Notes to complete gas exchange in mammals

The structure of an alveolus and associated capillaries is shown in Figure 12 (though the walls, for clarity, have been drawn disproportionately thick).

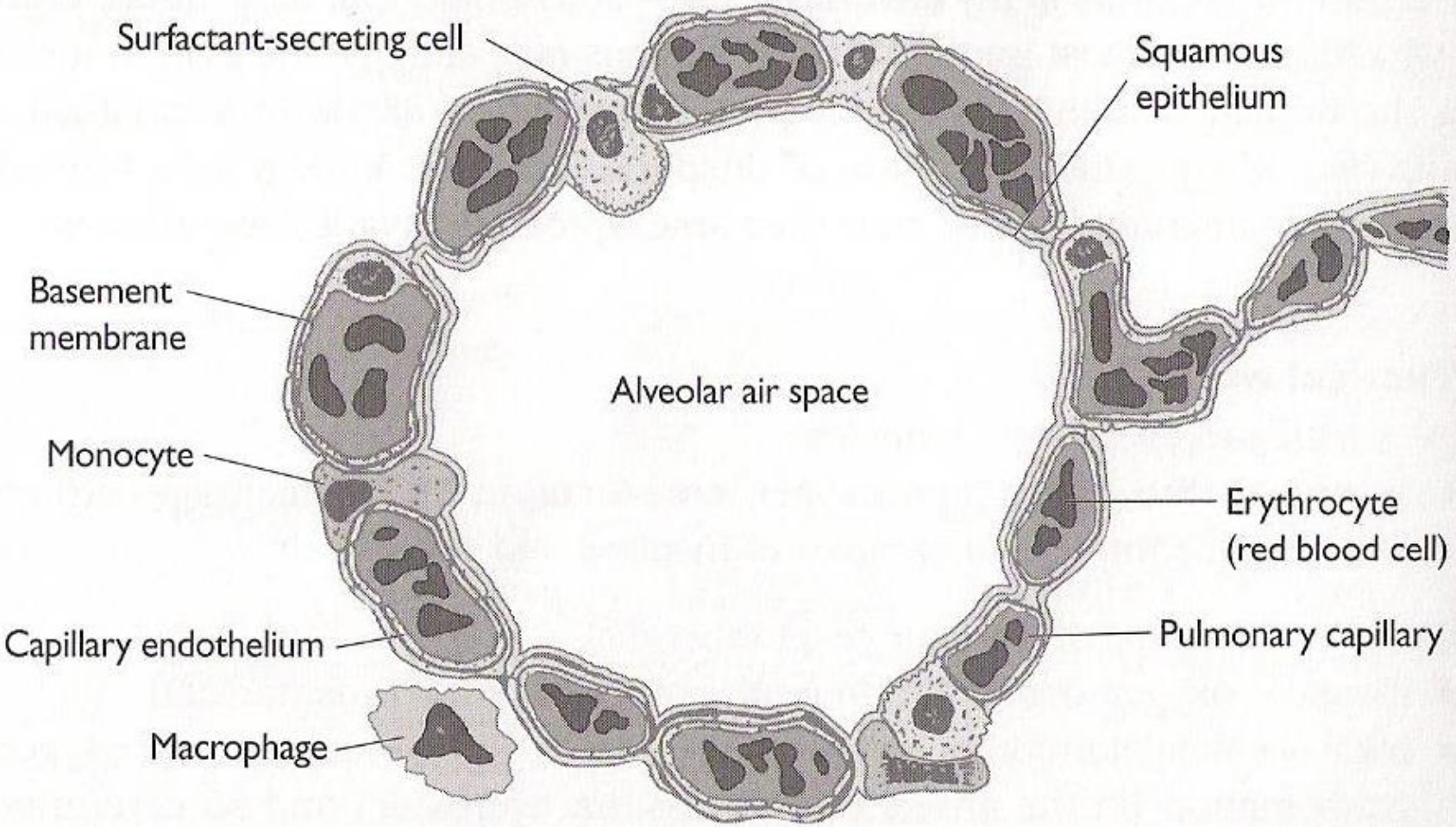


Figure 12 The structure of an alveolus and associated pulmonary capillaries

Mass flow of air to respiratory surface – this is achieved through the mechanics of **ventilation** (breathing). This ensures a regular supply of air into and out of the lungs and a concentration gradient is maintained

Structure of the lungs: **Fill the blanks on your worksheet using the word bank**

terminal bronchioles
bronchus
Alveoli
bronchi

trachea
alveolar duct
bronchial tree
gas exchange

blood capillaries
nostrils
bronchioles
thorax

Air is breathed in through the nostrils or mouth, and enters or leaves the lungs through the trachea. The lungs sit in the thorax (thoracic cavity). The trachea branches into two bronchi (singular bronchus) and these branch into ever finer bronchioles forming a bronchial tree. The terminal bronchioles lead to clusters of alveoli, with an alveolar duct linking each alveolus. Each single alveolus is tightly wrapped in blood capillaries – the site of gas exchange

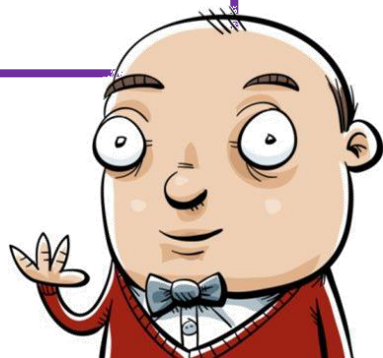
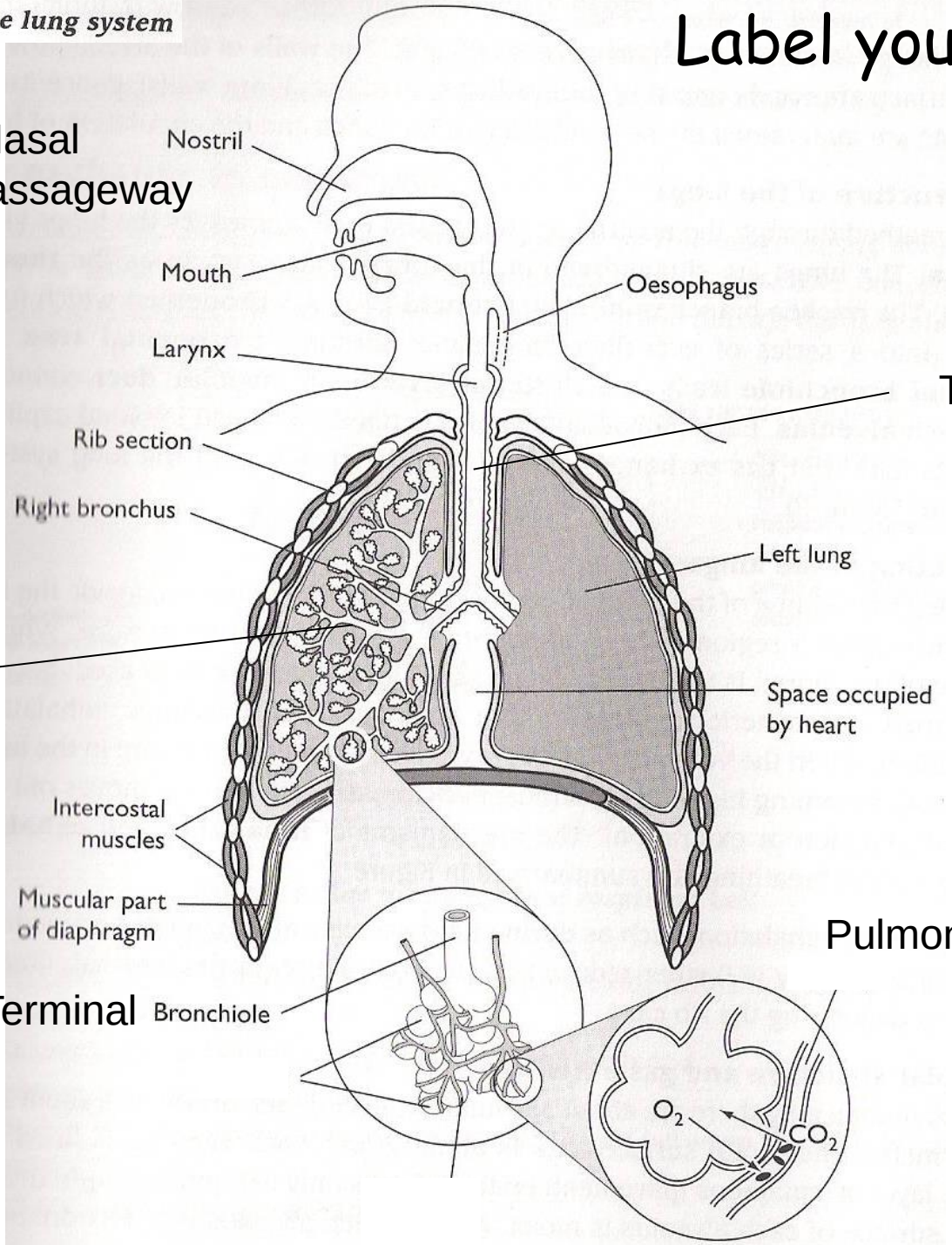


Figure 10 The structure of the lung system

Label your diagram:



/Nasal passageway

Trachea

Bronchiole

Pulmonary

Ventilation of the lungs:

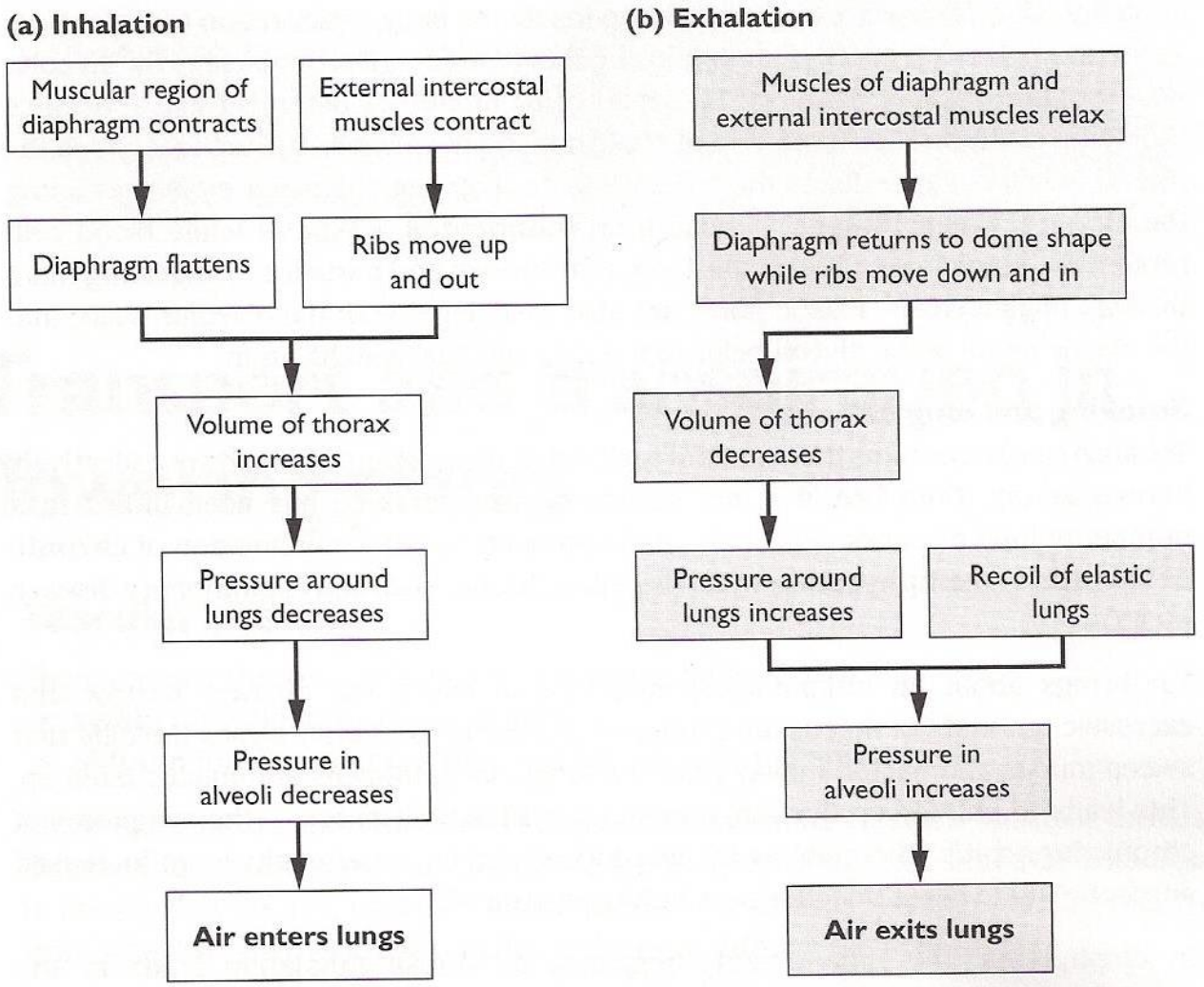
Read the following information and answer the questions on your page:

Changing the volume of the thoracic cavity changes the air pressure inside the lungs. Air moves from a region of high pressure to a region of low pressure. When the volume of the thorax is increased, the pressure in the lungs is decreased, becoming lower than atmospheric pressure so that air moves into the lungs (inhalation or inspiration). When the volume of the thorax is decreased, the pressure in the lungs is increased, becoming higher than atmospheric pressure so that air moves out of the lungs (exhalation or expiration). The mechanisms of **inhalation** and **exhalation**, during normal breathing, are summarised in Figure 11.

During forced exhalation, such as during hard exercise and coughing, the volume of the thoracic cavity is further reduced by the contraction of the internal intercostal muscles depressing the rib cage.

1. When the volume of the thoracic cavity changes, what changes inside the lungs?
2. What dictates the direction air will move/what gradient?
3. As the volume of the thorax increases what happens to the air pressure in the lungs?
4. What happens next and what is this called?
5. What happens to increase the air pressure inside the lungs?
6. What happens next and why?
7. What is that process called?
8. During hard exercise and coughing, what process occurs and why is this useful?

Ventilation worksheet:



Stand up, take a deep breath and talk yourself through the mechanisms of ventilation:

c) - Millions of alveoli create a large surface area for gas exchange to occur

- Layer of moisture lines each alveolus which the gases must dissolve into before they can diffuse through the cells

- Dense network of capillaries with circulation of blood maintains diffusion gradients for gas exchange

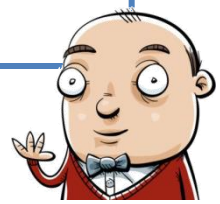
- Elastic fibres in the alveoli allow for elastic recoil to expel air during exhalation

d) The monocyte moves into the alveolus where it becomes a macrophage that engulfs any bacteria through phagocytosis

Alveoli structure

Did you know?

There are approximately 350 million alveoli in each human lung! Each ~200μm in diameter, making a total surface area of about 70m^2 (about 4 parking spaces!)



- Alveoli are lined with single layer of squamous (pavement/flattened) epithelial cells no more than 0.3μm thick
- Inner surface is moist so gases can dissolve and diffuse through the cell surface membranes. Evaporation of this moisture is minimal due to its location deep inside the body

- Surrounding each alveolus is a dense network of narrow blood capillaries (7-10 μm)
- Erythrocytes are flattened against these capillary walls as they squeeze through
- The capillaries also have walls one cell thick consisting of squamous endothelium/epithelium (small diffusion distance)

The structure of an alveolus and associated capillaries is shown in Figure 12 (though the walls, for clarity, have been drawn disproportionately thick).

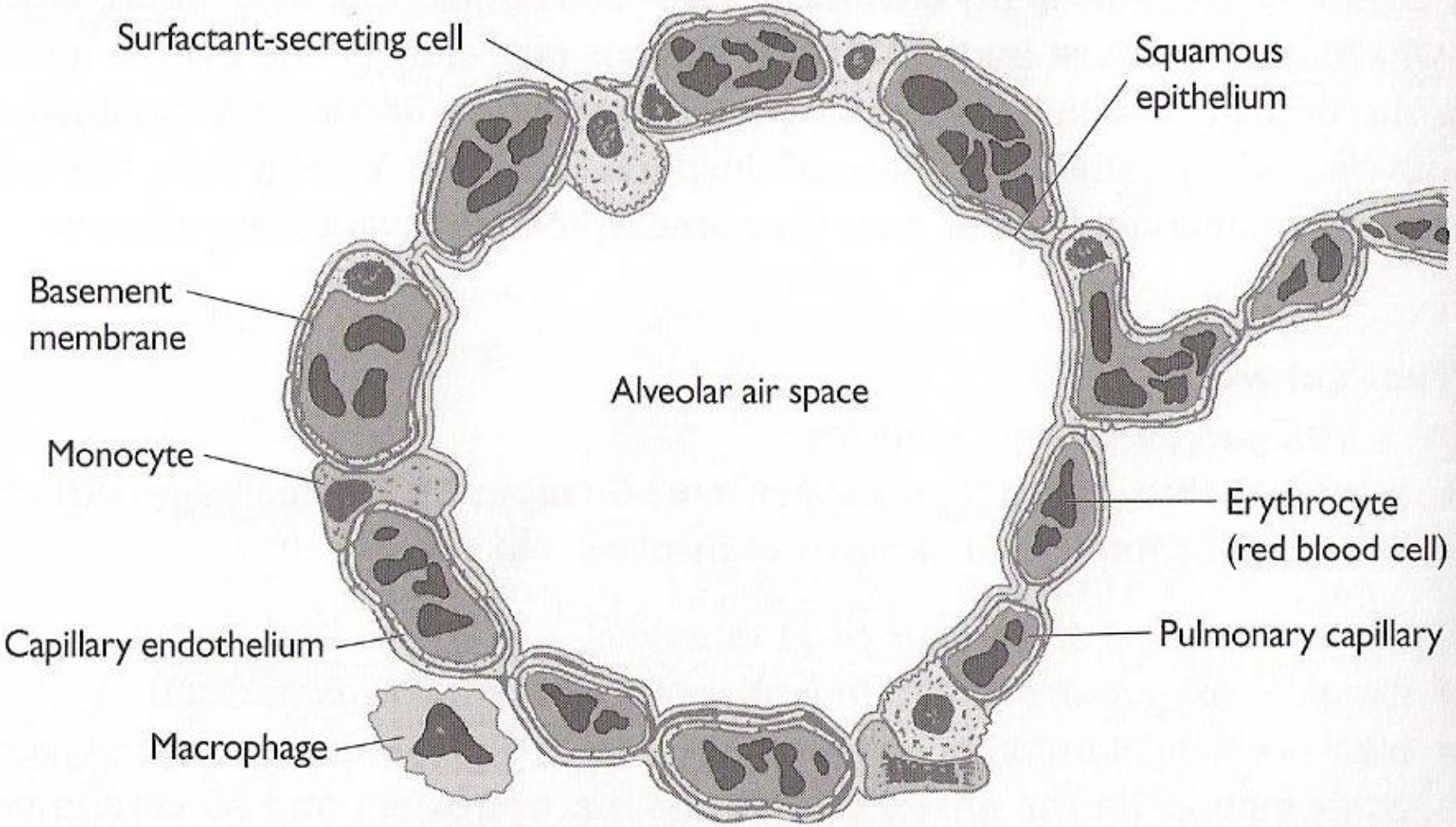


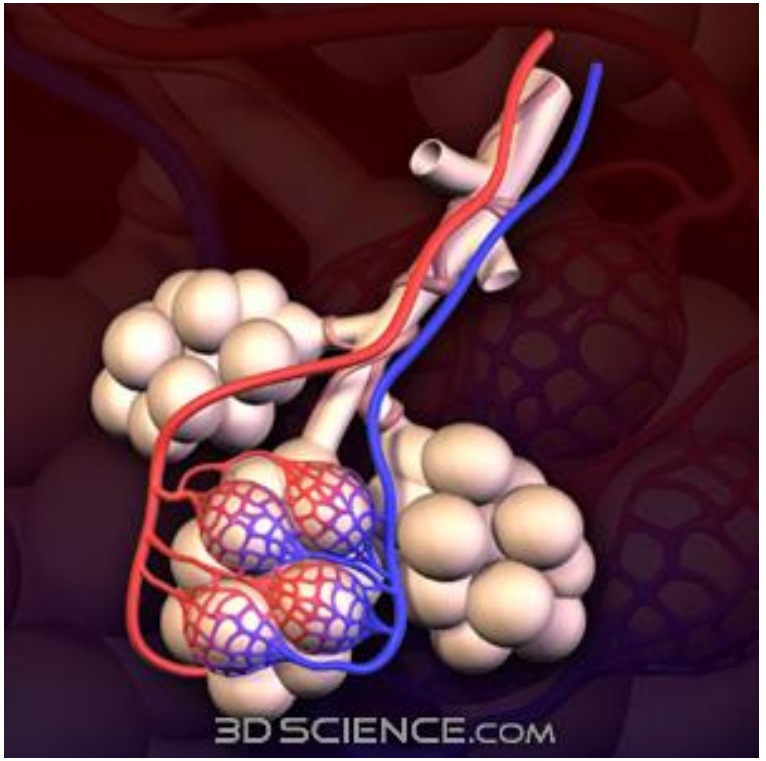
Figure 12 The structure of an alveolus and associated pulmonary capillaries

Surfactant in moisture layer of alveoli:

- This anti sticking chemical reduces surface tension of the fluid coating the alveoli so that the alveoli remain open

- If the detergent like surfactant wasn't present then the cohesive forces of the polar water molecules could collapse the alveoli

- It is produced by surfactant secreting cells (septal cells) in the alveolar wall



Macrophage cells are present in the alveolar walls:

- These white blood cells are derived from white blood cell precursors called monocytes
- They protect the lungs from microbes and other particles by ingesting them through phagocytosis

Elastic fibres are associated with the alveolar walls

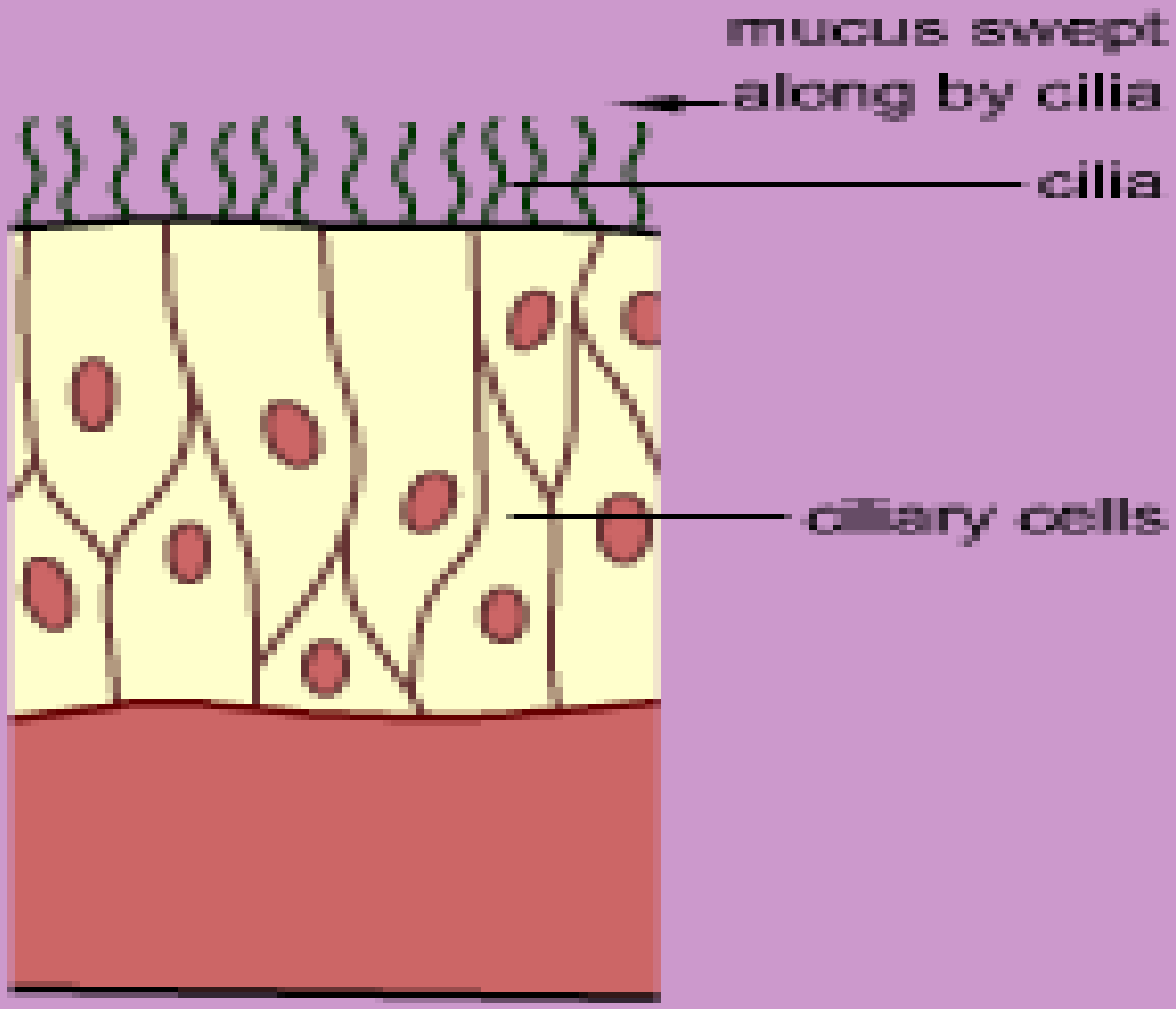
- The elastic recoil caused by these fibres allow the alveoli to force air out during exhalation

Check out these microscope slides of lung tissue and alveoli...
http://apbrwww5.apsu.edu/thompsonj/Anatomy%20&%20Physiology/2020/2020%20Exam%20Reviews/Exam%203/CH22%20Alveolar%20anatomy%20images.htm

How smoking effects the lungs:

- The 1000s of toxic chemicals in tobacco smoke are collectively known as **tar**
- Smokers can suffer from a range of lung diseases caused by these toxic chemicals
- Smokers suffer from a combination of chronic bronchitis and emphysema, called COPD: chronic obstructive pulmonary disease

What the cilia do:



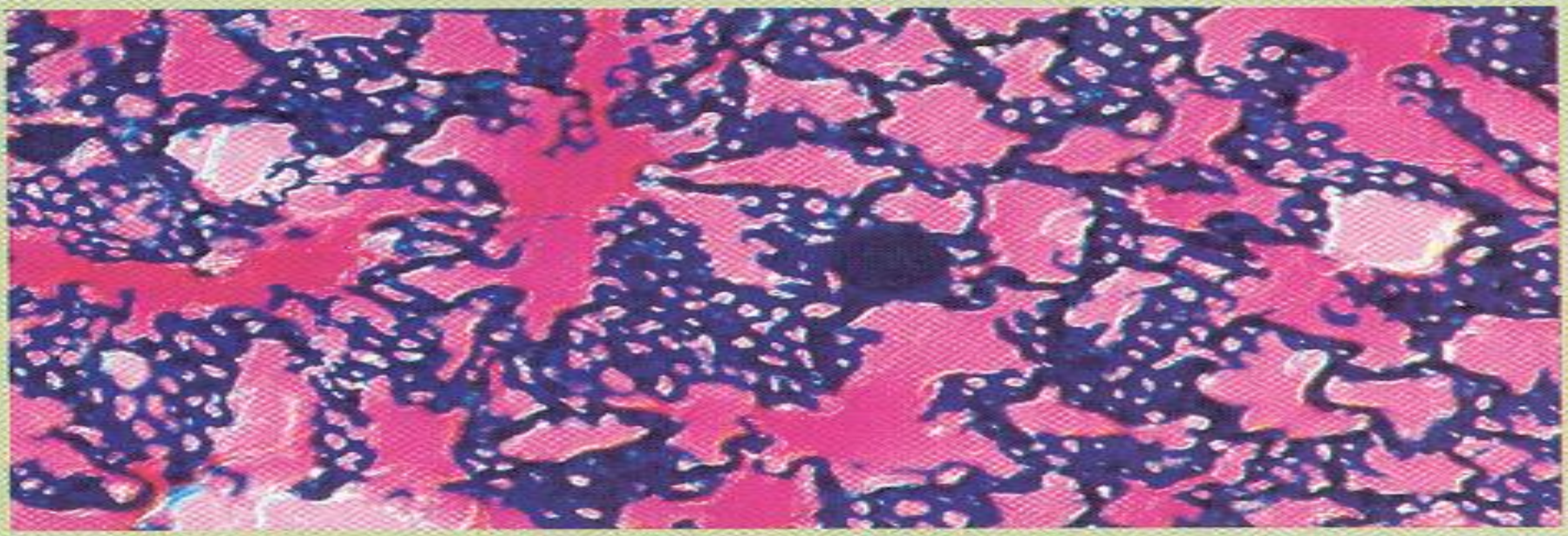
- Tar irritates the mucous membranes (epithelial lining) of the bronchi and airways so they become inflamed and the lumen narrows; also excessive amounts of mucus are produced
- It also paralyses the cilia in the bronchi that sweep mucus and bacteria away from the lungs so pathogens and mucus build up
- This increases a persons susceptibility to chest infections e.g. pneumonia
- Phlegm build up, coughing and breathlessness (*due to reduced air reaching alveoli*) are all symptoms of **chronic bronhcitis**

Normal bronchi

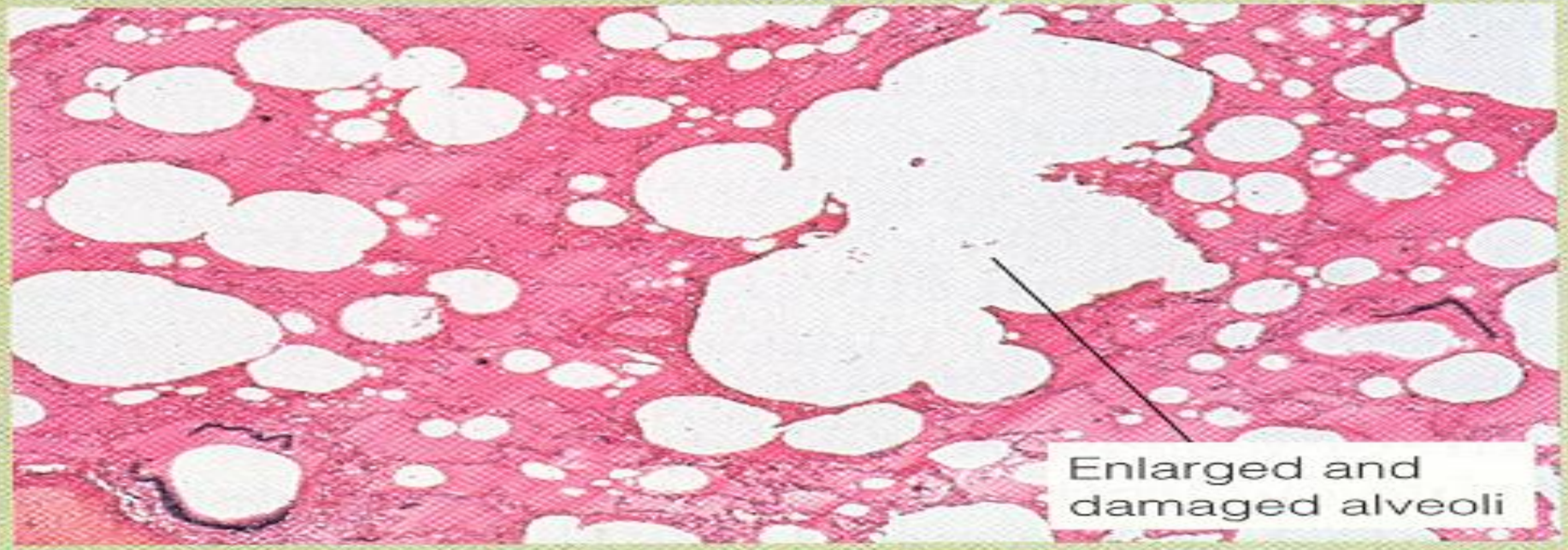
Bronchitis

Emphysema:

- The inflammation caused by smoke inhalation causes alveolar walls to break down
- The surface area for gas exchange is reduced and it is difficult to obtain oxygen
- Elastic fibres also breakdown, making elastic recoil difficult during exhalation to expel air laden with carbon dioxide and low in oxygen
- *(Some studies have suggested that protease enzymes react to smoke and digest the protein elastin in the alveoli – reducing elasticity)*



Normal healthy lung tissue



Lung cancer:

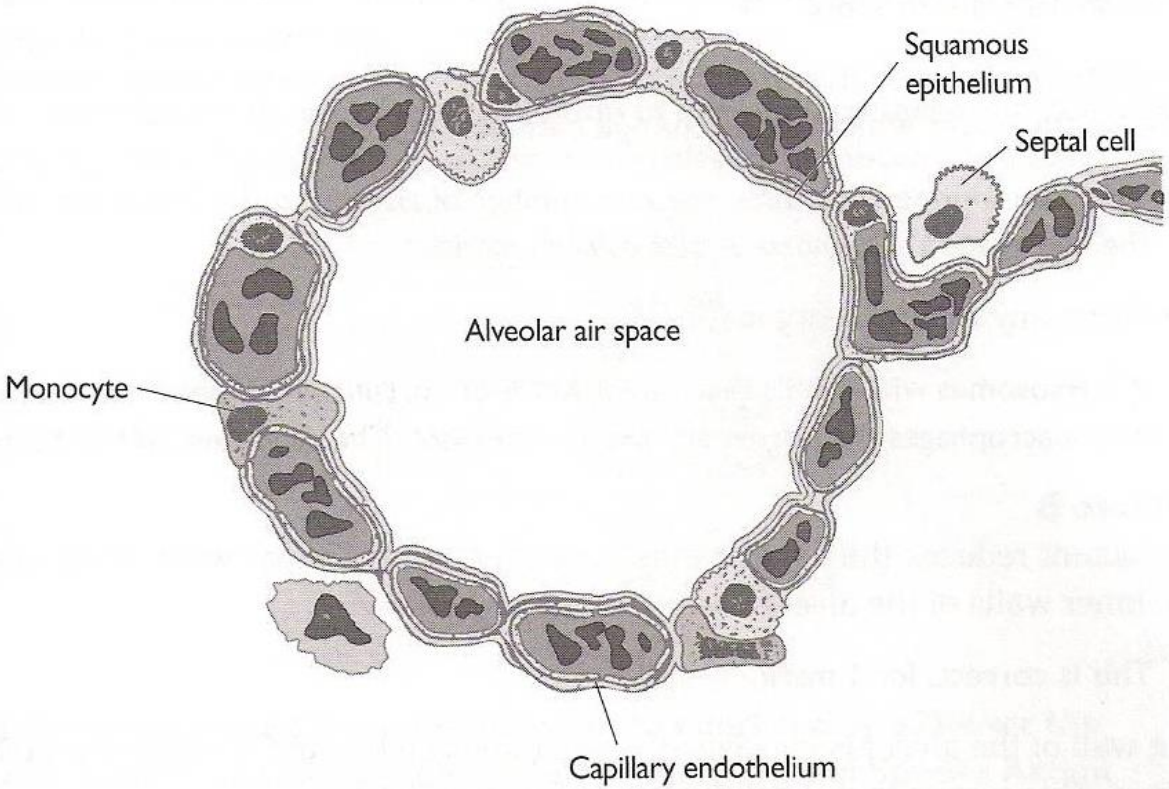
- This is **uncontrolled** cell division in lung tissue
- Tobacco smoke contains many **carcinogens** substances that may induce cancer
- **Tar** is most important
- They can cause damage/changes to **the DNA** in the bronchial tissue lining (epithelial cells)
- These cells may divide in a modified or uncontrolled way to produce a **tumour** – a mass of unspecialised cells
- A **cancerous/malignant** tumour may spread to other tissues in the lungs and or rest of body over time

Lung cancer causes most cancer death in women in the UK

A cancerous lung *(white parts are the tumour and the black parts have been discoloured due to smoking):*

PPQu:

The diagram below shows a section through an alveolus and associated structures.



(a) The septal cell shown in the diagram above secretes surfactant. What is the role of surfactant in the alveolus? (1 mark)

(b) State one adaptation, shown in the diagram, which facilitates gaseous exchange. Explain how this adaptation aids gaseous exchange. (2 marks)

(c) State one adaptation, *not* shown in the diagram, which is needed for efficient gaseous exchange. Explain how this adaptation aids gaseous exchange. (2 marks)

(d) State a role for the monocyte shown in the diagram. (1 mark)

Total: 6 marks

Answers:

a) Surfactant reduces the surface tension in the moist layer by preventing the cohesive water molecules from sticking together. If this happened the alveoli will collapse

b) Wall of alveolus consists of squamous epithelium cells which are thin. This creates a short diffusion pathway

NOTE:

The term 'membrane' can be confusing. It is not cell membranes that are thin but the cells of the alveolar walls — they form a squamous epithelium. The *rate* of diffusion is not altered — it is the distance over which the gases have to diffuse that is reduced. The important thing to remember here is to be precise. The candidate fails to score.