9. Gas Exchange

9.1 The Gas Exchange System

Paper 2

Question Paper

1 Fig. 4.1 is a scanning electron micrograph showing the tissue that lines the bronchi in the gas exchange system.

Fig. 4.2 is a transmission electron micrograph of a horizontal section made at the position indicated by the two arrows in Fig. 4.1.

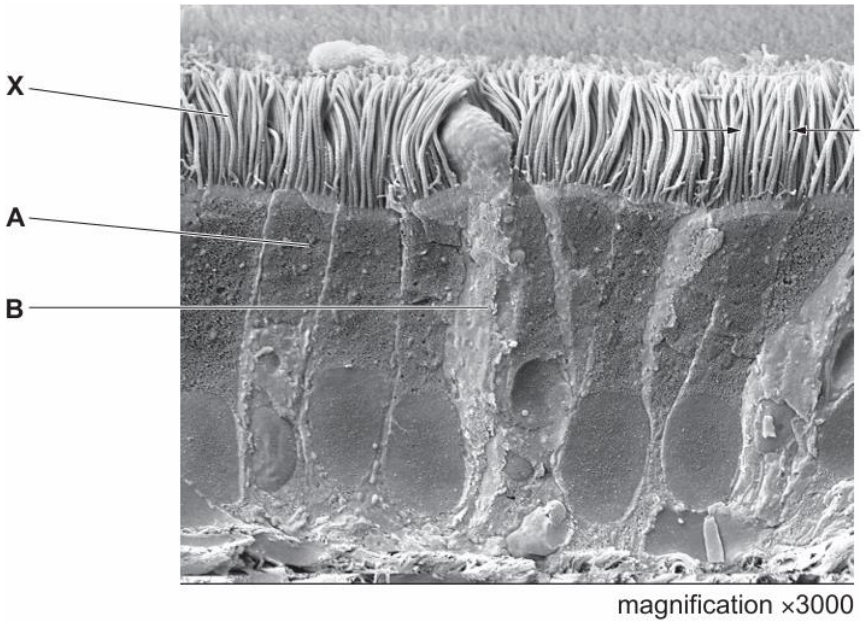


Fig. 4.1

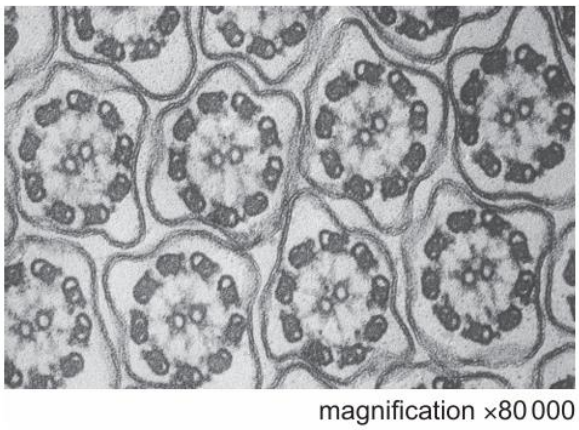


Fig. 4.2

(a) (i) Name the cells labelled **A** and **B** in Fig. 4.1.

A .....

B .....

[2]

(ii) Describe how the tissue shown in Fig. 4.1 is adapted to its function in the gas exchange system.

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..... [3]

2 Smooth muscle is a tissue composed of smooth muscle cells. The cells contain cytoplasm packed with proteins that are involved in contraction and relaxation.

(a) Smooth muscle is present in the airways of the gas exchange system.

Explain how smooth muscle cells in the walls of the **bronchioles** contribute to the function of these airways.

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..... [2]

3 People who become infected with human immunodeficiency virus (HIV) are at risk of developing HIV/AIDs, particularly if antiretroviral therapy (ART) is not available.

(d) *P. jirovecii* can adhere (attach) to squamous epithelial cells of the alveoli and to the network of fibrous proteins that support the alveolar wall, known as the extracellular matrix (ECM). Examples of proteins in the ECM are elastin and collagen.

Adhesion (attachment) of *P. jirovecii* to alveolar epithelial cells and the ECM stimulates the growth of its population.

(ii) One consequence of the pneumonia that results from *P. jirovecii* infection is a decrease in the quantity of oxygen that is delivered to body tissues.

Explain why a severe *P. jirovecii* infection results in a decrease in the quantity of oxygen that is delivered to body tissues.

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..... [3]

4 **(a)** Fig. 3.1 is a photomicrograph of a transverse section through a region of the wall of the bronchus in the gas exchange system.

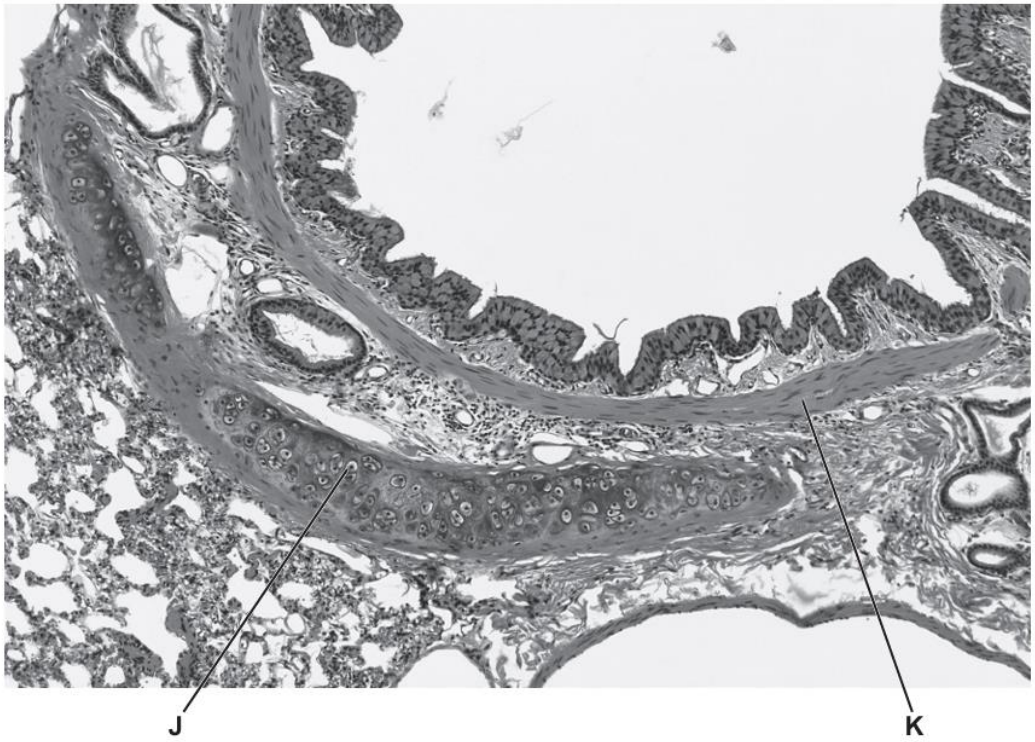


Fig. 3.1

Identify the tissues **J** and **K** shown in Fig. 3.1, **and** suggest how the wall of a bronchiole differs from the wall of the bronchus for these two tissues.

J .....

K .....

difference .....

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[3]

5 The Weibel Lung model was developed after an extensive study of the gas exchange system. The model includes detailed measurements of airway diameters (lumen diameters of the airways). In the model, different parts of the gas exchange system are identified with a generation number, as outlined in Fig. 6.1.

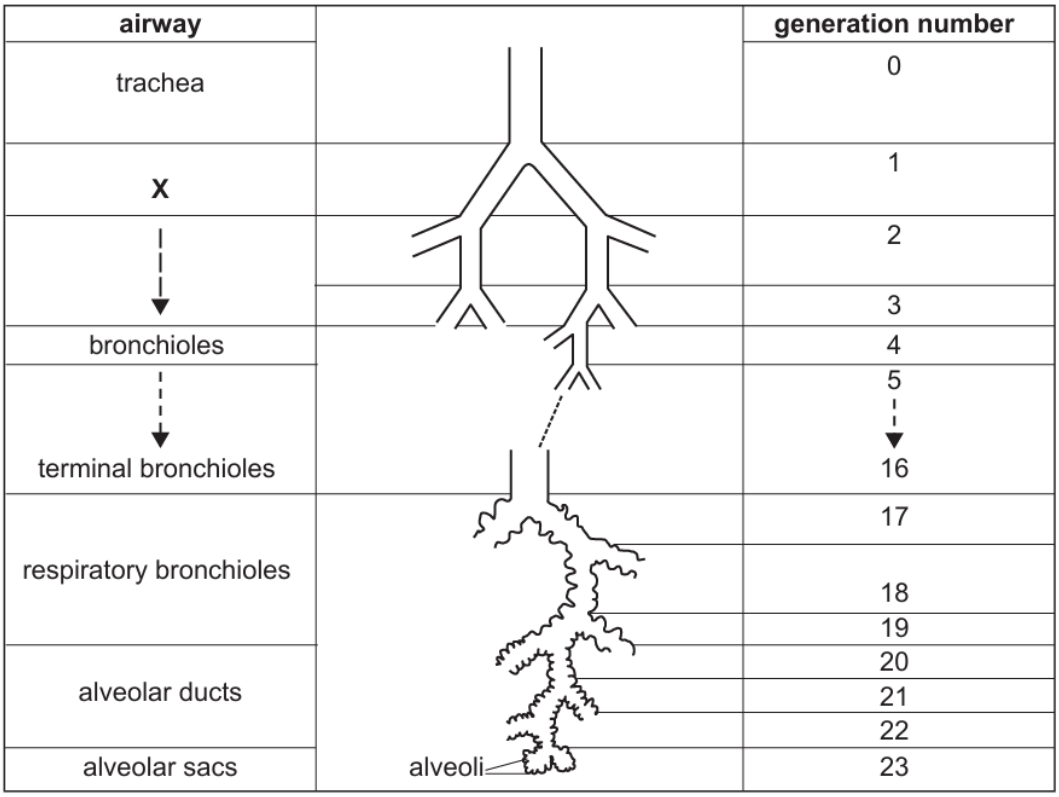


Fig. 6.1

(a) The Weibel Lung model describes how each airway divides into two.

Name the airways in generation 1, labelled **X** in Fig. 6.1, that branch from generation 0.

..... [1]

(b) The airways are well supplied with blood. However, the airways from generation 0 to generation 16, shown in Fig. 6.1, are **not** able to carry out gas exchange.

Suggest why the airways from generation 0 to generation 16 are **not** able to carry out gas exchange.

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..... [2]

(c) High-resolution computed tomography (HRCT) is an imaging technique that is used to obtain measurements of airway diameters in people with a pulmonary (lung) disease. Regular, repeated imaging must be avoided because it involves exposure to harmful radiation.

Scientists researched the use of a different technique, HP gas MRI, that does **not** involve harmful radiation. Two types of MRI image, known as projection and multi-Slice, were used to obtain measurements of airway diameters.

Fig. 6.2 shows the results of the HP gas MRI study compared with the Weibel Lung model, for generations 0 to 5. The Weibel Lung model was used as a standard reference for airway diameters.

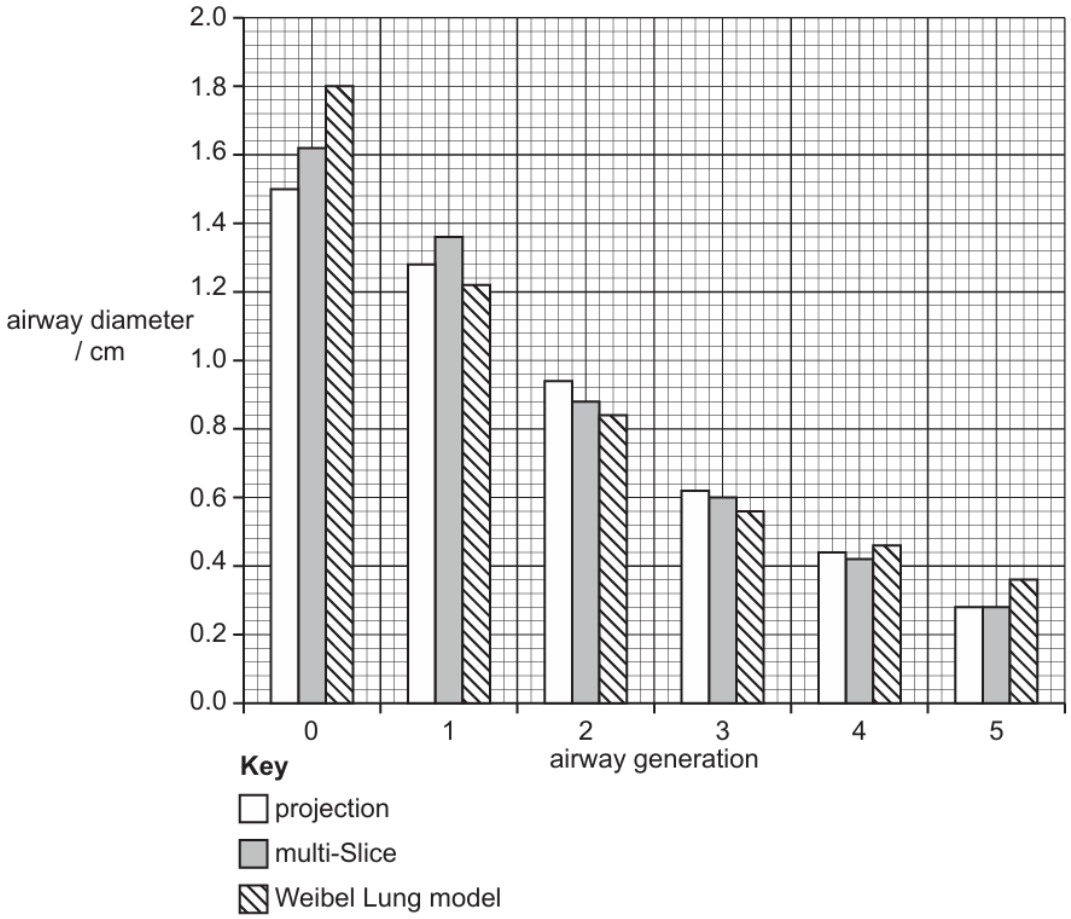


Fig. 6.2

(i) State the relationship shown in Fig. 6.2 between airway diameter and airway generation for the Weibel Lung model data.

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..... [1]

(ii) With reference to the data in Fig. 6.2, explain whether HP gas MRI could be a useful alternative to HRCT in obtaining airway diameter measurements.

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6 Fig. 5.1 is a photomicrograph of a transverse section of a bronchus in the lungs.

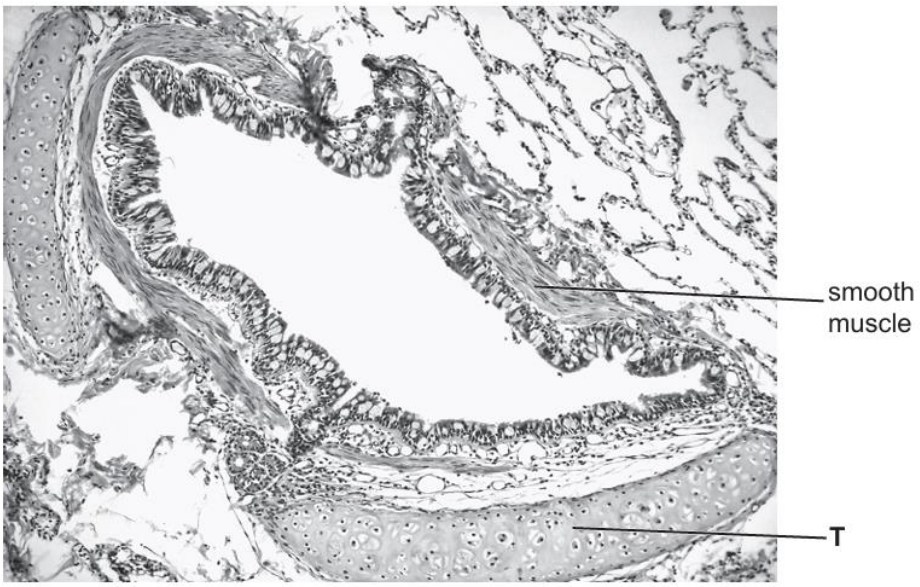


Fig. 5.1

(a) (i) Identify the tissue labelled **T** in Fig. 5.1.

..... [1]

(ii) Describe the function of smooth muscle in the bronchus.

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..... [2]

7 Fig. 5.1 is a photomicrograph of a transverse section through part of the bronchus of the human gas exchange system. The image is of a good resolution for a light microscope.

The bronchial epithelium is a single layer of cells lining the lumen of the bronchus.

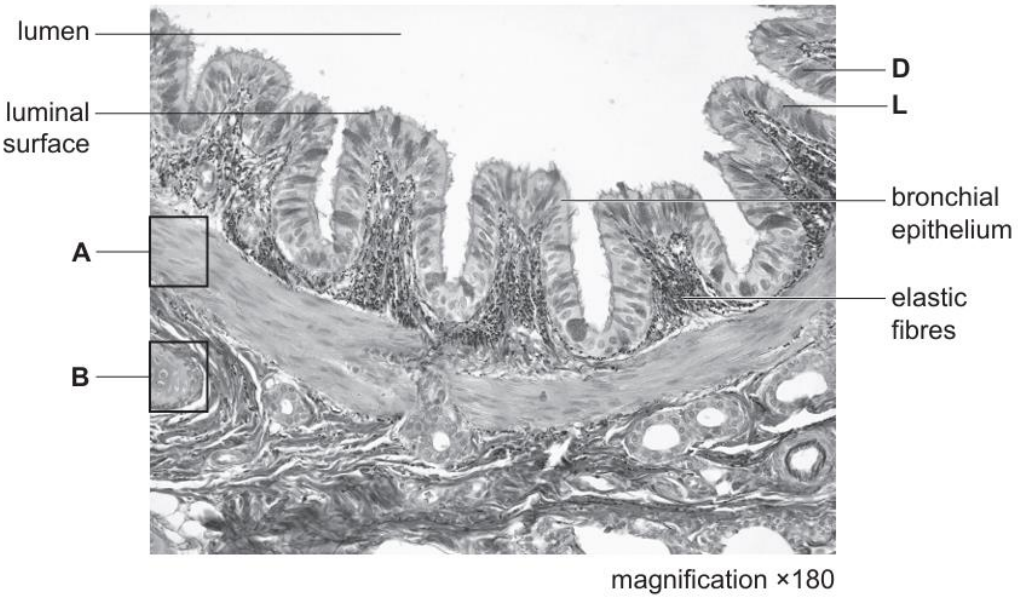


Fig. 5.1

(a) The luminal surface shown in Fig. 5.1 is not clearly defined and appears slightly blurred.

State why the luminal surface of the bronchial epithelium appears slightly blurred, even though the resolution of the image is good.

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..... [1]

(b) Some cells of the bronchial epithelium shown in Fig. 5.1 appear darker than others. For example, cell **D** appears darker than cell **L**.

With reference to the bronchial epithelium shown in Fig. 5.1, explain why some cells, such as cell **D**, appear darker and other cells, such as cell **L**, appear lighter.

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..... [2]

(c) In Fig. 5.1 the tissue in box **B** is cartilage.

The tissue shown in box **A** is different from the tissue in box **B**.

Outline the differences in the structure **and** function of tissue **A** compared with tissue **B**.

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..... [3]

8 Fig. 1.1 and Fig. 1.2 are photomicrographs showing the distribution of tissues in the lungs.

Fig. 1.1 is a photomicrograph of a section through part of the lungs.

Fig. 1.2 is a high-power view of the area indicated on Fig. 1.1.

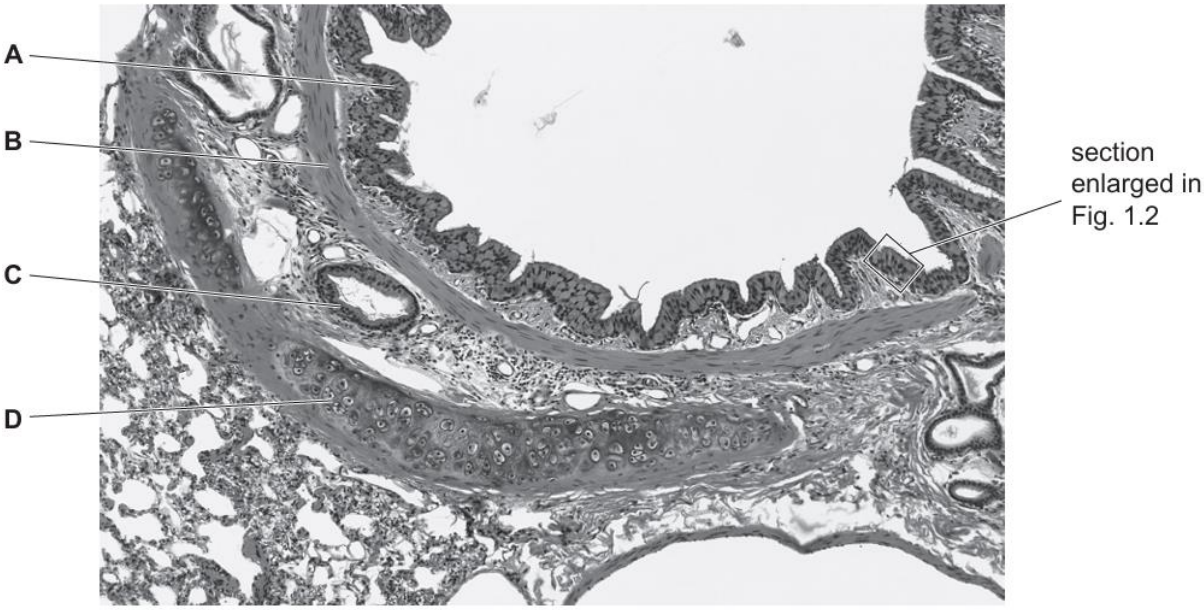


Fig. 1.1

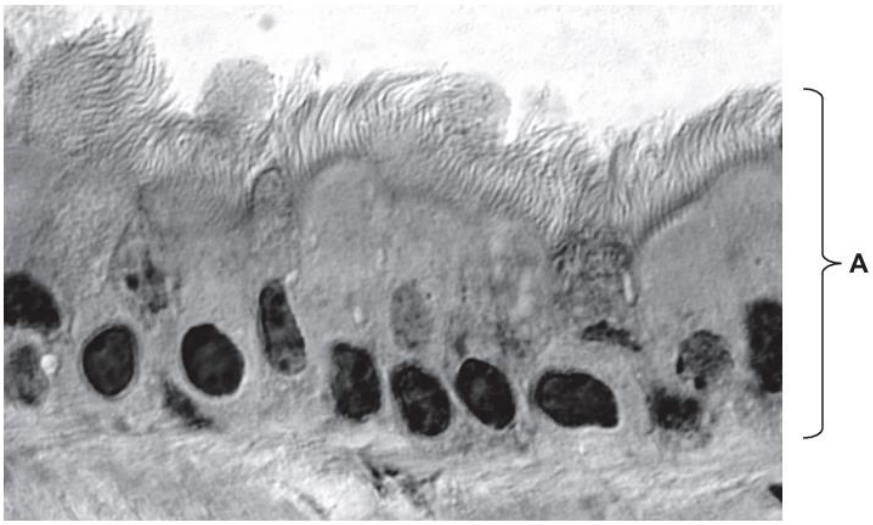


Fig. 1.2

(a) State the names of the tissues **A**, **B** and **D**.

A .....

B .....

D .....

[3]

(b) Describe the role of the glands labelled **C** in Fig. 1.1 in maintaining the health of the gas exchange system.

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..... [3]

9 The airways of the gas exchange system are lined with epithelium. Gradual changes in the structural features of this epithelium occur as the airways branch and become increasingly narrow.

(a) Table 4.1 shows the changes that occur in the number of goblet cells in the epithelium of the different structures of the gas exchange system.

Table 4.1

gas exchange structure	number of goblet cells in epithelium
trachea	many
bronchi	many
larger bronchioles	very few
smaller bronchioles	none
alveoli	none

Goblet cells produce mucus, which is important in maintaining the health of the airways.

The smallest bronchioles closest to the alveoli are known as respiratory bronchioles.

Suggest **and** explain why respiratory bronchioles do not have any goblet cells.

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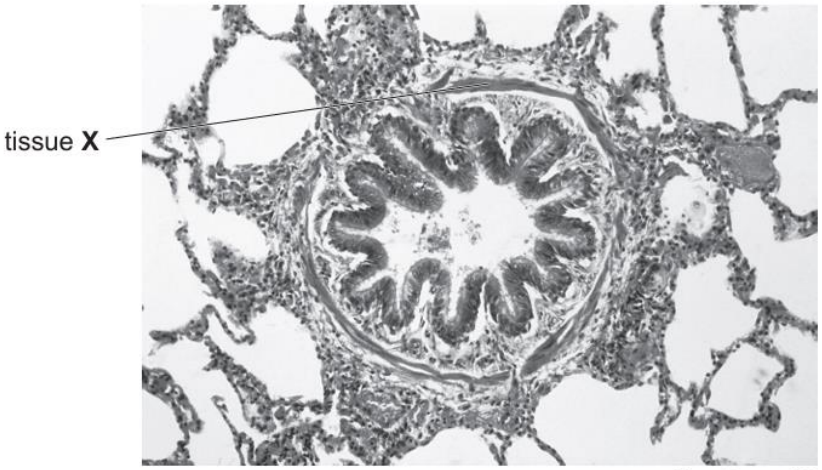
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..... [2]

(b) Fig. 4.1 is a photomicrograph of a section through a bronchiole, which is surrounded by alveoli.



magnification ×40

Fig. 4.1

(i) There are structural differences between the epithelium of the bronchiole and the epithelium of an alveolus.

Describe the differences between the epithelium of bronchioles and the epithelium of alveoli, **other than** differences in the number of goblet cells.

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..... [3]

(ii) Tissue **X**, shown in Fig. 4.1, is located in the wall of the bronchiole.

Name tissue **X and** outline the function of tissue **X** in the bronchiole.

tissue **X** = ...

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..... [3]

10 A person who is exposed to tobacco smoke is at greater risk of lung cancer and chronic obstructive pulmonary disease (COPD).

Many people with COPD have both chronic bronchitis and emphysema. These diseases cause changes in the gas exchange system. For example, changes occur in the total lung surface area to volume ratio (SA:V).

(a) Tar in tobacco smoke has a number of effects on the cells lining the gas exchange system.

State the main effects of tar on the cells lining the gas exchange system that are related to lung cancer **and** to chronic bronchitis.

lung cancer .....

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chronic bronchitis .....

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..... [3]

11 A person who is exposed to tobacco smoke is at greater risk of lung cancer and chronic obstructive pulmonary disease (COPD).

Many people with COPD have both chronic bronchitis and emphysema. These diseases cause changes in the gas exchange system. For example, changes occur in the total lung surface area to volume ratio (SA:V).

(d) Some people with emphysema may be offered lung volume reduction surgery (LVRS), in which diseased lung tissue is surgically removed.

One expected outcome of the surgery is an improvement in total lung surface area to volume ratio (total lung SA:V).

Suggest why there is an improvement in total lung SA:V after the surgery has been carried out.

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..... [2]

12 The causative organism of measles is *Morbillivirus*. Young children who have not been vaccinated for measles are at highest risk of becoming ill and of developing complications associated with the disease.

(c) Young children with measles may develop difficulties with breathing. This is made worse if the child is continually exposed to tobacco smoke. Tobacco smoke contains harmful compounds, such as carbon monoxide.

(i) Inhaled tobacco smoke passes through the larynx (voice box) and other structures in the gas exchange system to reach the alveoli.

Complete Fig. 5.1 to list, in the correct sequence, the main structures of the gas exchange system through which the tobacco smoke passes to reach the alveoli.

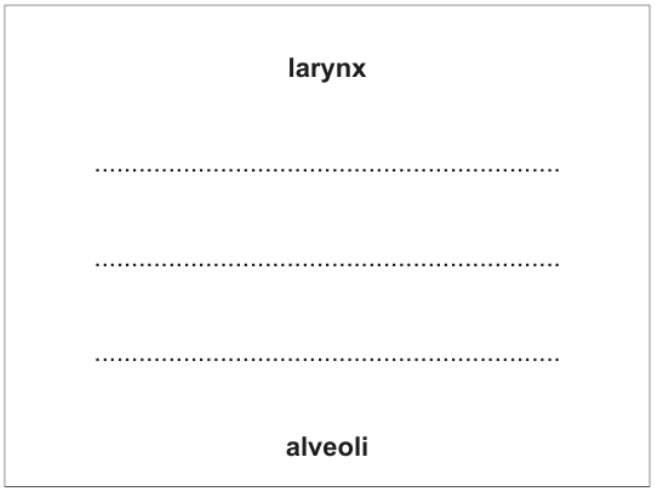


Fig. 5.1

13 Collagen is a major component of the cartilage found in some of the structures of the human gas exchange system. Cells that synthesise and secrete the components of cartilage are known as chondrocytes.

(b) (i) Describe the distribution of cartilage in the human gas exchange system.

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(ii) Outline the function of cartilage in the human gas exchange system.

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14 **(a)** Fig. 5.1 is a photomicrograph of a section through the lungs showing a bronchus and some alveoli.

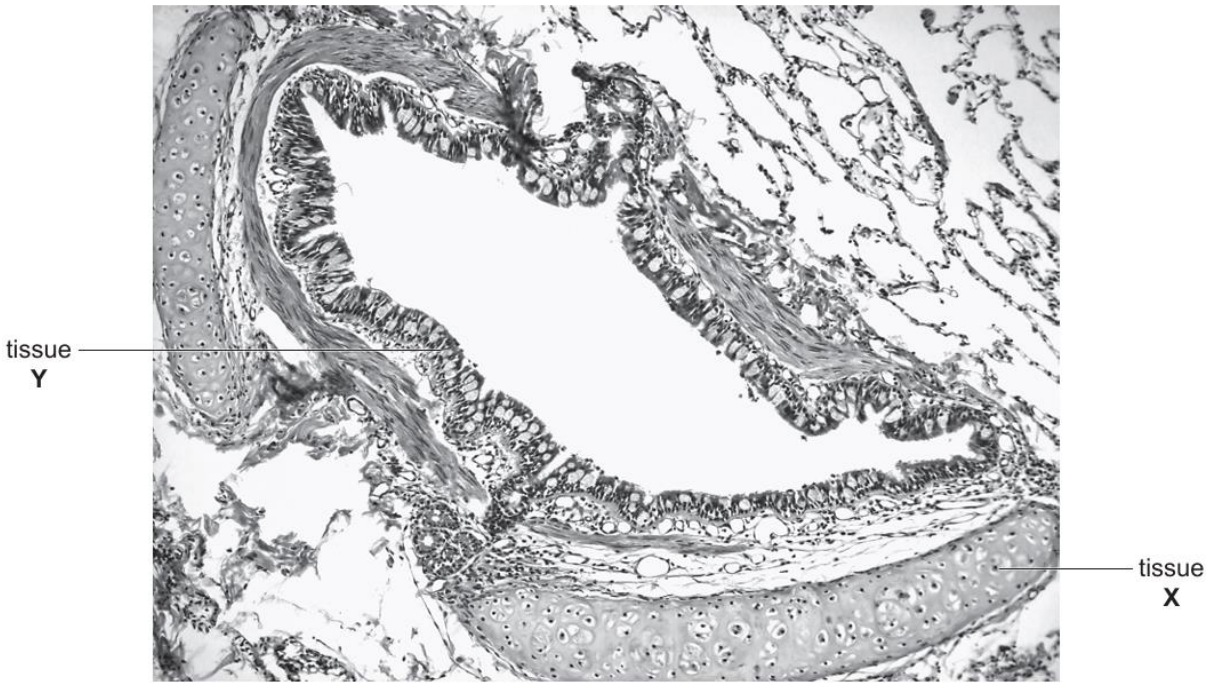


Fig. 5.1

(i) State the function of tissue **X** labelled in Fig. 5.1.

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..... [1]

(ii) Describe how the distribution of tissue **X** in the trachea differs from that shown in Fig. 5.1.

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..... [1]

(iii) Describe how the epithelial tissue, **Y**, is adapted for its function.

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..... [2]

15 Fig. 3.1 is a photomicrograph of a section through lung tissue.

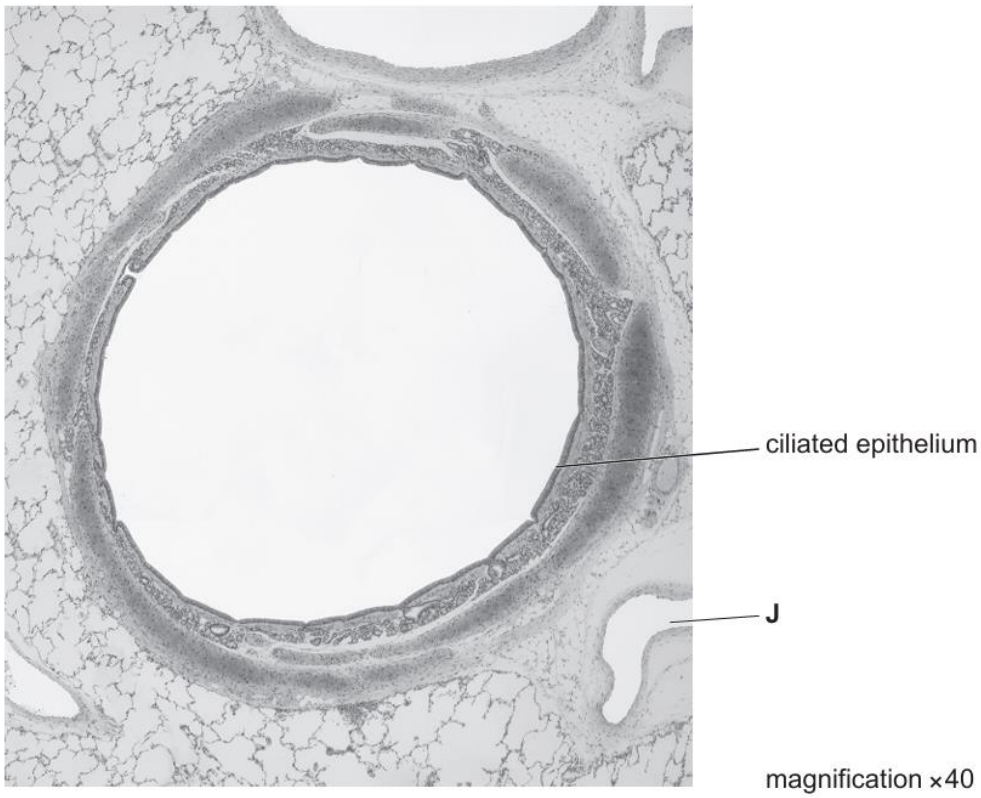


Fig. 3.1

(a) State the feature visible in Fig. 3.1 that identifies the structure in the centre of the image as the bronchus **and** list other visible features that help to confirm this identification.

feature to identify the bronchus .....

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other features .....

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[3]

(b) Identify the structure labelled **J** in Fig. 3.1.

State the evidence visible in Fig. 3.1 that supports your answer.

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[2]

(c) The ciliated epithelium labelled in Fig. 3.1 consists of goblet cells and ciliated epithelial cells.

Outline how goblet cells and cilia work together to maintain healthy lung tissue.

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..... [2]

16 People who smoke tobacco are at an increased risk of developing non-infectious diseases of the gas exchange system and the cardiovascular system.

In 2004, a study was carried out on the most popular brands of filter cigarettes from each of the six World Health Organization (WHO) regions.

In this study, the smoke passing through the filter was analysed for the tar, nicotine and carbon monoxide (CO) content for each brand of cigarette. For each WHO region, the mean content of tar, nicotine and carbon monoxide of the different brands of cigarette was calculated.

The results are shown in Fig. 2.1.

Key to WHO regions

AFRO = African Region
AMRO = Region of the Americas
EMRO = Eastern Mediterranean Region
EURO = European Region
SEARO = South-East Asia Region
WRPO = Western Pacific Region

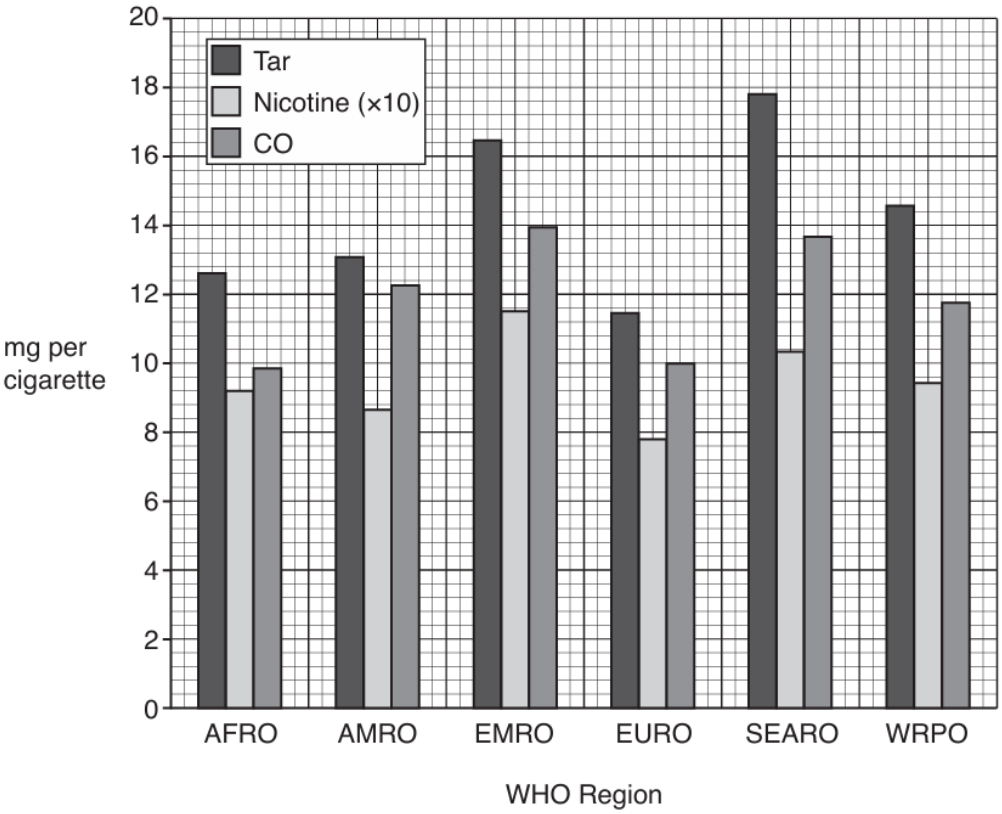


Fig. 2.1

(a) With reference to Fig. 2.1, list the **two** WHO regions where smokers are at the highest risk of developing diseases of the gas exchange or cardiovascular systems.

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..... [1]

17 Some tissues of the gas exchange system include cells that are able to produce and secrete mucins. Mucins are stored in vesicles in these cells, ready for secretion. Once outside the cell, mucins adsorb water to form mucus.

(a) Name the structures in the gas exchange system that produce and secrete mucins.

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..... [2]

18 When tobacco smoke is inhaled, chemicals such as nicotine and carbon monoxide enter the circulatory system through the gas exchange system. Tar builds up on the lining of the gas exchange system.

Many people decide to give up smoking tobacco in order to improve their health.

(a) Some of the structures in the human gas exchange system through which tobacco smoke passes are shown in Fig. 5.1.

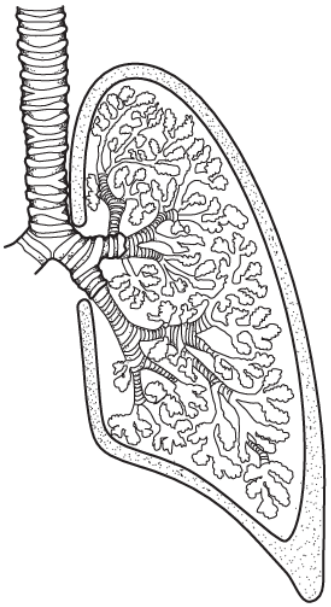


Fig. 5.1

Describe the gross structure of the human gas exchange system.

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.....[3]

19 Fig. 1.1**A** is a photomicrograph of healthy lung tissue.

Fig. 1.1**B** is a photomicrograph of lung tissue from a person with emphysema, a chronic obstructive pulmonary disease (COPD). The images are both at magnification ×40.

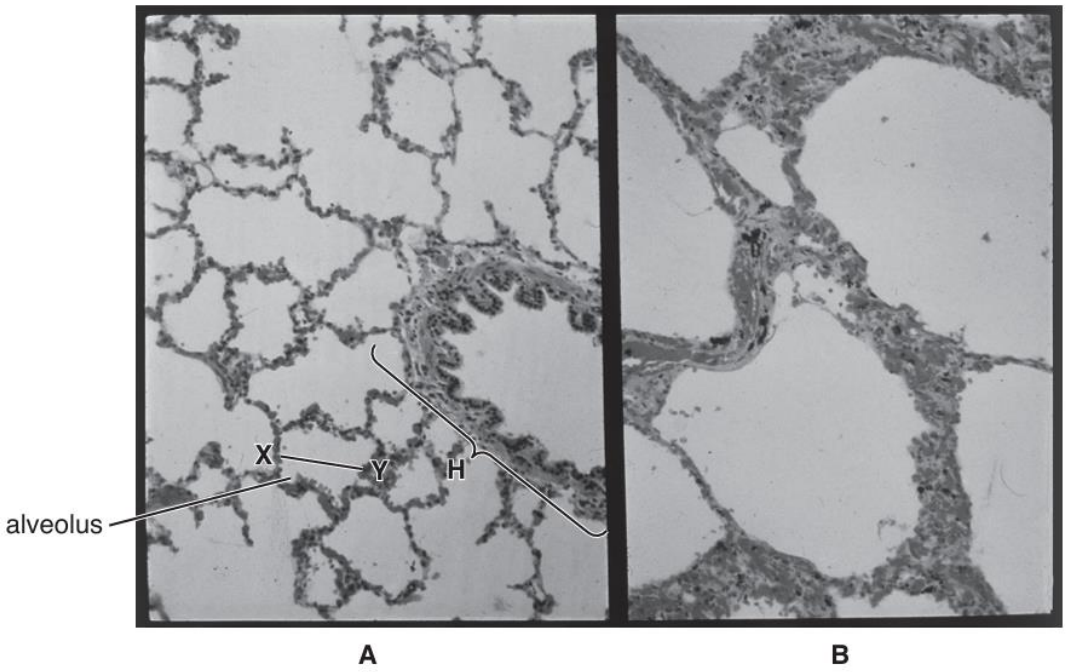


Fig. 1.1

(a) Name the structure labelled **H** in Fig. 1.1**A**.

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(c) Gas exchange in the lungs occurs in the alveoli.

Describe the process of gas exchange in healthy lungs **and** suggest how this compares with gas exchange in the diseased lung shown in Fig. 1.1**B**.

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..... [4]

20 Fig. 1.1 shows the human gas exchange system.

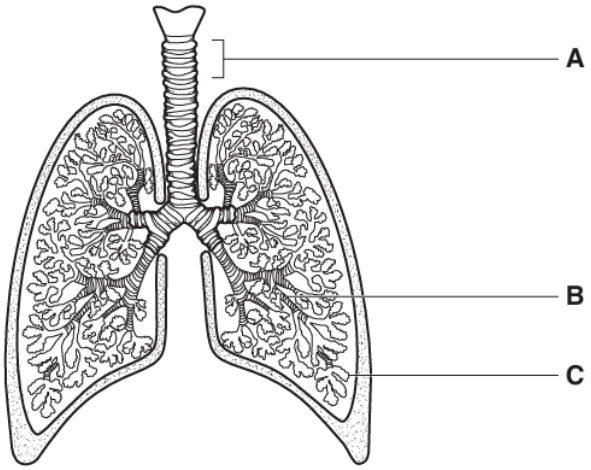


Fig. 1.1

(a) Name the structures labelled **A**, **B**, and **C** in Fig. 1.1.

A .....

B .....

C ..... [3]

(b) Name a **non-infectious** disease that affects the human gas exchange system.

..... [1]