Exercise walk-through

11.1.1

Ventilation, air composition, exercise and keeping the airways clean

IGCSE Biology

You must be able to

- describe the features of a gas exchange surface: large surface area, thin, good blood supply, good **ventilation** 通气
- identify the lungs, diaphragm, ribs, intercostal muscles, **larynx** 喉, **trachea** 气管, **bronchi** 支气管, **bronchioles** 细支气管, **alveoli** 肺泡 and their capillaries, including the internal and external intercostal muscles
- state the function of the cartilage in the trachea
- explain how the ribs, the internal and external intercostal muscles and the diaphragm produce the volume and pressure changes that ventilate the lungs
- investigate and describe the differences between inspired and expired air, using **limewater** 石灰水 as a test for carbon dioxide, and explain those differences
- investigate, describe and explain the effect of physical activity on the rate and depth of breathing

You must be able to

- explain the role of goblet cells, **mucus** 黏液 and ciliated cells in protecting the breathing system

1 The method

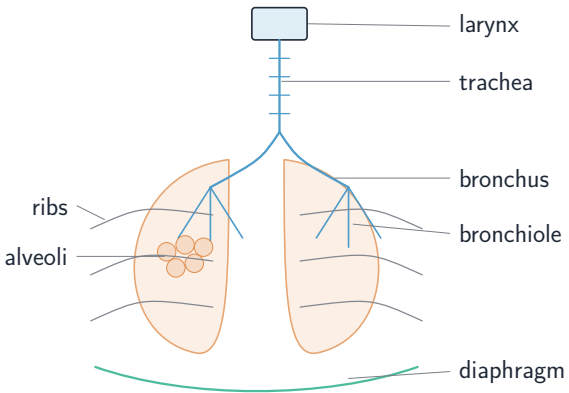
Method — The parts, and the one function you are asked for

Air travels: **larynx** → **trachea** → **bronchi** → **bronchioles** → **alveoli**, where the exchange happens.

- The **cartilage** in the trachea wall is the only part whose *function* is examined: it holds the trachea **open**, so that air can always pass even when the pressure inside drops.
- The **intercostal muscles** lie between the ribs. The **external** ones pull the ribs **up and out**; the **internal** ones pull them **down and in**.

Method — The parts, and the one function you are asked for

Air travels: larynx … trachea … bronchi … bronchioles … alveoli , where the exchange happens



Method — Why an alveolus is a good gas exchange surface

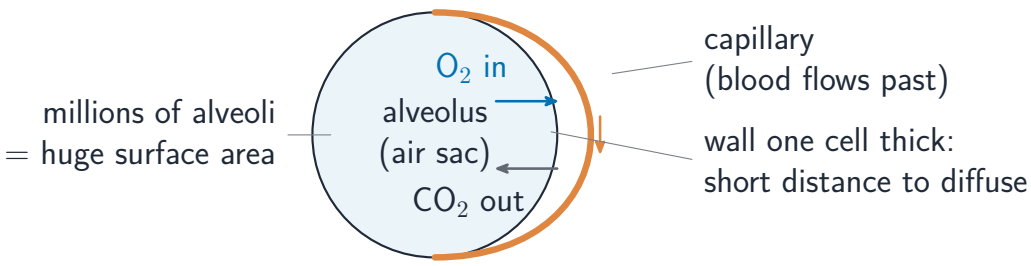
Four features, and each one must be paired with **what it does**:

feature	**why it helps**
large surface area – millions of alveoli	more gas can diffuse at the same time
thin – the wall is one cell thick	a **short diffusion distance** 扩散距离
good blood supply – a network of capillaries	keeps a steep **concentration gradient** 浓度梯度
good ventilation – air is replaced with every breath	also keeps the gradient steep

- Naming a feature alone is half a mark's work. "Large surface area **so more diffusion can happen at once**" is the full answer.

Method — Why an alveolus is a good gas exchange surface

Four features, and each one must be paired with what it does : center



Method — Ventilation: what moves, what happens to volume, what happens to pressure

Answer in this order every time: **muscles** → **ribs and diaphragm** → **volume** → **pressure** → **air moves**.

Method — Ventilation: what moves, what happens to volume, what happens to pressure

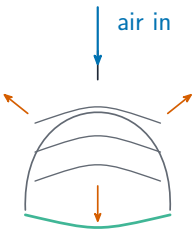
	breathing in	**breathing out**
external intercostal muscles	contract	relax
internal intercostal muscles	relax	contract
ribs	move **up and out**	move **down and in**
diaphragm	**contracts** and flattens	**relaxes** and domes up
volume of the thorax	**increases**	**decreases**
pressure in the thorax	**decreases**	**increases**
air	moves **in**	moves **out**

Method — Ventilation: what moves, what happens to volume, what happens to pressure

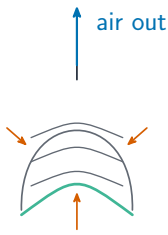
- Air always moves from **higher** pressure to **lower** pressure. Writing “the lungs suck the air in” earns nothing.
- The diaphragm **contracts to flatten**. Saying it “relaxes downwards” is the commonest error on this unit.

Method — Ventilation: what moves, what happens to volume, what happens to pressure

Answer in this order every time: muscles … ribs and diaphragm … volume … pressure … air moves .



breathing in
thorax bigger,
pressure lower



breathing out
thorax smaller,
pressure higher

green = diaphragm orange arrows = movement

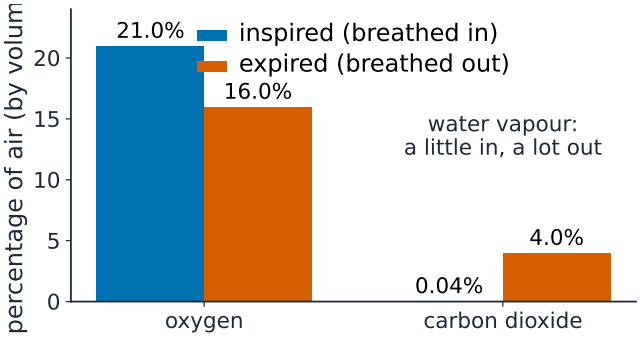
Method — Inspired and expired air

gas	inspired	expired	why
oxygen	about 21%	about 16%	some diffused into the blood, to be used in **respiration 呼吸作用**
carbon dioxide	about 0.04%	about 4%	made by respiration in the body cells, and diffused out of the blood
water vapour	little	a lot	the alveoli and airways are **moist**, and water evaporates from them

The limewater test. Bubble each sample of air through limewater. **Expired air turns the limewater milky much faster**, because it contains far more carbon dioxide. The inspired-air tube is the **control**: it goes milky only slowly, which shows the difference is real.

Method — Inspired and expired air

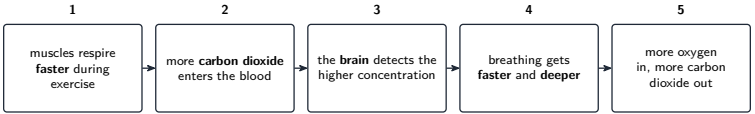
The inspired-air tube is the control : it goes milky only slowly, which shows the difference is real



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

Method — Exercise and breathing

- Both the **rate** (breaths per minute) and the **depth** (volume of each breath) increase.
- The trigger the exam wants is the **carbon dioxide concentration in the blood**, detected by the **brain**. Answers built on "the body needs more oxygen" miss the marking point.

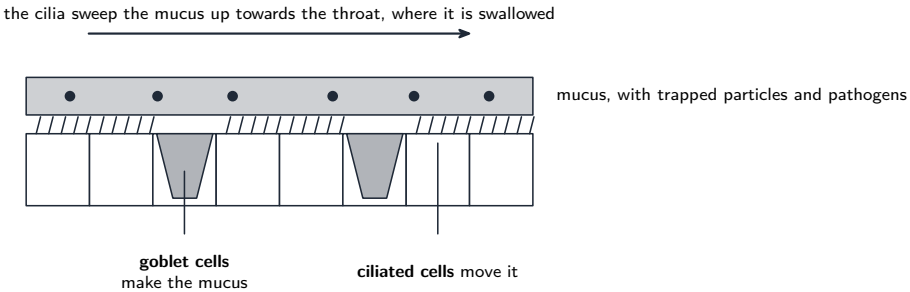


The brain responds to the **carbon dioxide** concentration, not to a shortage of oxygen. Every step here is a separate marking point.

Method — Keeping the airways clean

- **Goblet cells** make the sticky **mucus**, which **traps** particles and pathogens in the air you breathe in.
- **Ciliated cells** carry hair-like **cilia** that beat and **sweep the mucus up** the trachea to the throat, where it is swallowed.
- Two cell types, two jobs. A question about protection wants both.

Method — Keeping the airways clean



Two cell types, two jobs. A question that asks about *protection* wants both: the mucus traps the particles, and the cilia carry them away from the lungs.

2 Practice

Practice 2.1 ▪ 2 marks

Name the tube that carries air from the larynx to the bronchi, and state the function of the cartilage in its wall.

Solution 2.1

Method: The parts, and the one function you are asked for — p.5

Worked steps

- the **trachea** B1
- the cartilage holds the trachea **open**, so air can always pass through it B1

Practice 2.2 ▪ 4 marks

State **two** features of a gas exchange surface, and explain how each one helps gas exchange.

Solution 2.2

Method: Why an alveolus is a good gas exchange surface — p.7

Worked steps

- any **two** features, each with its reason:
- **large surface area** B1 – so more gas can diffuse at the same time B1
- **thin, one cell thick** B1 – so the diffusion distance is short B1
- other acceptable pairs: a **good blood supply**, or **good ventilation**, each because it keeps a steep concentration gradient

Practice 2.3 ▪ 3 marks

Describe what the external intercostal muscles and the diaphragm do when a person breathes in.

Solution 2.3

Worked steps

- the **external intercostal muscles contract** B1
- so the ribs move **up and out** B1
- the **diaphragm contracts** and **flattens**, moving down B1

Practice 2.4 ▪ 3 marks

Explain how the volume and the pressure inside the thorax change when a person breathes in, and why this makes air enter the lungs.

Solution 2.4

Method: Ventilation: what moves, what happens to volume, what happens to pressure — p.9

Worked steps

- the volume of the thorax **increases** B1
- so the pressure inside it **decreases**, and becomes lower than the air pressure outside B1
- air therefore moves **from the higher pressure outside to the lower pressure inside**, and enters the lungs B1

Practice 2.5 ▪ 2 marks

Describe what you would see when expired air is bubbled through limewater, and state what the control should be.

Solution 2.5

Method: Inspired and expired air — p.13

Worked steps

- the limewater turns **milky** (cloudy white) quickly B1
- the control is a second tube of limewater through which **inspired air** is drawn; it goes milky only slowly, showing the difference is caused by the expired air B1

Practice 2.6 ▪ 2 marks

State the function of goblet cells and the function of ciliated cells.

Solution 2.6

Method: Keeping the airways clean — p.16

Worked steps

- goblet cells make **mucus**, which traps particles and pathogens B1
- ciliated cells have **cilia** that sweep the mucus up to the throat, where it is swallowed B1

3 Exam-style

Exam-style 3.1 ▪ 1 mark

Which row describes the thorax when a person breathes **in**?

	external intercostal muscles	**diaphragm**	**volume of thorax**	**pressure in thorax**
A	contract	contracts and flattens	increases	decreases
B	contract	relaxes and domes up	increases	decreases
C	relax	contracts and flattens	decreases	increases
D	relax	relaxes and domes up	decreases	increases

Solution 3.1

Method: Ventilation: what moves, what happens to volume, what happens to pressure — p.9

Worked steps

A

- breathing in: the external intercostals contract and the diaphragm contracts and flattens, so the thorax gets **bigger** and the pressure inside gets **lower** B1

Exam-style 3.2 ▪ 6 marks

The table shows the composition of inspired and expired air.

gas	**inspired air / %**	**expired air / %**
oxygen	21	16
carbon dioxide	0.04	4

Exam-style 3.2 (a) ▪ 2 marks

Explain why expired air contains less oxygen than inspired air.

Solution 3.2 (a)

Method: Inspired and expired air — p.13

Worked steps

- oxygen **diffuses** from the air in the alveoli into the blood B1
- because it is used by the body cells in **respiration**, which keeps its concentration in the blood low B1

Exam-style 3.2 (b) ▪ 2 marks

Expired air also contains much more water vapour. Explain why.

Solution 3.2 (b)

Worked steps

- the alveoli and the airways have **moist** surfaces B1
- water **evaporates** from them into the air, so the air breathed out carries much more water vapour B1

Exam-style 3.2 (c) ▪ 2 marks

Expired air still contains 16% oxygen. Explain why this makes mouth-to-mouth resuscitation useful.

Solution 3.2 (c)

Worked steps

- 16% is still a high enough concentration of oxygen for it to **diffuse into the casualty's blood** in the alveoli B1
- so their cells can still respire, which keeps them alive until help arrives B1

Exam-style 3.3 ▪ 12 marks

A student measured her breathing rate and the volume of each breath before, during and after five minutes of exercise.

when	**breathing rate / breaths per minute**	**volume of each breath / dm^3**
at rest	14	0.5
during exercise	30	1.8
5 minutes after exercise	18	0.8

Exam-style 3.3 (a) ▪ 2 marks

Calculate the volume of air she breathed in one minute at rest, and in one minute during exercise.

Solution 3.3 (a)

Method: Exercise and breathing — p.15

Worked steps

- multiply the rate by the volume of each breath M1

at rest: $14 \times 0.5 = \mathbf{7}$ dm$^{\mathbf{3}}$ per minute during: $30 \times 1.8 = \mathbf{54}$ dm$^{\mathbf{3}}$ per minute A1

Exam-style 3.3 (b) ▪ 2 marks

Describe the effect of exercise on her breathing.

Solution 3.3 (b)

Worked steps

- the breathing **rate** rose, from 14 to 30 breaths per minute B1
- the **depth** of each breath rose too, from 0.5 to 1.8 dm^3 B1

Exam-style 3.3 (c) ▪ 4 marks

Explain, in terms of carbon dioxide, why her breathing changed during exercise.

Solution 3.3 (c)

Worked steps

- her muscles **respired faster** during the exercise, to release more energy B1
- so they produced more **carbon dioxide**, which entered the blood B1
- the **brain** detected the increased carbon dioxide concentration in the blood B1
- and increased the **rate and depth** of breathing, so that more carbon dioxide is removed and more oxygen taken in B1

Exam-style 3.3 (d) ▪ 2 marks

Five minutes after the exercise stopped, her breathing rate was still above its resting value. Explain why.

Solution 3.3 (d)

Worked steps

- the carbon dioxide concentration in her blood has **not yet returned** to its resting level B1
- so the brain is still stimulating faster, deeper breathing until the extra carbon dioxide has been removed B1

Exam-style 3.3 (e) ▪ 2 marks

State **two** variables she should keep the same if she repeats the investigation with a friend.

Solution 3.3 (e)

Worked steps

- any **two** of: the **type** of exercise; how **long** the exercise lasts; how **hard** the exercise is; the time after exercise at which the measurements are taken B1 B1