

**UNIT 4:** Respiration and the human transport system

**Recommended Prior Knowledge:** Students need to have some knowledge of energy transfer, and to be able understand simple chemical equations.

**Context:** Respiration is a fundamental process that will be referred to in most of the subsequent units. Transport can be linked to Unit 2.

**Outline:** This Unit covers the important topic of respiration, which will be met again when the carbon cycle is dealt with in Unit 9. Gas exchange in humans, and the effects of cigarette smoke lead on from this. In animals, unlike plants, the transport system is involved in the carriage of gases between the gaseous exchange surface and the body tissues, and so coverage of this leads on naturally from a consideration of gas exchange. Some teachers, however, may prefer to deal with transport first, and then respiration; there are sound arguments for either sequence. There is considerable opportunity for practical work in the respiration topics, but the practical work on the transport section is probably limited to study of the structure of the various organs and tissues. Respiration and pulse rate can be linked by investigations of exercise.

	Learning Outcomes	Suggested Teaching Activities	Resources
II 8	Respiration. Define <i>respiration</i> as the chemical reactions that break down nutrient molecules in living cells to release energy. State the uses of energy in the body of humans: <ul style="list-style-type: none"> <li>- muscle contraction</li> <li>- protein synthesis</li> <li>- cell division</li> <li>- active transport</li> <li>- growth</li> <li>- the passage of nerve impulses</li> <li>- the maintenance of a constant body temperature.</li> </ul>	Students should understand that respiration is a reaction (or series of reactions) that takes place inside living cells: cell respiration. A very common error is to confuse it with 'breathing', and to think that it takes place only in the lungs. Students should also realise that every living cell including plant cells respire. Explain that carbon dioxide has to be removed from respiring cells.	<a href="http://www.biotopics.co.uk/humans/respro.html">www.biotopics.co.uk/humans/respro.html</a>  this web site provides an introduction to respiration.

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II 8.1	<p>Aerobic respiration.</p> <ul style="list-style-type: none"> <li>Define <i>aerobic respiration</i> as the release of a relatively large amount of energy in cells by in the presence of oxygen</li> <li>State the word equation for aerobic respiration.</li> </ul> <p>Supplement</p> <ul style="list-style-type: none"> <li>State the equation for aerobic respiration using symbols</li> </ul> $(C_6H_{12}O_6 + 6O_2 \rightarrow 6CO_2 + 6H_2O)$	<p>Emphasise that the function of respiration is to release energy from food (usually glucose) in a form that the organism can use. Students should not state that respiration 'produces' energy. A class discussion will probably pick out a good range of uses of energy.</p> <p>It can be helpful to compare respiration with combustion - the overall equation is the same, but respiration occurs in a series of small reactions that do not suddenly release large amounts of heat energy. Link with carbon cycle in Unit 9 IV 3</p> <p>The energy content of a food, such as a potato crisp or a cube of bread, can be estimated by allowing it to heat a known volume of water as it burns in air. (This investigation is often done using peanuts, but teachers should be aware that an increasing number of children are allergic to nuts)</p> <p>This investigation can include variables such as volume of water and the mass of carbohydrate.</p> <p>Discussion about the errors and limitations of the investigation show the students that science experiments can be inaccurate.</p> <p>Aerobic respiration can also be studied in small invertebrates, maggots or woodlice, or germinating seeds such as mung beans, suspended over a solution of hydrogen carbonate for a few days.</p>	<p><a href="http://www.knowledgerush.com/kr/encyclopedia/Vital_capacity">http://www.knowledgerush.com/kr/encyclopedia/Vital_capacity</a></p>

	Learning Outcomes	Suggested Teaching Activities	Resources
II 8.2	<p>Anaerobic respiration</p> <ul style="list-style-type: none"> <li>Define <i>anaerobic respiration</i> as the release of a relatively small amount of energy by the breakdown of food substances in the absence of oxygen</li> <li>State the word equation for anaerobic respiration: <ul style="list-style-type: none"> <li>in muscles during hard exercise (glucose to lactic acid)</li> <li>and the microorganism yeast (glucose to alcohol and carbon dioxide)</li> </ul> </li> <li>Describe the role of anaerobic respiration in yeast during brewing and bread making.</li> <li>Compare aerobic respiration and anaerobic respiration in terms of relative amounts of energy released.</li> </ul> <p>Supplement</p> <ul style="list-style-type: none"> <li>State the balanced equation for anaerobic respiration in muscles</li> <li><math>C_6H_{12}O_6 \rightarrow 2C_3H_6O_3</math></li> <li>and in the microorganism yeast</li> <li><math>C_6H_{12}O_6 \rightarrow 2C_2H_5OH + 2CO_2</math></li> </ul> <p>using symbols</p> <ul style="list-style-type: none"> <li>Describe the effect of lactic acid in muscles during exercise (include oxygen debt in outline only)</li> </ul>	<p>Anaerobic respiration can be investigated using a suspension of yeast in boiled, cooled water. Boiling drives off all dissolved oxygen. The carbon dioxide released can be detected by passing it through lime water or hydrogencarbonate indicator solution.</p> <p>Students studying the supplement may already have investigated the use of yeast in bread-making, in Unit 2, II 6.1. This is a good opportunity for all students to investigate, for example, whether adding amylase or ascorbic acid, affects the rate at which dough rises.</p> <p>Anaerobic respiration in muscles can be considered when investigating physical activity in 8.3. It also links with yoghurt making: Unit 2, 6.2.1. It helps students to understand oxygen debt if they know that lactic acid is oxidised after the exercise in the liver by the extra oxygen provided by fast breathing.</p>	

	<b>Learning Outcomes</b>	<b>Suggested Teaching Activities</b>	<b>Resources</b>
<b>II 8.3</b>	<p>Gas Exchange</p> <ul style="list-style-type: none"> <li>List the features of gaseous exchange surfaces in animals.</li> <li>Identify on diagrams and name the                             <ul style="list-style-type: none"> <li>larynx</li> <li>trachea</li> <li>bronchi</li> <li>bronchioles</li> <li>alveoli</li> <li>associated capillaries</li> </ul> </li> </ul> <ul style="list-style-type: none"> <li>State the differences in composition between inspired and expired air</li> <li>Use lime water as a test for carbon dioxide to investigate the differences in composition between inspired and expired air</li> <li>Investigate and describe the effects of physical activity on rate and depth of breathing</li> </ul>	<p>The idea of gaseous exchange may already have been discussed in Unit 3, in the context of the intake and loss of gases from leaves. A gaseous exchange surface can be defined as a surface across which gases pass as they enter or leave the body.</p> <p>For animals, oxygen enters as carbon dioxide leaves. Students should relate their understanding of diffusion to the structure of the alveoli and cross reference to Unit 2, 6.3.6 and Unit 3, 7.1.1</p> <p>Students should be able to locate each structure on a diagram and to understand that there are two bronchi and several bronchioles. Link with transport in this unit: 7.2</p> <p>The differences between expired and inspired air, in terms of carbon dioxide content and water vapour content, should be investigated experimentally. Lime water or hydrogencarbonate indicator may be used to test for carbon dioxide.</p> <p>Pie charts or tables showing the percentage composition of air are useful and show that nitrogen remains constant. Students should be able to use their knowledge of gas exchange and respiration to explain these differences.</p> <p>This should be investigated experimentally. A simple, repeatable form of exercise, such as step-ups, is the most useful for generating quantitative results. Students can plan their own investigation by comparing activities such as walking, running, skipping or hopping with definite constant variables of time / distance.</p> <p>The importance of three or five trials per exercise can be introduced to obtain the mean of the raw data and to identify anomalies. Students should use their knowledge of aerobic and anaerobic respiration to explain why breathing rate does not drop immediately to normal when exercise stops.</p> <p>The concept of breathing rate / pulse rate 'at rest' can be introduced.</p>	<p>The use of past examination papers especially paper 2 reinforce the respiratory structure.</p>

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<p><b>II 8.3</b></p>	<p>Supplement</p> <ul style="list-style-type: none"> <li>• Describe the role of the                             <ul style="list-style-type: none"> <li>– ribs</li> <li>– internal and external intercostal muscles</li> <li>– diaphragm</li> </ul> </li> </ul> <p>in producing volume and pressure changes leading to the ventilation of the lungs.</p> <ul style="list-style-type: none"> <li>• Explain the role of mucus and cilia in protecting the gas exchange system from pathogens and particles</li> <li>• Explain the link between                             <ul style="list-style-type: none"> <li>– physical activity and</li> <li>– rate and depth of breathing in terms of changes in the rate at which tissues respire and</li> <li>– therefore of carbon dioxide concentration and</li> <li>– pH in tissues and in the blood</li> </ul> </li> </ul>	<p>Students should link the structure of the respiratory studied in the Core with the muscles involved in breathing. A wooden or plastic model of the intercostal muscles can clarify the action. Students often find this topic difficult, and it is a good idea to use a model of some kind to illustrate how increasing the volume of the thorax leads to a reduction in pressure. The 'balloons in a bell jar' model shows this effectively. Physics students can relate the action to that of an engine piston.</p> <p>The cilia are fine hairs that trap the mucus secreted by the goblet cells. Students can consider the role of the mucus in relation to coughing, pneumonia and tuberculosis. Asthma may be discussed if appropriate.</p> <p>Students should begin to understand the link between carbon dioxide in the blood and the change of the blood's pH due to carbonic acid. The increase of tidal volume with increased exercise should be understood. Unit 5,10.5 Drugs includes smoking and its effects on the body. Teachers could discuss smoking in this unit. Students should understand that cilia become less active, and goblet cells more active, when exposed to cigarette smoke, so that mucus collects in the lungs. Bacteria are likely to breed in it, leading to bronchitis and other infections. Alveoli lose their elasticity, and coughing may damage their walls, leading to breathlessness and eventually to emphysema. Cancer can be triggered by exposure to many of the chemicals in tar.</p> <p>This topic interests students and the teacher can ask them to conduct a survey on the smokers in school or to design a poster on the effects of smoking or to prepare a power point display. The teacher should mention the addictiveness of smoking due to the nicotine and how smoking can lead to taking non-prescribed drugs such as marijuana.</p> <p>Smoking machines where a cigarette is connected a filter and the air is drawn through the cigarette by a water pump shows the tar extracted from one cigarette.</p>	<p><a href="http://www.biologycorner.com/worksheets/lungcapacity.html">www.biologycorner.com/worksheets/lungcapacity.html</a></p> <p><a href="#">Drug Abuse</a>  <a href="#">The effects of smoking and drug abuse, more a teacher resource.</a>  <a href="#">Drug Abuse</a>  <a href="#">Editor: Craig Donnellan</a>  <a href="#">Independence Educational publishers. Cambridge.</a>  <a href="#">1-872995-51-9</a></p>

<p><b>II 7.2</b></p> <p><b>II 7.2.1</b></p>	<p>Transport in humans</p> <ul style="list-style-type: none"> <li>• Describe the circulatory system as a system of tubes with a pump and valves to ensure one-way flow of blood</li> <li>• Describe the double circulation in terms of a low pressure circulation to the lungs and a high pressure circulation to the body tissues and relate these differences to the different functions of the two circuits</li> </ul> <p>Heart</p> <ul style="list-style-type: none"> <li>• Describe the structure of the heart including:             <ul style="list-style-type: none"> <li>- the muscular wall</li> <li>- the septum</li> <li>- the chambers</li> <li>- the valves</li> <li>- the associated blood vessels</li> </ul> </li> <li>• Describe the function of the heart in terms of:             <ul style="list-style-type: none"> <li>- muscular contraction</li> <li>- the working of the valves</li> </ul> </li> <li>• Investigate, state and explain the effect of physical activity on pulse rate</li> </ul>	<p>Diagrams of the heart, showing both external and internal structure, need to be known. Ensure that students realise that both sides of the heart beat together.</p> <p>The direction of blood flow through the heart, the separation of oxygenated and deoxygenated blood, and the functions of the valves should be understood.</p> <p>It is recommended that the idea of a double circulatory system, in which blood passes twice through the heart during one complete circuit of the body, is covered here, as this helps to make sense of the structure and function of the heart.</p> <p>A model of the heart can be useful when explaining the structure.</p> <p>Diagrams with coloured arrow lines will help students to learn the structure of the heart. Students need to understand that the left ventricle has a thicker muscular wall than the right ventricle.</p> <p>The effect of exercise on heart beat relates closely to the effects of physical activity on rate and depth of breathing, dealt with earlier in this Unit.</p> <p>The understanding of the roles of the heart valves be linked to the double circulatory system in 7.2</p> <p>The role of the coronary arteries in supplying the heart muscle with oxygen.</p>	<p><a href="http://peer.tamu.edu/curriculum_modules/Organsystems/module_4/whatweknow_circulation.htm">http://peer.tamu.edu/curriculum_modules/Organsystems/module_4/whatweknow_circulation.htm</a></p> <p>Structure of your heart  <a href="http://www.wehealnewyork.org/services/cardiology/structure.html">http://www.wehealnewyork.org/services/cardiology/structure.html</a></p>
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	<b>Learning Outcomes</b>	<b>Suggested Teaching Activities</b>	<b>Resources</b>
<b>II</b> <b>7.2.1</b>	<ul style="list-style-type: none"><li>• Describe coronary heart disease in terms of the blockage of coronary arteries and state the possible causes<ul style="list-style-type: none"><li>– diet</li><li>– stress</li><li>– smoking</li></ul></li></ul> and preventive measures	<p>Students may already have some ideas about factors that increase the likelihood of suffering from heart disease, and class discussion will probably bring out most of the major influences. A person's genes are also thought to play a major role in this.</p> <p>There is scope for discussion on the effects of diet, exercise, smoking on the health of the heart throughout a person's life.</p> <p>Stress can cover many situations but at a simple level students can understand that problems at work and in the family cause stress and may increase blood pressure in adults.</p> <p>Blockage of the arteries can be covered here as the build up of plaque. The importance of the coronary arteries in heart disease and the link to a diet high in saturated fats should be made.</p> <p>Reference could be made to obesity and the possible connection with heart disease.</p>	

	<b>Learning Outcomes</b>	<b>Suggested Teaching Activities</b>	<b>Resources</b>
<b>II</b> <b>7.2.2</b>	<p>Arteries, veins and capillaries</p> <ul style="list-style-type: none"> <li>Name the main blood vessels to and from the <ul style="list-style-type: none"> <li>heart</li> <li>lungs</li> <li>liver</li> <li>kidney</li> </ul> </li> <li>Describe the structure and functions of <ul style="list-style-type: none"> <li>arteries</li> <li>veins</li> <li>capillaries</li> </ul> </li> </ul> <p>Supplement</p> <ul style="list-style-type: none"> <li>Explain how structure and function are related in <ul style="list-style-type: none"> <li>arteries</li> <li>veins</li> <li>capillaries</li> </ul> </li> <li>Describe the transfer of materials between capillaries and tissue fluid.</li> </ul>	<p>The teacher could reinforce that the hepatic portal vein carries glucose and amino acids from the small intestine Unit. 2 but not carbon dioxide.</p> <p>Transparencies or microscope slides of sections through an artery and a vein can be used to help students to understand the differences in structure  .A table can be used to compare the structure with the functions  .Structure can be related to function between them.  Emphasise that arteries do not pump blood and that capillaries are one cell thick.  Elastic bands of different sizes can illustrate the difference between an arterial wall and the thinner walls of veins.  Students should understand that arteries have blood flowing at high pressure but at much lower pressure in veins.  The narrow lumen of the arteries helps to maintain blood pressure while the large lumen of the veins reduces resistance to blood flow.</p> <p>Diffusion is responsible for the transfer of materials between capillaries and tissue fluid.</p>	



	Learning Outcomes	Suggested Teaching Activities	Resources
II 7.2.3	<p>Blood</p> <ul style="list-style-type: none"> <li>• Identify red and white blood cells as seen under a light microscope, on prepared slides and in diagrams and photomicrographs</li> <li>• List the components of blood as <ul style="list-style-type: none"> <li>– red blood cells</li> <li>– white blood cells</li> <li>– platelets</li> <li>– plasma</li> </ul> </li> <li>• State the functions of blood</li> <li>• red blood cells <ul style="list-style-type: none"> <li>– haemoglobin and oxygen transport</li> </ul> </li> <li>• white blood cells <ul style="list-style-type: none"> <li>– phagocytosis and antibody formation</li> </ul> </li> <li>• platelets <ul style="list-style-type: none"> <li>– causing clotting (no details)</li> </ul> </li> <li>• plasma transport of: <ul style="list-style-type: none"> <li>– blood cells</li> <li>– ions</li> <li>– soluble nutrients</li> <li>– hormones</li> <li>– carbon dioxide</li> <li>– urea</li> <li>– plasma proteins</li> </ul> </li> </ul>	<p>Students should see transparencies or microscope slides of stained blood samples, and be able to distinguish red cells, white cells and platelets.</p> <p>They should understand that red cells transport oxygen and also carbon dioxide, and know that they contain haemoglobin. but do not have a nucleus.</p> <p>Links can be made back to Unit 2, and the need for iron in the diet. Discuss the adaptations of red blood cells to their functions as reinforcement for the function of specialised cells, covered in Unit 1.</p> <p>White blood cells fight disease by providing infection from pathogens, they contain a nucleus and respond to different antigens. Clotting should be mentioned, as a mechanism to prevent loss of blood and entry of pathogens, but Core students need no detail at all of how it takes place, other than that platelets are involved.</p> <p>Students should appreciate the role of the plasma in transporting many substances including heat from the liver and muscles to all parts of the body.</p> <p>Tissue fluid can be thought of simply as plasma that has leaked out of capillaries.</p> <p>Students should understand that substances move from blood to tissues and vice versa. by diffusion. Link with respiration: 8.3</p>	<p><a href="http://www.bbc.co.uk/schools/gcsebitesize/science/aqa/human/defendingagainstinfectionrev2.shtml">http://www.bbc.co.uk/schools/gcsebitesize/science/aqa/human/defendingagainstinfectionrev2.shtml</a></p>

	Learning Outcomes	Suggested Teaching Activities	Resources
	Supplement <ul style="list-style-type: none"> <li>• Describe the immune system in terms of               <ul style="list-style-type: none"> <li>– antibody production</li> <li>– tissue rejection</li> <li>– phagocytosis</li> </ul> </li> <li>• Describe the formation of the lymphatic system in               <ul style="list-style-type: none"> <li>– circulation of body fluids and</li> <li>– the production of lymphocytes</li> </ul> </li> <li>• Describe the process of clotting (fibrinogen to fibrin only)</li> </ul>	<p>A relatively simple approach to this complex topic is required. Some white blood cells are phagocytes, and the process of phagocytosis should be understood.</p> <p>Lymphocytes, secrete antibodies (which are proteins) in response to contact with their particular antigen, which may be an invading pathogen or a foreign tissue that has been transplanted.</p> <p>Students may be interested to learn how immunity to a disease can be conferred by vaccination.</p> <p>This topic also links with kidney transplants, covered in Unit 5. a transplanted organ triggers an immune response, antibodies are secreted and the organ may be rejected.</p> <p>The lymphatic system returns tissue fluid to the blood in the form of lymph fluid. It prevents the build-up of fluid in the tissues.</p> <p>Diagrams can help students understand this alternative transport system and links can be made to the lacteals in the villus and the absorption of fatty acids and glycerol: Unit 2, 6.3.6</p> <p>Lymphocytes are produced by lymph glands during an infection. Students need to understand that fibrinogen is a soluble protein, which is converted to the insoluble fibrin when a blood vessel is damaged. Calcium is required for this, so links can be made back to Unit 2,.6.1</p>	