The Mammalian Respiratory System

A Level

All mammals share the same basic respiratory system structure: a single trachea branches into two separate lungs, each of which consists of progressively smaller branches that eventually end in alveoli, where gas exchange with the bloodstream occurs.

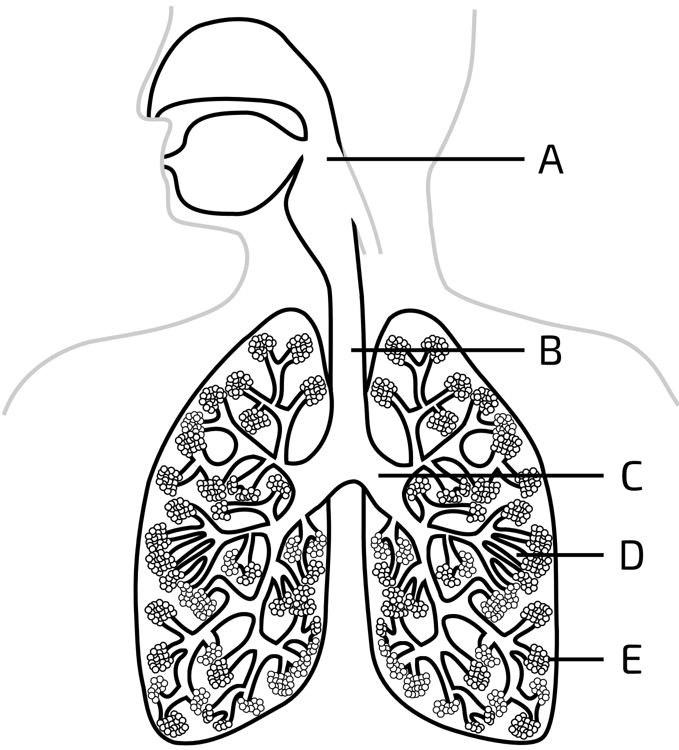

Figure 1: A simplified diagram of the human respiratory system. Specific regions are labelled (A-E). Region "A" separates into two tubes, one of which is the oesophagus (top part shown in grey) which leads to the digestive system (not shown). Structures "E" are not shown to scale.

Part A Respiratory anatomy

Match the name to the label from **Figure 1** in the table below.

Label	Name
A	
B	
C	
D	
E	

Items:

trachea **bronchiole** **pharynx** **alveolus** **bronchus**

Part B Respiratory functions

Match the structure/cell type to the function in the table below.

Function	Structure/cell type
secrete mucus onto the lining of the trachea to trap dust and pathogens	
move mucus upwards (away from the lungs) towards the pharynx	
provide structural support to the trachea and bronchi	
surround the bronchioles and can contract to reduce airflow to the lungs	
surround the alveoli, allowing them to expand during inhalation	
where gas exchange occurs between the air and the blood	

Items:

elastic fibres **ciliated epithelial cells** **goblet cells** **cartilage rings** **smooth muscle** **alveoli**

Part C Gas exchange efficiency

Which of the following statements correctly describe how features of the mammalian respiratory system ensure efficient gas exchange?

Select all that apply.

- [ ] The lungs are composed of many alveoli which **decreases** the surface area to volume ratio.
- [ ] The lungs are composed of many alveoli which **increases** the surface area to volume ratio.
- [ ] The wall of each alveolus is very **thin.**
- [ ] The wall of each alveolus is very **thick.**
- [ ] Each alveolus is covered by a dense network of capillaries, which maximises the amount of gas exchange that can occur.
- [ ] There is countercurrent flow between the blood and the air in the lungs, which maintains a high diffusion gradient.
- [ ] Airflow through the lungs is unidirectional which means that oxygen diffuses into the blood during both inhalation **and** exhalation.
- [ ] The lungs are **actively ventilated** rather than relying on passive diffusion.

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Alveoli

A Level

P P P

Alveoli are tiny air sacs found in mammalian lungs. It is here that gas exchange occurs between the blood and the air.

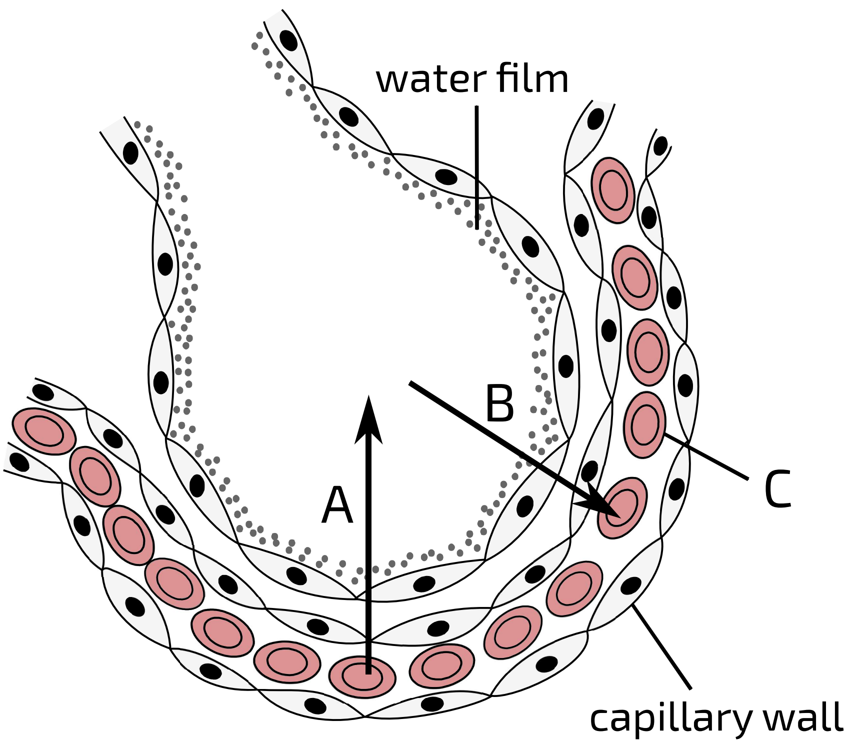

Figure 1: A cross-section of a mammalian alveolus and associated blood capillary. The water film covering the alveolar epithelial cells prevents the cells from drying out. Arrows (A,B) represent the movement of gases.

Part A Gas A

What is the name of the gas that moves in direction **A** in **Figure 1**?

Part B Gas B

What is the name of the gas that moves in direction **B** in **Figure 1**?

Part C Gas exchange

By which process do gases **A** and **B** move between the alveolus and the blood capillary?

- simple diffusion
- facilitated diffusion
- osmosis
- active transport

Part D Cell type

What is the name of cell type **C** in **Figure 1**?

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The Fish Respiratory System

A Level

P P P

The fish respiratory system is made up of complex structures called gills. These highly vascularised structures are able to absorb dissolved oxygen from the surrounding water as it flows past. The diagram below shows part of a fish gill.

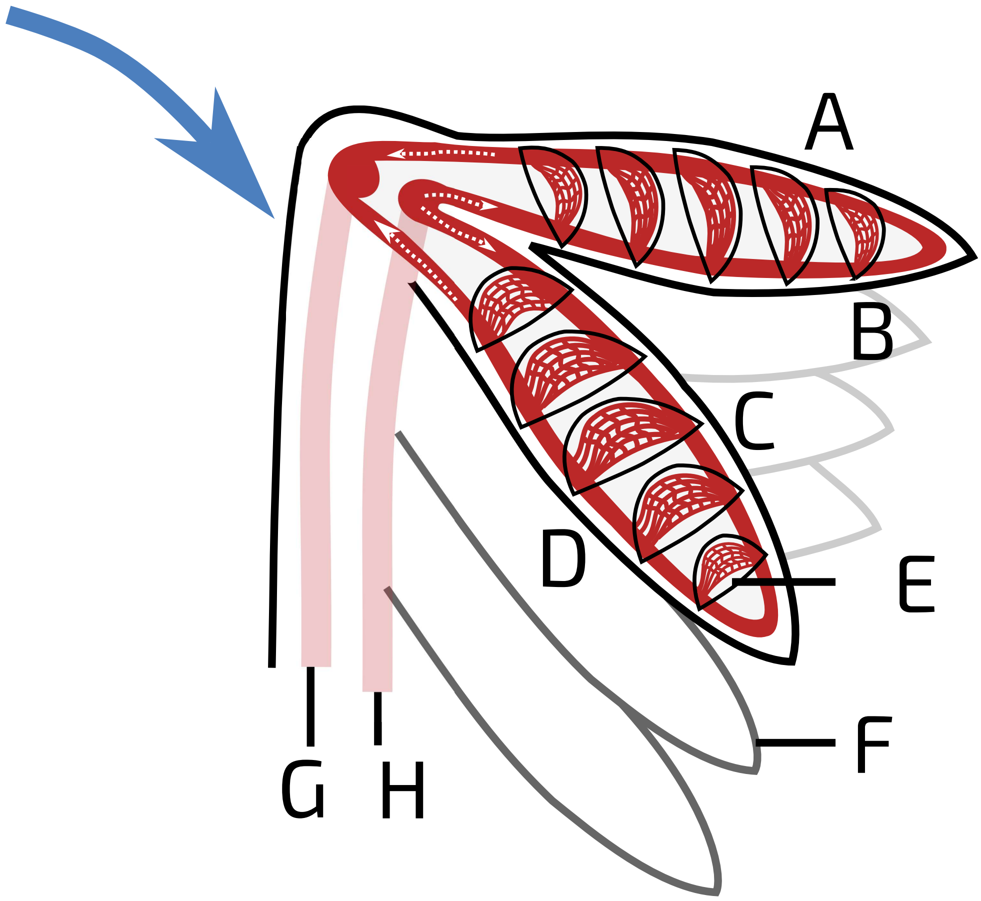

Figure 1: A simplified diagram of part of a fish gill. The blue arrow shows the flow of water towards the gill. Blood vessels are shown in red, with white dotted arrows showing the direction of blood flow. Labels A-D label represent positions in space. Labels E-F represent gill structures. Labels G-H represent gill arteries. The blood vessels and other structures present in the top layer of the gill are also present in every other layer, but are not shown here.

Part A Gill anatomy

Description	Label
Blood flows in the direction of...	
Water flows in the direction of...	
gill filament	
gill lamella	
afferent artery (carrying deoxygenated blood into the gills)	
efferent artery (carrying oxygenated blood out of the gills)	

Items:

A to B & D to C B to A & C to D E F G H

Part B Gill ventilation

Most fish ventilate their gills by a process called "buccal pumping", in which water is actively drawn in through the [ ] and pumped out over the [ ]. Water moves over the gills in the [ ] direction as/to the direction of blood movement through the gills - an example of [ ]. This maximises the diffusion gradients of oxygen and carbon dioxide between the blood and the water, ensuring that the blood becomes more saturated with [ ] than if water and blood moved in the [ ] direction.

Fish can also ventilate their gills by a process called "ram ventilation". Instead of actively drawing in water and pumping it out, they keep their mouth open as they swim forwards. Some bony fish (e.g. bluefin tunas) and some cartilaginous fish (e.g. great white sharks) can only ventilate their gills in this way. This means they must keep swimming in order to take in [ ].

Items:

cocurrent exchange **same** **countercurrent exchange** **carbon dioxide** **gills** **buccal cavity (mouth)** **opposite** **oxygen**

Part C Gill covering

In most cartilaginous fish, the gills are visible.

However, in bony fish, the gills are covered with a protective bony flap that opens as water is pumped out.

What is the name of this bony flap?

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[Home](#) [Gameboard](#) Biology Physiology Mammalian Breathing

Mammalian Breathing

A Level P P P

In vertebrates, the organ responsible for gas exchange between the blood and the environment (lungs or gills) is actively ventilated. The mechanisms of ventilation ("breathing") are different among vertebrates. The questions below relate specifically to mammalian breathing.

Part A Inhalation

During inhalation, the lungs expand. This is caused by the following processes:

- The diaphragm ____, changing from a ____ to a ____. This causes the thorax to expand downwards.
- The external intercostal muscles ____. This causes the ribcage to move upwards and outwards, causing the thorax to expand in these directions.

The increase in the volume of the thorax causes thoracic pressure to ____. This causes air to move into the lungs through the nose/mouth.

Items:

contracts **relaxes** **flatter shape** **more domed shape** **contract** **relax** **increase** **decrease**

Part B Exhalation

During exhalation, the lungs return to their resting size. This is caused by the following processes:

- The diaphragm [ ] from a [ ] to a [ ]. This causes the thorax to reduce in volume.
- The external intercostal muscles [ ]. This causes the ribcage to move down and inwards, causing the thorax to reduce in volume.

The decrease in the volume of the thorax causes thoracic pressure to [ ]. This causes air to move out of the lungs through the nose/mouth.

Normal exhalation is a passive process, caused by muscle relaxation and elastic recoil of the alveoli. However, other muscles (e.g. the abdominal muscles and internal intercostal muscles) can actively contract to increase exhalation rate if necessary (e.g. during exercise).

Items:

contracts **relaxes** **flatter shape** **more domed shape** **contract** **relax** **increase** **decrease**

Part C Breathing statements

Which of the following is/are correct when a healthy human **breathes in**? Select all that apply.

- [ ] The ribcage moves up and out because air enters the lungs.
- [ ] The volume of the thorax decreases and the thoracic pressure increases.
- [ ] Energy is required to contract the intercostal muscles but not the diaphragm.
- [ ] The alveoli expand and the elastic fibres surrounding them are stretched.
- [ ] none of the above

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[Home](#) [Gameboard](#) Biology Physiology Pulmonary Ventilation Rate

Pulmonary Ventilation Rate

A Level

Pulmonary Ventilation Rate (PVR) is a measure of the volume of air that moves in and out of the lungs per minute. It is measured using a spirometer, and can be used to assess fitness levels and diagnose respiratory diseases.

Part A Formula

The formula for calculating pulmonary ventilation rate is as follows:

$$\text{Pulmonary ventilation rate (PVR)} = \square \; \square \; \square$$

Items:

tidal volume | vital capacity | breathing rate | $\times$ | $\div$ | $+$ | $-$

Part B Pulmonary ventilation rate calculation

Using a spirometer, an individual's tidal volume and breathing rate were measured.

Tidal volume $= 500\,\mathrm{cm}^3$

Breathing rate $= 12$ breaths per minute

Calculate this individual's pulmonary ventilation rate.

Part C Breathing rate calculation

Using a spirometer, an individual's pulmonary ventilation rate and tidal volume were measured.

Pulmonary ventilation rate $= 6.4\,\mathrm{dm}^3$

Tidal volume $= 400\,\mathrm{cm}^3$

Calculate this individual's breathing rate.

Part D Tidal volume calculation

Using a spirometer, an individual's pulmonary ventilation rate and breathing rate were measured.

Pulmonary ventilation rate $= 8.1\,\mathrm{dm}^3$

Breathing rate $= 18$ breaths per minute

Calculate this individual's tidal volume.

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Spirometry Analysis

A Level

In a test to compare the function of the human respiratory system in different individuals, individuals were asked to breathe out as hard as possible for as long as possible. The volume exhaled was recorded using a spirometer.

The graph shows the results obtained after carrying out this test on two males with the same height and body mass.

The investigators were particularly interested in two measurements:

- Forced Vital Capacity (FVC): the maximum total volume of air an individual can forcefully breathe out after breathing in as deeply as possible
- Forced Expiratory Volume (FEV1): the maximum volume of air an individual can forcefully breathe out in 1 second

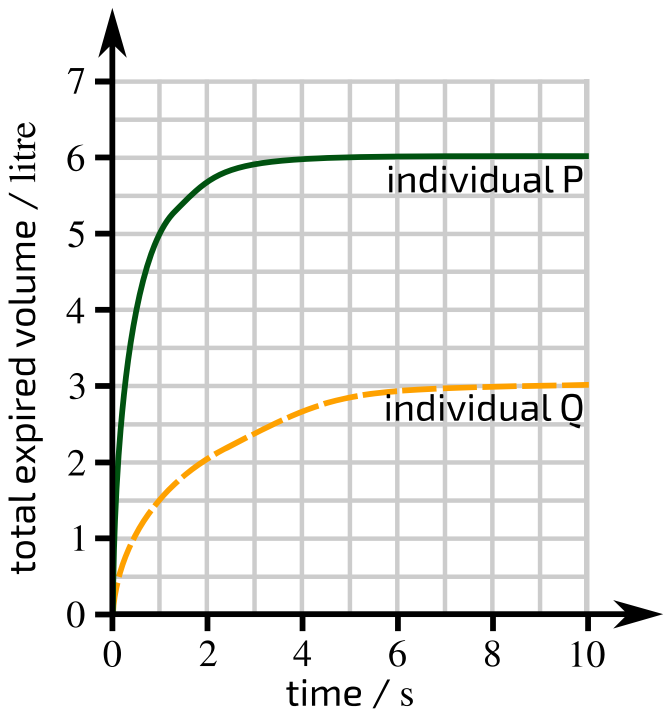

Figure 1: Spirometry results. The total expired volume of air is shown over time for two individuals.

Part A Forced Vital Capacities

How much greater is the forced vital capacity (FVC) of individual P than individual Q?

Give your answer as a percentage to the nearest percent.

Part B Forced Expiratory Volumes

How much greater is the forced expiratory volume (FEV1) of individual P than individual Q?

Give your answer as a percentage to the nearest percent.

Part C Breathing mechanisms

Which of the following statements are correct? Select all that apply.

- [ ] Individual Q's diaphragm was **more** domed at 7 seconds than at 2 seconds.
- [ ] Individuals Q's diaphragm was **less** domed at 7 seconds than at 2 seconds.
- [ ] Between 0 and 1 seconds, the external intercostal muscles of both individuals are **contracting**.
- [ ] Between 0 and 1 seconds, the external intercostal muscles of both individuals are **relaxing**.
- [ ] The elastic fibres surrounding individual P's alveoli are **more** stretched at 2 seconds than at 0 seconds.
- [ ] The elastic fibres surrounding individual P's alveoli are **less** stretched at 2 seconds than at 0 seconds.

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Home Gameboard Biology Physiology Peak Expiratory Flow

Peak Expiratory Flow

A Level

C C C

Peak expiratory flow (PEF) is a measure of the maximum rate at which a person can exhale.

The graph below shows the typical PEF values for men of different ages and heights.

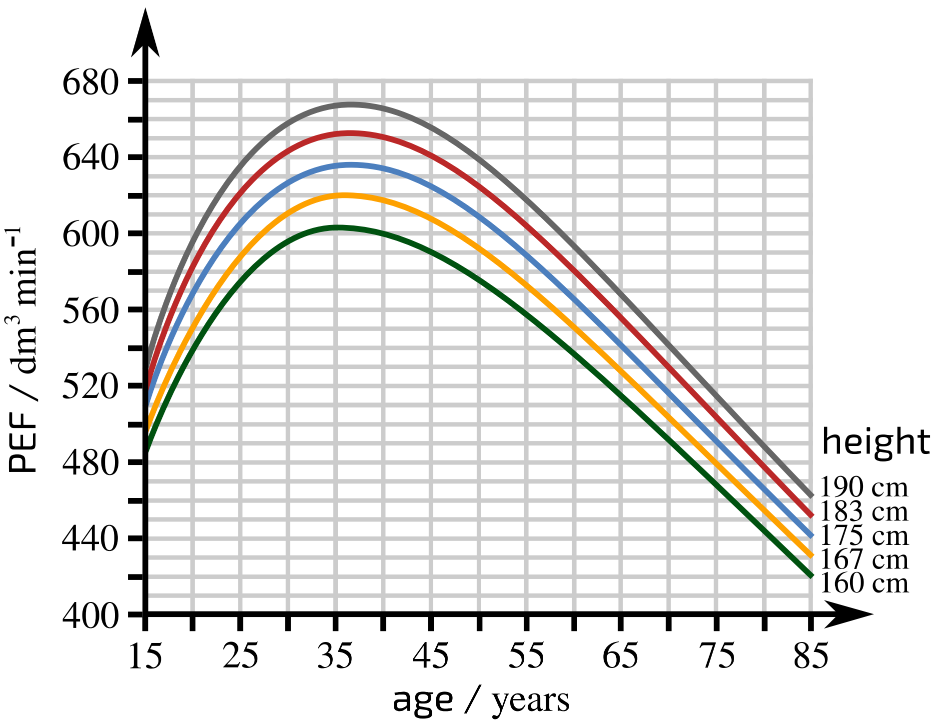

Figure 1: Typical peak expiratory flow (PEF) rates for men of different ages and heights.

Part A Percentage difference

How much higher is the PEF of a 45 year old man of $183\,\mathrm{cm}$ than the PEF of a 20 year old man of $175\,\mathrm{cm}$?

Give your answer as a percentage to the nearest percent.

Part B Percentage increase

For a man of $167\,\mathrm{cm}$, how much higher is their PEF at 35 years old than their PEF at 15 years old?

Give your answer as a percentage to the nearest percent.

Part C Percentage decrease

For a man of $167\,\mathrm{cm}$, how much lower is their minimum PEF than their maximum PEF?

Give your answer as a percentage to the nearest percent.

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