WJEC (Eduqas) Biology A-level

Topic 2.2 - Adaptations for gas exchange

Flashcards

How does an organism's size relate to its surface area to volume ratio?

How does an organism's size relate to its surface area to volume ratio?

The larger the organism, the lower the surface area to volume ratio.

How does surface area to volume (SA/V) ratio affect transport of molecules?

How does surface area to volume (SA/V) ratio affect transport of molecules?

The lower the SA/V ratio, the further the distance molecules must travel to reach all parts of the organism. Diffusion alone is not sufficient in organisms with small SA/V ratios.

Why do larger organisms require mass transport and specialised gas exchange surfaces?

Why do larger organisms require mass transport and specialised gas exchange surfaces?

- Small SA/V ratio
- Diffusion insufficient to provide all cells with the required oxygen and to remove all carbon dioxide
- Large organisms more active than smaller organisms

Name four features of an efficient gas exchange surface.

Name four features of an efficient gas exchange surface.

- Large surface area
- Short diffusion distance
- Steep diffusion gradient
- Ventilation mechanism

Describe the gas exchange mechanism in the Amoeba.

Describe the gas exchange mechanism in the Amoeba.

- Unicellular organism with a large SA/V ratio
- Thin cell membrane provides short diffusion distance
- **Simple diffusion** across the cell surface membrane is sufficient to meet the demands of respiratory processes

Describe the gas exchange mechanism in flatworms.

Describe the gas exchange mechanism in flatworms.

- Multicellular organisms with a relatively small SA/V ratio (in comparison to the Amoeba)
- However, flat structure provides a **large surface area** and reduces the diffusion distance
- **Simple diffusion** is sufficient to meet the demands of respiratory processes

Describe the gas exchange mechanism in earthworms.

Describe the gas exchange mechanism in earthworms.

- Cylindrical, multicellular organisms with a relatively small SA/V ratio (in comparison to the flatworm)
- **Slow moving** and **low metabolic rate** ∴ require little oxygen
- Rely on **external surface** for gas exchange
- **Circulatory system** transports oxygen to the tissues and removes carbon dioxide, maintaining a steep diffusion gradient

Define ventilation.

Define ventilation.

The movement of fresh air into a space and stale air out of a space to maintain a steep concentration gradient of oxygen and carbon dioxide.

Name the organ of gaseous exchange in fish.

Name the organ of gaseous exchange in fish.

Gills

What are gill filaments?

What are gill filaments?

- Main site of gaseous exchange in fish, over which water flows
- They overlap to increase resistance to flowing water - slowing it down and maximising gaseous exchange.
- Found in large stacks, known as **gill plates**, and have **gill lamellae** which provide a large surface area and good blood supply for exchange

Explain the process of ventilation in bony fish.

Explain the process of ventilation in bony fish.

- **Buccal cavity** volume increases and pressure decreases to enable water to flow in
- Contraction of the buccal cavity forces water across the gills
- Pressure in the gill cavity rises, opening the **operculum**. Water leaves

How is a steep diffusion gradient maintained across the entire gas exchange surface in bony fish?

How is a steep diffusion gradient maintained across the entire gas exchange surface in bony fish?

Due to counter current flow.

Define counter current flow.

Define counter current flow.

Blood and water flow in **opposite directions** across the gill plate.

How does counter current flow maintain a steep diffusion gradient? What is the advantage of this?

How does counter current flow maintain a steep diffusion gradient? What is the advantage of this?

- Water is always next to blood of a lower oxygen concentration
- Keeps rate of diffusion constant and enables 80% of available oxygen to be absorbed

What type of flow is exhibited in cartilaginous fish?

What type of flow is exhibited in cartilaginous fish?

Parallel flow

Define parallel flow.

Define parallel flow.

Water and blood flow in the **same direction** across the gill plate.

Compare counter current and parallel flow.

Compare counter current and parallel flow.

Counter current flow	Parallel flow
Blood and water flow in **opposite** directions across the gill plate	Water and blood flow in the **same** direction across the gill plate
Steep diffusion gradient maintained, allowing diffusion of oxygen across the whole gill plate	Diffusion gradient **not maintained** ∴ diffusion of oxygen does not occur across the whole plate
High rate of diffusion	**Lower** rate of diffusion
More efficient - more oxygen absorbed into the blood	**Less efficient** - less oxygen absorbed into the blood
Found in **bony fish**	Found in **cartilaginous fish**, e.g. sharks

Name and describe the main features of an insect's gas transport system.

Name and describe the main features of an insect's gas transport system.

- **Spiracles** - small, external openings along the thorax and abdomen through which air enters, and air and water leave the gas exchange system
- **Tracheae** - large tubes extending through all body tissues, supported by rings of chitin to prevent collapse
- **Tracheoles** - smaller branches dividing off the tracheae

What is the main site of gas exchange in insects?

What is the main site of gas exchange in insects?

Tracheoles

Describe the adaptations of the insect tracheal system to a terrestrial environment.

Describe the adaptations of the insect tracheal system to a terrestrial environment.

- Spiracles can be **opened** or **closed** to regulate diffusion
- **Bodily contractions** speed up the movement of air through the spiracles
- **Highly branched tracheoles** provide a large surface area
- **Impermeable cuticle** reduces water loss by evaporation

Describe the ventilation of the tracheal system in insects.

Describe the ventilation of the tracheal system in insects.

- **Expansion** of the abdomen **opens the thorax spiracles** (through which **air enters**) and closes the abdominal spiracles
- **Compression** of the abdomen closes the thorax spiracles and **opens the abdominal spiracles** (through which **air is expelled**)

Compare the gas exchange surface of an active and inactive amphibian.

Compare the gas exchange surface of an active and inactive amphibian.

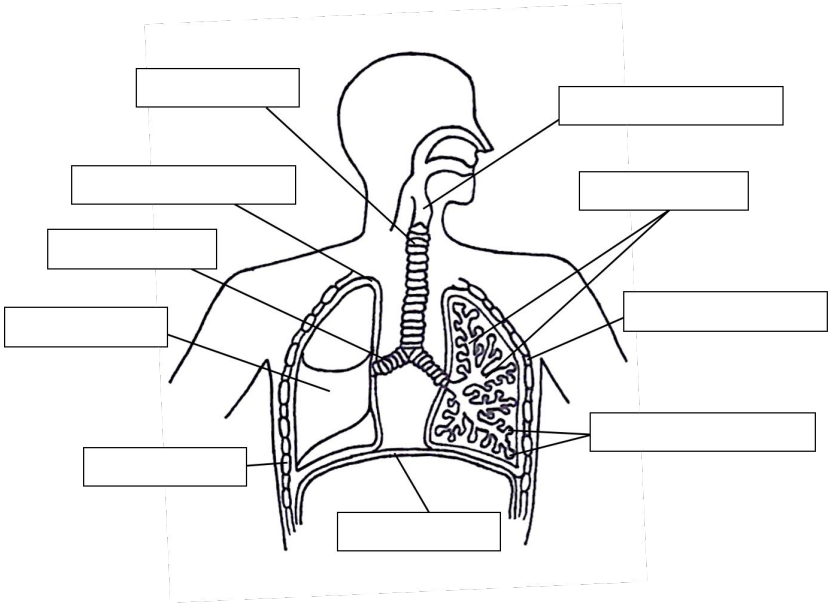
- Active amphibian has simple lungs
- Inactive amphibian relies on its moist external surface for gas exchange

How are mammals adapted for gas exchange?

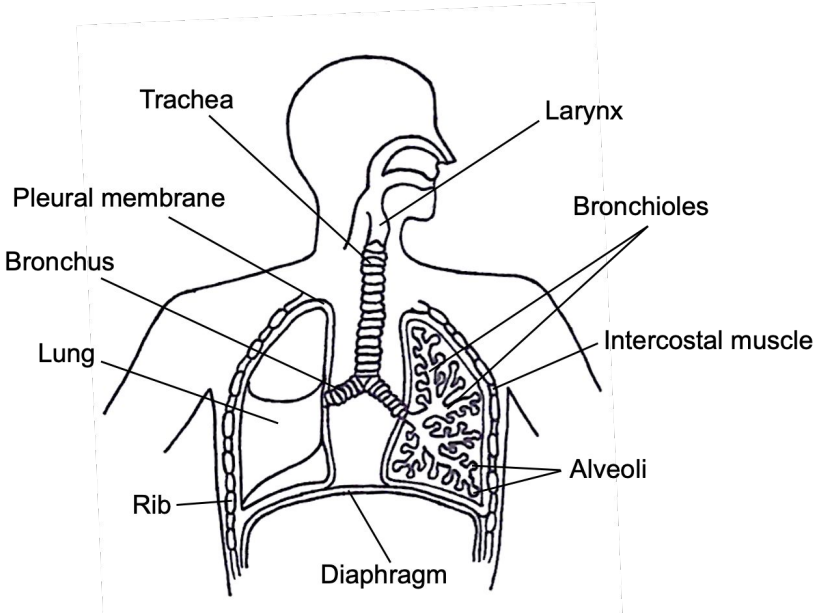
How are mammals adapted for gas exchange?

Alveoli provide a large surface area and thin diffusion pathway, maximising the volume of oxygen absorbed from one breath. They also have a plentiful supply of deoxygenated blood, maintaining a steep concentration gradient.

Fill in the missing labels in the diagram of the human respiratory system below.



Fill in the missing labels in the diagram of the human respiratory system below.



Describe the structure and function of the larynx.

Describe the structure and function of the larynx.

A hollow, tubular structure located at the top of the trachea involved in breathing and phonation.

Describe the trachea and its function in the mammalian gaseous exchange system.

Describe the trachea and its function in the mammalian gaseous exchange system.

- **Primary airway**, carries air from the nasal cavity down into the chest
- Wide tube supported by C-shaped **cartilage** to keep the air passage open during pressure changes
- Lined by **ciliated epithelial cells** which move mucus, produced by goblet cells, towards the back of the throat to be swallowed. This prevents lung infections

Describe the structure of the bronchi.

Describe the structure of the bronchi.

- Divisions of the trachea that lead into the lungs
- Narrower than the trachea
- Supported by rings of **cartilage** and lined by **ciliated epithelial cells** and **goblet cells**

Describe the structure and function of the bronchioles.

Describe the structure and function of the bronchioles.

- Many small divisions of the bronchi that allow the passage of air into the alveoli
- Contain **smooth muscle** to restrict airflow to the lungs but do not have cartilage
- Lined with a thin layer of **ciliated epithelial cells**

What is the primary gaseous exchange surface in humans?

What is the primary gaseous exchange surface in humans?

Alveoli

Describe the alveoli in the mammalian gaseous exchange system.

Describe the alveoli in the mammalian gaseous exchange system.

- Mini air sacs, lined with epithelial cells
- Walls **one cell thick**
- **Good blood supply** to maintain a steep diffusion gradient
- 300 million in each lung

What are the pleural membranes?

What are the pleural membranes?

Thin, moist layers of tissue surrounding the pleural cavity that reduce friction between the lungs and the inner chest wall.

Define pleural cavity.

Define pleural cavity.

The space between the pleural membranes of the lungs and the inner chest wall.

Describe ventilation in humans.

Describe ventilation in humans.

- The movement of fresh air into the lungs and stale air out of the lungs via inspiration and expiration
- Via **negative pressure breathing**

What are internal intercostal muscles?

What are internal intercostal muscles?

A set of muscles found between the ribs on the inside that are involved in forced exhalation.

What are external intercostal muscles?

What are external intercostal muscles?

A set of muscles found between the ribs on the outside that are involved in forced and quiet inhalation.

Explain the process of inspiration and the changes that occur throughout the thorax.

Explain the process of inspiration and the changes that occur throughout the thorax.

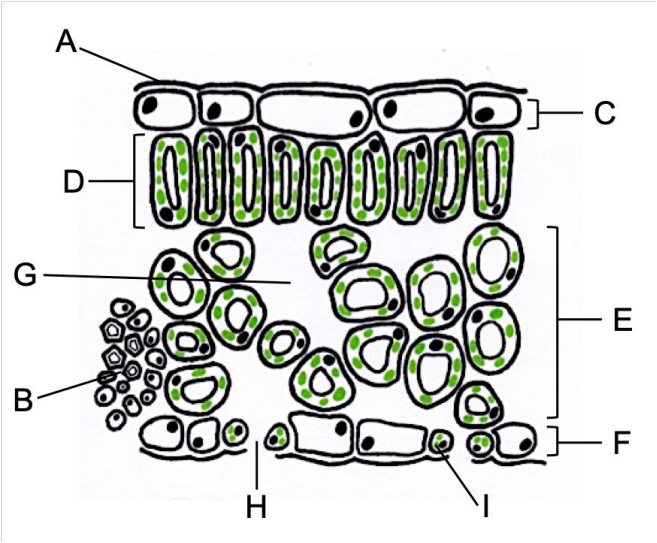
- External intercostal muscles contract (while internal relax), raising the ribcage
- Diaphragm contracts and flattens
- Outer pleural membrane moves out, reducing pleural cavity pressure and pulling the inner membrane out
- The alveoli expand. Alveolar pressure falls below air pressure so air moves into the trachea

What is surfactant?

What is surfactant?

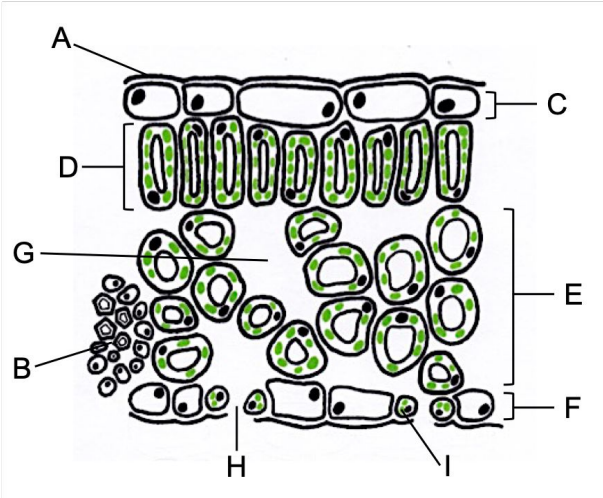
A fluid lining the surface of the alveoli that reduces surface tension and prevents collapse of the alveoli during exhalation.

Identify the structures of the dicotyledonous leaf labelled in the diagram below.



Identify the structures of the dicotyledonous leaf labelled in the diagram below.

A	waxy cuticle	**F**	lower epidermis
B	vascular bundle	**G**	air-filled space
C	upper epidermis	**H**	stoma
D	palisade mesophyll tissue	**I**	guard cell
E	spongy mesophyll tissue		



Describe the function of the waxy cuticle.

Describe the function of the waxy cuticle.

Reduces water loss from the leaf surface.

Describe how the upper epidermis is adapted for photosynthesis.

Describe how the upper epidermis is adapted for photosynthesis.

- Layer of **transparent** cells allow light to strike the mesophyll tissue
- Epidermal cells also **synthesise** the **waxy cuticle**, reducing water loss

Where is the palisade mesophyll layer located?

Where is the palisade mesophyll layer located?

Directly below the upper epidermis.

How is the palisade mesophyll layer adapted for photosynthesis?

How is the palisade mesophyll layer adapted for photosynthesis?

It receives the most light so contains the greatest concentration of chloroplasts.

How is the spongy mesophyll layer adapted for photosynthesis?

How is the spongy mesophyll layer adapted for photosynthesis?

- Contains **air spaces** that reduce the diffusion distance for carbon dioxide to reach the chloroplasts in the palisade layer
- Contains some chloroplasts

What is a vascular bundle?

What is a vascular bundle?

The vascular system in dicotyledonous plants. It consists of two transport vessels, the xylem and the phloem.

Why are vascular bundles important in photosynthesis?

Why are vascular bundles important in photosynthesis?

They form a large network to deliver water and nutrients to photosynthetic tissues and remove glucose.

Describe how the lower epidermis is adapted for photosynthesis.

Describe how the lower epidermis is adapted for photosynthesis.

It contains many **stomata** which enable the evaporation of water and inward diffusion of CO_2.

What are stomata?

What are stomata?

Small holes found on leaves that can be opened or closed by **guard cells** to control gas exchange and water loss.

Summarise the ‘malate’ theory.

Summarise the ‘malate’ theory.

The ‘malate’ theory states that the accumulation or loss of malate and K^+ ions by guard cells results in changes in turgor pressure that open or close the stomata.

By what mechanism do K^+ ions enter guard cells?

By what mechanism do K^+ ions enter guard cells?

Active transport

How does the accumulation of K^+ and malate ions affect guard cells?

How does the accumulation of K^+ and malate ions affect guard cells?

- Lowers the water potential of guard cells
- Water moves in by osmosis
- Guard cells becomes turgid, opening the stomata

Why is starch important for stomatal opening?

Why is starch important for stomatal opening?

Starch is converted to malate ions.