

Model Answers: Medium

1

The correct answer is **B** as **oxygen** and **carbon monoxide** both bind to same area on **haemoglobin**, whereas **carbon dioxide** binds to a different location.

Increased **carbon dioxide** lowers the oxygen affinity of **haemoglobin** - this is known as the **Bohr Effect**. **Carbon dioxide** lowers the pH of the blood (by forming carbonic acid) and this causes **haemoglobin** to release its **oxygen**. The **Bohr Effect** is beneficial as cells with increased metabolism (i.e. respiring tissues) release more **carbon dioxide** and therefore promote the release of **oxygen** from **haemoglobin** at the areas of greatest need.

Haemoglobin contains four **haem groups** each capable of binding one **oxygen** molecule. **Carbon monoxide** binds to **haemoglobin** at the same sites as **oxygen**, however, it does so around 200 times more tightly. This means when **carbon monoxide** is present, it binds to **haemoglobin** preferentially over **oxygen**, therefore fewer **haemoglobin** particles are available to bind and deliver **oxygen**. This causes the gradual suffocation associated with **carbon monoxide poisoning**.

2

The correct answer is **C** as bronchioles have **collagen, elastic fibres** and **cilia** but are not involved in **gas exchange** (gas exchange only occurs in the alveoli). Knowing that narrows the choice down to **C** or **D** and (while you are not expected to know the specific diameters of the different airways), given the overall size of the lungs, it would not be possible for the bronchioles to be 20mm in diameter (20mm would be more like the approximate diameter of the trachea), therefore the answer must be **C**.

Gas exchange in the **alveoli** is possible due to their thin, **squamous epithelial cell** walls (which create a **short diffusion distance**). They also have a **large surface area** and **extensive blood supply**.

3

The correct answer is **A** as:

- **trachea** have **cartilage** (to prevent collapse from low pressure during inhalation)
- **trachea** have **goblet cells** (to produce mucus to trap dirt and pathogens)
- **trachea** have **smooth muscle** (to provide strength and flexibility to the trachea)

Alveoli have none of these features as they are too small - their walls are only one cell thick so there is no space for **cartilage**, **goblet cells** or **smooth muscle**.

The **trachea** is a wide flexible tube, the lumen of which is kept open by **C-shaped rings** of **cartilage**. The gaps between the rings of **cartilage** are filled by a bundle of **smooth muscle** and **elastic tissue**. Together these hold the lumen of the **trachea** open while still allowing flexibility during **inhalation** and **exhalation**.

4

The correct answer is **B** as the diagram shows **goblet cells** and **ciliated epithelial cells**. **Goblet cells** are only found in the **trachea** and the **bronchi**. **Ciliated epithelial cells** are found in the **trachea**, **bronchi** and in the larger **bronchioles**.

Goblet cells and **ciliated epithelial cells** work together to keep the respiratory tract free of dirt and pathogens. The **goblet cells** secrete **mucus** (shown on the diagram as circles within the goblet cell) and this mucus traps inhaled particulate matter. The **ciliated epithelial cells** have tiny, hair like projections (called cilia) that beat rhythmically and sweep the mucus (and trapped dirt) up and out of the respiratory tract.

5

The correct answer is **D** as the wall contains all three features. **Exocytotic vesicles** are present in **goblet cells** (where they release **mucus**). **Cartilage** prevents collapse from low pressure during inhalation. **Ciliated cells** waft mucus (containing dirt and trapped pathogens) out of the respiratory system.

6

The correct answer is **C** as **carboxyhaemoglobin** is haemoglobin with carbon **monoxide** bound to it, not carbon **dioxide**. Haemoglobin with carbon **dioxide** bound to it is called **carbaminohaemoglobin** (this is a common mistake so be careful!).

Also, carbon monoxide binds to haemoglobin almost irreversibly, 200 times tighter than oxygen binding, so dissociation of carboxyhaemoglobin is very unlikely. This is what leads to carbon monoxide poisoning

A and **D** are both referring to the same effect. It is easier to bind a second and third oxygen molecule to **haemoglobin** than the first molecule. This is because the **haemoglobin** molecule changes its shape (or conformation) as **oxygen** binds, however, the fourth **oxygen** is the most difficult to bind. The binding of **oxygen** to **haemoglobin** can be plotted on a graph (with the **partial pressure of oxygen in the blood** on the x-axis and the **relative oxygen saturation of haemoglobin** on the y-axis). The resulting graph (called an oxygen dissociation curve) will be S-shaped.

B is correct as up to **four** oxygen molecules are bound to each **haemoglobin** and as oxygen molecules come in pairs (i.e. **O₂**) this equals 8 atoms.

7

The correct answer is **C** the **folded inner lining** allows the **bronchiole** to **expand** and **contract** during **ventilation**. The folding also permits the contraction and relaxation of smooth muscles around the bronchioles (leading to constriction and dilation of the lumen) which is important in directing airflow to chosen sections of the lung.

A is incorrect as this would be a negative attribute. Trapping foreign particles in the bronchioles would lead to a build-up of dirt and pathogens and an increased risk of pulmonary infection. This is why bronchioles have **ciliated epithelium** cells to move trapped foreign particles out of the lungs.

B is incorrect as while the folding does result in a larger surface area, this is more of a by-product than a causal effect and is not a property required for bronchiole function.

D is incorrect as gas exchange only occurs in the alveoli. The walls of the other vessels are too thick for gas exchange to occur.

8

The correct answer is **D** as **carbon monoxide** has a **greater** affinity for haemoglobin than oxygen and **carbon dioxide** has a **lower** affinity for haemoglobin than oxygen.

Haemoglobin contains four **haem groups** each capable of binding one **oxygen** molecule. **Carbon monoxide** binds to **haemoglobin** at the same sites as **oxygen**, however, it does so around 200 times more tightly. This means when **carbon monoxide** is present, it binds to **haemoglobin** preferentially over **oxygen**, therefore fewer **haemoglobin** particles are available to bind and deliver **oxygen**. This causes the gradual suffocation associated with **carbon monoxide poisoning**.

Carbon dioxide concentration is able to change the affinity of haemoglobin to oxygen. Increased **carbon dioxide** lowers the oxygen affinity of **haemoglobin** - this is known as the **Bohr Effect**. **Carbon dioxide** lowers the pH of the blood (by forming carbonic acid) and this causes **haemoglobin** to release its **oxygen**. The **Bohr Effect** is beneficial as cells with increased metabolism (i.e. respiring tissues) release more **carbon dioxide** and therefore promote the release of **oxygen** from **haemoglobin** at the areas of greatest need.

9

The correct answer is **C** as **X** are **ciliated epithelial cells** and **Y** are **smooth muscle cells**. Ciliated epithelial cells waft dirt and pathogens (trapped in mucus produced by goblet cells) up and out of the respiratory system. Smooth muscle controls the width of the diameter by constriction and dilation, therefore allowing a degree of control over airflow.

10

The correct answer is **A** because:

- **Bronchioles** have no **glands** or **cartilage** but do have **smooth muscle** in the walls and the larger sections have **ciliated epithelial cells**.
- The **trachea** and the **bronchus** are very similar in structure. The main difference is in the shape of the **cartilage**. The trachea has **C-shaped cartilage rings**, whereas the bronchi have crescent-shaped **plates of cartilage**. The lumen of the trachea is also wider than the lumen of the bronchus
- **Alveoli** don't have any of the features present in the other three airways, instead they are composed entirely of **squamous epithelial cells**

The reason the trachea has **C-shaped** cartilaginous rings is because the **oesophagus** lies behind the **trachea**. The rings allow the trachea to collapse slightly so food can pass down the oesophagus after swallowing.

Squamous epithelial cells are flattened cells. They are present in the walls of the **alveoli** and **capillaries** in the lungs where they are vital in reducing the diffusion distance for gas exchange.