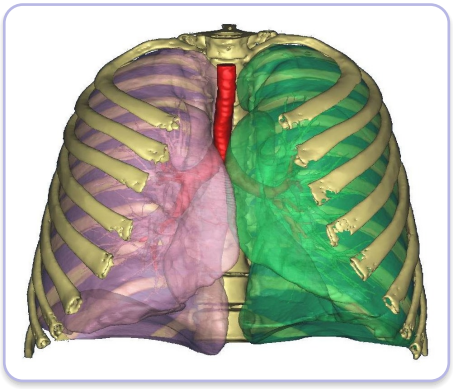
large surface area

thin – a short distance

good blood supply

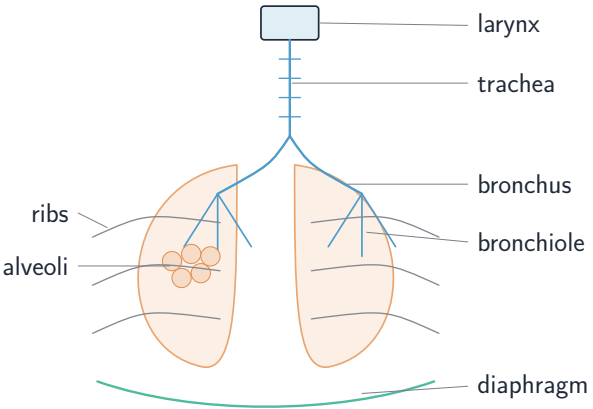
good **ventilation** 通气

Gas exchange 气体交换: O_2 in, CO_2 out, by **diffusion** 扩散. A steep concentration difference keeps it fast.



Gas exchange needs a large surface area

The breathing system



The air path:

trachea 气管

↓

bronchi 支气管

↓

bronchioles 细支气管

↓

alveoli 肺泡

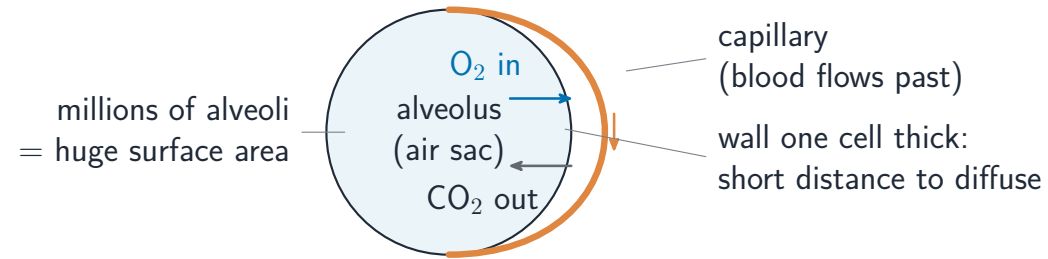
The **ribs** 肋骨, **intercostal muscles** 肋间肌 & **diaphragm** 膈肌 move the air.

The alveolus

Millions of **alveoli** 肺泡 are perfect surfaces:

- huge surface area
- wall one cell thick
- wrapped in **capillaries** 毛细血管

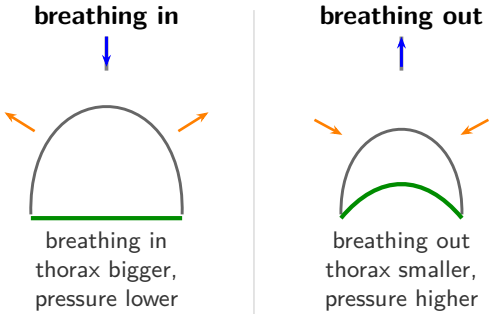
O_2 diffuses in; CO_2 diffuses out.



2

Breathing

How you breathe

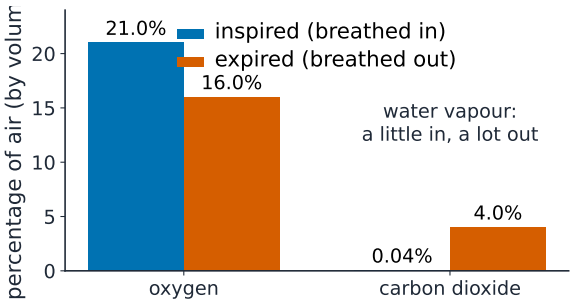


Breathing in 吸气: intercostals & diaphragm contract → **thorax** 胸腔 bigger → pressure drops → air in. Breathing out is the reverse.

Inspired vs expired air

Expired air has less O_2 (21%→16%), more CO_2 (0.04%→4%) & more water vapour.

> **Limewater** 石灰水 turns cloudy faster with expired air – it has more CO_2.



expired air: ↓ O_2, ↑ CO_2, ↑ water vapour (vs inspired)

Exercise and clean airways

exercise

more CO_2 in blood → brain
→ faster, deeper breathing

clean airways

goblet cells 杯状细胞
make **mucus** 黏液; **ciliated cells** 纤毛细胞 sweep it up

How the airways stay clean

the problem	inhaled air carries dust, **particles** 粒子 and **pathogens** 病原体
goblet cells	secrete mucus, which traps them
ciliated cells 纤毛细胞	tiny hairs that sweep the mucus and its trapped dirt up to the throat, where it is swallowed
cartilage 软骨	rings holding the trachea and bronchi open, so they cannot collapse
inhaling 吸气	intercostal muscles and diaphragm contract, the chest volume rises, pressure falls, and air moves in
exhaling 呼气	they relax, volume falls, pressure rises, and air moves out

> Smoking paralyses the cilia, so mucus is not cleared – which is why a smoker coughs and why infections settle in the chest.

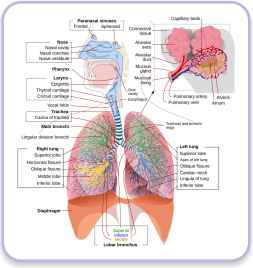
Worked example – breathing at rest and in exercise

At rest a person takes 12 breaths per minute of 500 cm^3. In exercise it becomes 20 breaths of 900 cm^3. Find each minute volume.

- Minute volume = rate $\times$ depth.
- rest: $12 \times 500 = 6000$ cm^3/min $= 6$ dm^3
- exercise: $20 \times 900 = 18\,000$ cm^3/min $= 18$ dm^3
- three times as much air each minute

Both the rate and the depth increase. Muscles need more oxygen and produce more carbon dioxide, and it is the rising CO_2 the body detects.

The breathing system, continued



The lungs sit in the chest behind the **ribs** 肋骨, on the sheet of muscle called the **diaphragm** 膈肌, with the **intercostal muscles** 肋间肌 between the ribs. Air passes the **larynx** 喉 – the voice box at the top of the windpipe – then the **bronchi** 支气管, one tube to each lung.

Exam tips

- A gas exchange surface is large, thin, with a good blood supply and good ventilation.
- Air path: larynx → trachea → bronchi → bronchioles → alveoli.
- Breathing in: external intercostal muscles and diaphragm contract → thorax bigger → pressure lower → air in. Breathing out is the opposite.
- Expired air has **less** oxygen, **more** carbon dioxide and **more** water vapour. Limewater tests for carbon dioxide.
- Exercise → more carbon dioxide in the blood → brain → faster, deeper breathing.

3 Recap

Worked example – inspired vs expired air

Expired air has more CO_2 and water vapour, and is warmer. Explain each.

- Body cells respire, making CO_2; blood carries it to the alveoli and it diffuses out.
- So expired CO_2 ($\approx 4\%$) $>$ inspired ($\approx 0.04\%$).
- The alveoli are moist; water evaporates from that film into the air.
- The air is warmed to body temperature inside the lungs.
- Oxygen falls ($21\% \rightarrow 16\%$) – but not to zero: only some diffuses out.

Expired air still holds plenty of oxygen – that is exactly why rescue breathing works. Nitrogen is unchanged; the body does not use it.

Topic 11 – key takeaways

1 Surface

large, thin, blood supply, ventilation

2 Alveoli

millions; one-cell wall; capillaries

3 Breathing

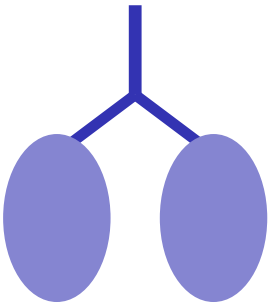
contract $\rightarrow$ bigger thorax $\rightarrow$ air in

4 Expired air

less O_2, more CO_2 & water

Check yourself

1. Name two features of a good gas-exchange surface.
2. Where does gas exchange happen in the lungs?
3. What happens to the diaphragm when you breathe in?
4. Which gas is higher in expired air?



Answers **1.** e.g. large surface area & thin **2.** the alveoli **3.** it contracts and flattens **4.** carbon dioxide