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Human Perspectives ATAR Units 1 & 2

Answers

Chapter 4 The respiratory system allows gas exchange

Questions 4.1

Recall knowledge

1 List the structures that air will travel down, starting from outside of the body.

Answer: Nose → pharynx → larynx → trachea → bronchi → bronchioles → lungs/alveoli

2 Describe the structure of the trachea.

Answer: The trachea is made up of C-shaped cartilage rings, with an epithelial lining that produces mucus.

3 Describe the function of the 'pleural fluid'.

Answer: A thin layer of fluid found between the pleura membranes. Pleural fluid holds the lungs against the inside of the chest wall and allows the lungs to slide along the chest wall without friction while breathing.

4 Describe the difference between a primary bronchus and a tertiary bronchus.

Answer: The primary bronchus branches off from the trachea and is larger in diameter than the tertiary bronchus. There are two bronchi, and many tertiary bronchi.

Apply knowledge

5 Explain the importance of the convolutions of the mucus membranes in the nasal cavity.

Answer: The convolutions provide a larger surface area to the nasal cavity, allowing for greater filtering, humidifying and warming of the air as it enters the body.

6 Explain how the airways in the respiratory system are similar to the branches on a tree.

Answer: The trachea represents the tree trunk. The primary bronchi are the larger branches; each divide into secondary bronchi (smaller branches) and again into tertiary bronchi before the bronchioles and the terminal bronchioles that are similar to the smaller twigs found on a tree.

7 Compare and contrast the structure of the trachea, bronchi and bronchioles.

Answer: Compare: The trachea, bronchi and bronchioles all allow for the passage of air into the lungs. They all contain mucus-producing epithelium to trap contaminants.

Contrast: The trachea contains cartilage rings in a 'C' shape; the bronchioles contain cartilage rings; the bronchioles do not contain cartilage, only smooth muscle and elastin.

Questions 4.2

Recall knowledge

1 Describe what happens to the pressure of air in the lungs during inspiration.

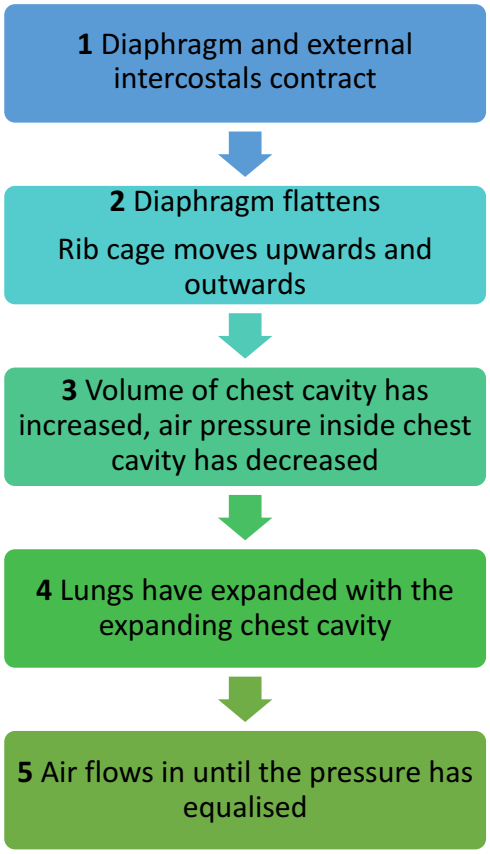
Answer: For air to flow into the lungs, the pressure of the air in the lungs must be less than the atmospheric pressure outside the body. This is achieved by increasing the volume of the chest cavity.

2 Complete the following sentence: Air flows from areas of _____ pressure to areas of ____ pressure.

Answer: Higher; Lower

3 Use a flow chart to list the steps that occur during inspiration.

Answer:



Apply knowledge

4 Lou Gehrig's disease, also called motor neurone disease, can cause paralysis of the diaphragm. Predict the effects of this on the body, justifying your answer.

Answer: Normal, quiet breathing relies primarily on the movement of the diaphragm. If the diaphragm is paralysed, inhalation can only occur with active contraction of the external intercostal muscles. This could cause fatigue and an inability to fully inflate the lungs for efficient gas exchange.

Motor neurone disease (MND) also leads to the degeneration of motor neurons responsible for voluntary muscle contraction. As the disease progresses, all respiratory muscles will cease to function, and the person will die from respiratory failure.

Questions 4.3

Recall knowledge

1 How thick is the wall of the alveolus?

Answer: One cell thick, or 1 micrometre

2 Describe the movement of oxygen between the air and the blood.

Answer: Oxygen dissolves in the moisture on the surface of the alveoli and then will diffuse from an area of higher concentration to one of lower concentration. There is a higher concentration of oxygen in the alveoli, compared to the blood arriving to the alveoli from the pulmonary arteries. Therefore, oxygen will diffuse into the bloodstream from the alveoli.

3 Explain why the concentration of carbon dioxide in the blood in the capillaries surrounding the alveoli is higher than in the air within the alveoli.

Answer: Carbon dioxide levels is higher in the blood in the capillaries because the blood being delivered to the alveoli is carrying the waste product from the body's cellular respiration, around 4% carbon dioxide. Inhaled air has around 0.04% carbon dioxide.

4 Explain why it is important that there is a constant flow of blood through the capillaries surrounding the alveoli.

Answer: The constant flow of blood through the capillaries means that a concentration gradient is always established and maintained for diffusion of oxygen into the capillaries and carbon dioxide into the alveoli. If the blood flow was not constant, an equilibrium of dissolved gases would occur with no further gas exchange.

5 Explain how the pleural fluid plays an important role in gas exchange.

Answer: Pleural fluid holds the lungs against the surface of the chest wall, so that the lungs expand when the respiratory muscles contract during breathing. The alveoli inflate due to the changes in air pressure caused by the lung expansion and therefore gas exchange can occur between the surface of the alveoli and the blood capillaries.

Apply knowledge

6 People with cystic fibrosis produce an excessive amount of thick mucus, primarily in the lungs and digestive system. Explain how this would affect the respiratory system, and predict the symptoms exhibited.

Answer: The excess, thick and sticky, mucus produced will clog airways, and trap bacteria in it. This leads to further infection, inflammation and respiratory failure. Sufferers will have a persistent cough and be more vulnerable to lung infections of pneumonia and bronchitis. They may be frequently wheezy or experience shortness of breath.

Questions 4.4

Recall knowledge

1 Name the process that results in the alveoli breaking down and reducing the surface area.

Answer: Emphysema

2 Describe the changes that occur in the bronchioles during an asthma attack.

Answer: The smooth muscles contract, narrowing the bronchioles. Inflammation of the lining of the bronchioles also narrows the airway diameter and excess mucus will be produced, again narrowing the airway.

3 List the most common causes of lung cancer.

Answer: Tobacco smoking; exposure to asbestos fibres and other pollutants

Apply knowledge

4 Explain why pneumonia results in the patient feeling very tired.

Answer: Pneumonia causes excess mucus and fluid secretion into the alveoli, limiting the amount of air they can hold and also reduces the surface are for gas exchange. Therefore, there is a reduced capacity to oxygenate the blood and remove the carbon dioxide levels in the bloodstream. Less

oxygen available will result in the production of less ATP, and as a result, less energy available for the cells. This will lead to an overall feeling of fatigue/tiredness.

5 Construct a table to compare the cause, symptoms and treatment of emphysema, lung cancer, lung infections and asthma.

Answer:

	Cause	**Symptoms**	**Treatment**
Emphysema	Long-term exposure to irritating particles in the air. Smoking, people working in industry, people living in cities with high pollution levels.	Difficulty breathing out. Coughing, wheezing, shortness of breath, chest tightness, and an increased production of mucus	Oxygen delivery. Bronchiole dilators, Inhaled steroids, antibiotics
Lung cancer	A mass of cells in the lung tissue. Linked to exposure to tobacco smoke, asbestos fibres,	Excessive production of mucus leading to 'smokers cough' (often with blood), chest pain, wheezing and weight loss	Chemotherapy, radiation therapy, tumour may be surgically removed if a benign tumour.
Lung infections	Infection from a pathogen (bacteria, virus, fungi or other organism)	Excess secretion of mucus and fluid into the alveoli. Difficulty in breathing. Chest pain, fever, running nose, fatigue, wheezing.	Antibiotics (if a bacterial infection), antivirals (for a viral infection); oxygen therapy
Asthma	Allergic response to allergen, or a non-allergenic response leading to inflammation of the airways, excess mucus production and narrowed airways. Cold weather, exercise, smoke, some medication, stress and emotions.	Difficulty breathing, may be noisy (wheezing) or silent. Chest tightening, coughing, shortness of breath	Medications: inhaled corticosteroids, bronchodilators, steroids, anti-inflammatory medications.

Chapter 4 Activities

Activity 4.1 Examining the structure of the lungs

1 Identify the structures that can be seen:

b the trachea with its rings of cartilage; examine the rings to see whether they form a complete circle

Answer: The rings do not form a complete circle. They extend about two-thirds of the way around the trachea with a gap at the rear.

2 Squeeze the lungs between your thumb and a finger. Describe what you feel.

Answer: The lungs should feel soft and spongy.

3 Cut off a piece of lung and place it in a beaker of water. Does it float? What does this tell you about the lung?

Answer: Pieces of lung do float, indicating that the lung tissue contains a lot of air.

4 Cut open the trachea and observe the interior. Record your observations.

Answer: The rings of cartilage can be clearly seen on the inside of the trachea. They are very elastic.

5 Continue the cut in the trachea down through one of the bronchi, then through a secondary bronchus. Keep cutting until the air tubes become too small to see. Do the secondary bronchi have rings of cartilage? As you go along the air tubes from large to small, where do the cartilage rings stop?

Answer: The cartilage rings continue from the trachea into the main bronchi. In the secondary bronchi, the cartilage becomes irregular and the cartilage is in the form of plates rather than rings.

Activity 4.2 Investigating breathing

What to do

1 Brainstorm all the factors that could affect the rate of breathing.

Answer: Factors include exercise, diet, altitude, age, gender, stress, smoking habits. Other factors may be acceptable.

2 Choose one of these factors to investigate.

Answer: Students choice will vary.

3 Develop a hypothesis stating the expected trend between this factor and the rate of breathing.

Answer: Hypothesis must include the independent and dependent variable with a relationship.

4 Design an experiment to test your hypothesis.

a How will you change your independent variable (the factor that you are testing)?

Answer: Students choice will vary.

b How will you measure your dependent variable (the breathing rate)?

Answer: Students choice will vary although the use of a spirometer, either a homemade version or a medical grade spirometer, would be logical. Counting breaths is unreliable due to the conscious control of breathing.

c How will you control all the other factors?

Answer: Students choice will vary, however should include four or five different factors.

d How many trials will you conduct?

Answer: Students choice will vary, however should include a minimum of three for reliability.

5 Under your teacher's direction, conduct your investigation.

6 Collate your data in a table and calculate the average breathing rate for each variation of the factor you are testing.

7 Use your results to construct a graph.

a What type of graph should you use?

Answer: Students choice will vary. Discrete data would be best represented in a bar or column graph. Continuous data would appear as a line graph.

b Which variable is on the *x*-axis? Which variable is on the *y*-axis?

Answer: Usually the independent variable is on the *x*-axis. Usually the dependent variable is on the *y*-axis.

c What scale will you use?

Answer: Students choice will vary, but should result in a graph of an appropriate size that is legible.

d Draw the line of best fit for the data.

Answer: This may not be appropriate, depending on the data collected.

Studying your results

1 What trend does your data show? That is, what is the relationship between the independent and dependent variables?

Answer: A clear statement describing the relationship between the variables.

2 Discuss the reliability of your data. That is, how consistent are your results for the trials?

Answer: Reliability is reflected in minimal or no outliers and should result from multiple trials

3 Discuss the accuracy of your results. That is, how did you ensure that your measurements were correct?

Answer: Accuracy will depend on the instrument used to measure breathing rate, or the recorder counting the breaths.

4 Discuss the validity of your method. That is, how well did you control your variables? How well did you test the hypothesis?

Answer: Validity requires the method to be checked so that there are few uncontrolled variables occurring.

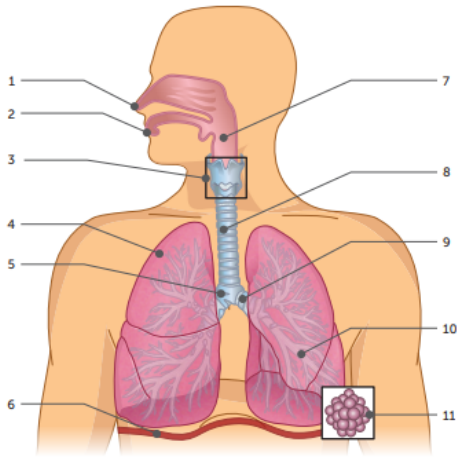
5 Discuss whether your results support your hypothesis.

Answer: Students should not use the term 'prove'. Hypotheses can only be supported or not supported.

Chapter 4 review questions

Recall

1 Label the parts of the respiratory system.



Answer:

1 – Nose

2 – Mouth

3 – Larynx

4 – Right lung

5 – Right bronchus

6 – Diaphragm

7 – Pharynx

8 – Trachea

9 – Left bronchus

10 – Bronchiole

11 – Alveoli

2 a Draw a diagram showing inspiration. As labels for your diagram, list the sequence of events that occur in inspiration.

Answer: Refer to Figure 4.5a on page 90 of the student book.

The drawing and labels should show that the:

• diaphragm contracts so that the chest cavity is enlarged downwards

• rib muscles contract, so that the rib cage moves up and out

• air pressure is now lower in the lung because of the larger volume

• air flows from higher pressure outside the lungs to lower pressure inside.

b Draw a diagram showing expiration. As labels for your diagram, list the sequence of events that occur in expiration.

Answer: Refer to Figure 4.5b on page 90 of the student book.

The drawing and labels should show that the:

• diaphragm relaxes and curves upwards so that the chest cavity becomes smaller

• rib muscles relax so that the rib cage moves down and inwards

• air pressure is now higher in the lung because of the smaller volume

• air flows from higher pressure inside the lungs to lower pressure outside.

3 List the characteristics of the lungs that make them well suited for gas exchange.

Answer:

- The alveoli give the lungs a huge internal surface area so that large amounts of gases can be exchanged in a relatively short time.
- Each alveolus is well supplied with blood vessels so that as much blood as possible is close to the air in the alveolus.
- Continuous flow of blood maintains a gas concentration difference between the air in the alveoli and the blood.
- The membrane that forms the wall of the alveolus is very thin, so that gas molecules do not have far to travel to move into or out of the blood.
- The lungs are positioned deep inside the body to prevent excessive evaporation of the fluid that covers the respiratory surfaces. It is important that the membrane of the alveolus be covered by a thin layer of moisture, because gases can diffuse into and out of the blood only when they are dissolved in fluid.
- Lung volume can be changed by respiratory muscles so that air is moved in and out of the lungs.

4 Describe precautions that you can take to reduce your risk of developing emphysema or lung cancer.

Answer: The greatest risk factor for lung disease is smoking, so do not smoke. Exposure to asbestos fibres and some chemicals also increase the chances of getting lung cancer, so wear a face mask in situations where these materials are likely to be present.

Explain

5 Explain why it is important that there is cartilage in the trachea and bronchi.

Answer: The cartilage allows the airways to remain open but remain flexible.

6 a Why is a concentration gradient important for the exchange of gases?

Answer: Movement of gases into and out of the blood occurs by diffusion, which can only occur when there is a concentration difference; gases diffuse from a region of higher concentration to one that is lower.

b Why is it that, in the lungs, oxygen diffuses into and carbon dioxide out of the blood, whereas in other body tissues, oxygen diffuses out of and carbon dioxide into the blood?

Answer: Diffusion occurs because of differences in concentration. The concentration of oxygen in the air breathed in is higher than the concentration in the alveolar blood, so it diffuses from the air into the blood. The opposite is true of carbon dioxide. In the tissues, the concentration of oxygen is lower than in the blood, so oxygen diffuses from the blood into the cells. Again, the opposite is true for carbon dioxide, because the cell produces large amounts of carbon dioxide as waste from cellular respiration.

c Explain how a concentration gradient for oxygen and carbon dioxide is maintained between the blood and the air in the alveoli.

Answer: The concentration gradient for oxygen and carbon dioxide is maintained by the following mechanisms:

- Blood flows constantly through the capillaries. As the blood flowing through the capillaries around each alveolus picks up oxygen and loses carbon dioxide, it is replaced by more blood pumped into the capillaries. This ‘new’ blood is low in oxygen and high in carbon dioxide so that the concentration gradient is maintained.
- Air moves in and out of the alveoli as we breathe in and out. The air that has picked up carbon dioxide from, and lost oxygen to, the blood is replaced by ‘new’ air with each breath. The ‘new’ air is low in carbon dioxide and high in oxygen.

7 Explain why the pressure in the lungs decreases during inspiration.

Answer: Air pressure decreases in the lungs during inspiration because the volume of the chest cavity increases. As the diaphragm flattens and the external intercostals contract to bring the ribcage upwards and outwards, the lungs will also expand. A higher volume will have a reduced air pressure.

8 Explain why asthma is such a serious condition.

Answer: Asthma causes difficulty breathing, and a reduced movement of air. Therefore, there is less gas exchange occurring and the blood will carry less oxygen. If this continues for an extended period, the patient may fall unconscious.

Apply

9 Compare and contrast bronchi and bronchioles.

Answer: Compare: Both are airways transporting air into and out of the lungs. Both have an epithelial lining capable of producing mucus to trap particles/contaminants.
Contrast: Bronchi have rings of C-shaped cartilage, smooth muscle and elastin, whereas bronchioles only have smooth muscle and elastin present.

10 To be effective, any surface where materials are taken into the body, or passed out of the body, must have a very large surface area. For the lungs, explain how a large surface area is achieved.

Answer: In the lungs a large surface area is achieved by having clusters of alveoli at the end of each bronchiole. The massive quantity of alveoli and the huge surface area they provide – compared with the small volume of air contained – make gas exchange in the lungs very efficient.

11 List five occupations in which people could be at risk of contracting emphysema. What precautions could be taken to reduce the risk of workers contracting the disease?

Answer: Any five of:

- timber mill workers
- chemical plant workers
- miners
- outdoor workers in cities that have high atmospheric pollution
- hospitality workers where smoking is allowed
- people working in smoky environments; for example, fire fighters.

Other correct occupations may be listed by students – evaluate on a case-by-case basis.

Reduce risks by (for example):

- wearing masks/breathing apparatus
- reducing daily exposure
- installing extraction fans
- prohibiting smoking in areas where non-smokers are likely to be affected.

12 Students measured the breathing rate and depth of breathing of a girl before and after exercise. Their results are shown in the following table.

	Breaths per minute	**Volume of air per breath (cm^3)**
At rest	19	460
After running	38	1075

a Calculate the total volume of air that the girl breathed in 1 minute before and after exercise.

Answer:

Before exercise: = 19 × 460 = 8740cm^3 or 8.74 litres

After exercise: = 38 × 1075 = 40850cm^3 or 40.85 litres

b What is the reason for the increase in rate and depth of breathing after exercise?

Answer: The increased rate and depth of breathing would have continued after exercise because the girl had incurred an oxygen debt caused by muscles respiring anaerobically.

c Describe the changes that would occur in the body to bring breathing back to the normal resting level after exercise.

Answer: The oxygen debt would have to be repaid. This would occur in the liver where lactic acid produced by anaerobic respiration is converted back to glucose.

13 Describe the types of lung damage that smoking can cause.

Answer: Smoke irritates the mucus membranes lining the air passages causing excessive production of mucus. Accumulated mucus cannot be removed and the trapped mucus causes alveoli to rupture, resulting in emphysema. This reduces the surface area available for gas exchange so that breathing becomes difficult. Cancerous growths may develop in the lungs or air passages. Secondary tumours may occur in other parts of the body.

Extend

14 If air enters the chest cavity through a puncture wound to the chest wall, the lung may collapse. As the collapsed lung is no longer attached to the chest wall, air cannot be made to move into and out of the lung. However, a person with a collapsed lung can function fairly normally.

a Explain how it would be possible for such a person to function in a fairly normal way.

Answer: The internal surface area of the lungs greatly exceeds that required for exchange of gases for normal activity. Thus, the surface area of one lung is sufficient.

b Would there be any activities that such a person would not be able to perform?

Answer: A person with only one functioning lung would not be able to engage in strenuous activity because the internal surface of one lung would not be sufficient to supply the increased demand for oxygen or to remove the increased amount of carbon dioxide produced.

15 The ability to voluntarily control breathing is important when speaking, but it is also important when eating or drinking. Explain why this is so.

Answer: When swallowing, the epiglottis closes off the trachea so that food and drink cannot enter the lungs and are instead directed down the oesophagus. (See Figure 4.4 on page 88.) Thus, it is important to control breathing while eating or drinking.

16 In expired air resuscitation (mouth-to-mouth resuscitation), air from the rescuer's lungs is blown into the patient's lungs. How is expired air able to keep the patient alive?

Answer: Expired air still contains 15.8% oxygen. Considering the lungs only take approximately 5% from inspired air, this is an adequate amount to sustain life.