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**Knowledge Rich Curriculum Plan**

Biology 3.3 Organisms Exchange with their environment

Year 12



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| **Lesson/Learning Sequence**  | **Intended Knowledge:***Students will know that…* | **Prior Knowledge:***In order to know this, students need to already know that…* | **Tiered Vocabulary and Reading Activity** |
| **Surface area:Volume** | Students will learn that organisms need to exchange substances with their environment eg O2 for respirstion, nutrients, excretion of waste products (CO2/urea) heat to maintain body temperature. Students will complete calculations to work out SA:Vol and show that larger organisms have adaptations to facilitate exchange as their SA:vol is reduced.In single celled organisms, substances can diffuse directly into and out of cells. Multicellular organisms need exchange organs/systems. They also have mass transport systems to transport substances. Circulatory system transports hormones, oxygen, glucose, antibodies, waste products. Plants have xylem and phloem.Adaptations – Animal sizeHippo has small SA:vol and so it is hard to lose heat from the body. A mouse has a large SA:Vol so loses heat more easily. Smaller organisms have a higher metabolic rate in order to generateShapeCompact shape has smaller SA:Vol minimising heat loss  | Students will know that the surface area of an animal or plant is the surface that is exposed to the environment and volume is the space inside. A larger organism has a smaller SA:Vol Surface area affects the rate of diffusionStudents will know that a large surface area is a feature of an exchange surfaceSmall animals have a higher SA:vol Xylem – vessel that carries water through the plant (transpiration)Phloem- vessel that carries sucrose around the plant (translocation)Students will be able to describe how some plants and animals are adapted to survive in different environments. Respiration is an exothermic reaction (gives out heat to surroundings)Students will be able to give examples of behavioural adaptations and physiological adaptations in animals | FacilitateMetabolic rate |
| **Gas Exchange in humans (Alveoli)** | Students will learn that epithelial tissue is common in the body and is usually found on exchange surfaces. The lungs have a large number of alveoli which provides a large surface area for gas exchange. The alveoli have a god blood supply- they are surrounded by a capillary network. As blood flows through the capillaries, a concentration gradient is maintained. Oxygen diffuses down a concentration gradient through the alveolar epithelium then the capillary endothelium ending up in the capillary. The thin endothelium allows for a short diffusion pathway- alveolar epithelium is only one cell thick.  | Students should already know that gas exchange occurs at the alveoli. Alveoli have a large surface area, thin walls and good supply for efficient exchange. Students will already know the mains structures of the respiratory system.Students will know that oxygen is required for respiration and we obtain oxygen through breathing. Waste Carbon dioxide is exhaled.  | AlveoliTracheaBronchiBronchiolesAlveolar EpitheliumConcentration Gradient |
| **Ventilation** | Students will learn the following is the mechanism for inspiration (breathing in)The external intercostal muscles contract and internal relax moving the ribcage up and outThe Diaphragm contracts and flattens increasing the volume of the thoracic cavity.As thoracic volume increases, lung pressure decreases and air moves in from high to low pressure (down a pressure gradient) Inspiration is an ‘active’ process as energy is required. Students will learn the following is the mechanism for Expiration (breathing out)The external intercostal muscles relax and internal contract moving the ribcage down and inThe Diaphragm relaxes and curves decreasing the volume of the thoracic cavity.As thoracic volume decreases, lung pressure increases and air moves out from high to low pressure (down a pressure gradient) Normal expiration is a ‘passive’ process as energy is not required. Expiration can be forced (eg blowing out candles) | Students should already know that ventilation is another term for the mechanism of breathing in and out.Ventilation is important in order to get O2 into the body and waste CO2 out.  | AntagonisticInspirationExpirationVentilation rateThoracic cavity |
| **Lung Diseases** | Students will learn that measures of lung function can help to diagnose lung diseases.Forced expiratory volume (FEV1)FEV1- Forced Expiratory volume – Max volume breathed out in 1secondForced Vital Capacity (FVC) FVC- Forced Vital Capacity- Maximum volume of air forcefully breathed out after a deep breath inCOPD- Chronic Obstructive Pulmonary Disease (Asthma, Chronic bronchitis, Emphysema)Tidal volume- volume of air in each ‘normal’ breath.A spirometer can be used to make lung function measurements.Asthma:* Asthma is an allergic response. WBCs release histamines
* Airways become inflamed and irritated
* Smooth muscle lining the bronchioles contracts and excess mucus is produced
* OBSTRUCTIVE disease
* Air flow in and out of the lungs reduced (FEV1 reduced-less air breathed out per second)
* FVC severely reduced (Maximum volume of air it is possible to forcefully breath out of the lungs after a really deep breath in
* Bronchodilator inhalers

Emphysema* Caused by smoking or long term exposure to air pollution. Foreign particles become trapped in the alveoli which causes inflammation. OBSTRUCTIVE disorder.
* Healthy lungs have lots of elastic tissue
* Tar in cigarette smoke also produces inflammatory response. This means phoagocytes are brought to the area. These produce **protease enzymes** which digest elastin (A protein found in cell walls of the alveoli)
* Elastin is elastic and helps the alveoli return to their normal shape after inhaling and exhaling.
* Alveoli can no longer expand and recoil & surface area reduced when walls are damaged
* Oxygen gradient reduced, rate of gas exchange is reduced
* People with emphysema have an increased ventilation rate as they try to get air into their lungs.

Tuberculosis* This is different from the others in that it is an infectious disease caused by a bacterium Mycobacterium tuberculosis. In 19th C 1in 5 died of it.
* Bacteria are breathed in and invade cells of alveoli and bronchioles. Immune cells build a wall around the bacteria in the lungs. As the bacteria multiply they form lumps called tubercles, where the bacteria remain alive but dormant. Infected tissue dies so (exchange) surface gets damaged. Tidal volume decreases. Also causes *Fibrosis*.
* Tubercles stimulate an inflammatory response, resulting in fibrous scar tissue. This can then result in pulmonary fibrosis.
* The TB bacteria can also spread through the blood to other organs which are destroyed as well.
* This causes weakness as the body wastes away; the body seems to ‘consume’ the body.
* Hence the old name ‘Consumption’

Fibrosis* This disease is caused by inhaling fine dust particles or chemicals/infection.
* The particles stimulate an inflammatory response which results in the growth of fibrous scar tissue around the alveoli
* Scar tissue reduces elasticity of lung tissue. This means the lungs cant expand as much so cant hold as much air. of alveoli so normal passive exhalation is reduced - lower oxygen diffusion gradient
* Tidal volume is reduced, so is FVC
* Scar tissue thickens alveolar walls – longer diffusion pathway and reduced surface area
* Sufferers have a faster ventilation rate than normal
 | Students will already know that lung cancer is a lung disease associated with smoking. Life experiences may mean that students already know about asthma and that an inhaler is used during an asthma attack. | EmphysemaAsthmaChronic Obstructive Pulmonary DiseaseFEV1FVCVital capacityTidal volumeTubercles |
| **Gas exchange (fish)** | Students will learn about the structure of fish gills including the operculum, gill filaments, lamellae.Students will learn that oxygen moves from the water into the blood of the fish by diffusion.There is a lower concentration of oxygen in the water than in the air so fish have a specialised breathing system. Water containing oxygen enters the mouth of the fish and passes out through the gillsEach gill is made of several layers of thin plates called gill filaments which provide a large surface area for gas exchange.The gill filaments are covered in tiny structures called lamellae which further increase the surface area. The lamellae have lots of capillaries and a thin surface later of cells which speeds up diffusion. Blood flowing through the lamellae in one direction and the water flows over the gills in the opposite direction (counted current system) this maintains a concentration gradient between the water and the blood. (Possible fish gill dissection) | Students will know that fish have gills in order to obtain oxygen.  | CountercurrentLamellaeFilaments |
| **Gas Exchange** **(insects)** | Students will learn that insects have microscopic air-filled pipes called tracheae which are used for gas exchange.Air moves into the tracheae through tiny pores on the surface called spiracles. Oxygen then travels down a concentration gradient to the cells. The tracheae branch off into smaller tracheoles which have thin permeable walls and go into individual cells. This means O2 can diffuse directly into the respiring cells, the insects circulatory system does not transport O2.Waste CO2 from the cells moves down a concentration gradient towards the spiracles to be released into the atmosphere. Insects use rhythmic abdominal movements to move air in and out of the spiracles. Gas exchange in this way can result in water being lost. Insects are adapted by closing their spiracles when resting. They also have a waterproof waxy cuticle and tiny hairs to trap moisture to reduce the concentration gradient.  | Students will know that insects are living things and so require O2 for respiration | SpiraclesTracheaTracheoles |
| **Digestion and absorption** | Students will learn that Our food is digested in two ways : Mechanical digestion – by the physical action of the teeth and stomach, pulverising the food. Chemical digestion – by the action of enzymes found in the digestive organs. * Amylase (salivary glands- mouth, pancreas- small intestine) is an enzyme which breaks down *starch (polysaccharide)* into disaccharide *sugars which are then broken down into monosaccharides*

The epithelial cells lining the ileum have membrane bound dissacharidases. These enzymes produce monosaccharides by hydrolysis of glycosidic bonds* Sucrose 🡪 Sucrase 🡪 Glucose + Fructose
* Maltose 🡪 Maltase 🡪 Glucose + Glucose
* Lactose 🡪 Lactase 🡪 Glucose + Galactose

The ileum is the third part of the small intestine. Membrane bound disaccharides are enzymes attached to the cell membrane in the ileum. They break down disaccharides into monosaccharides (glucose/fructose/galactose) The products of digestion are absorbed across the ilium epithelium into the blood stream.Glucose – Active transport (Na ions and co-transporter protein)Galactose- sameFructose – Facilitated diffusion through a transporter protein* Proteins are hydrolysed by peptidases.
1. **Endopeptidases** (e.g. Trypsin, chymotrypsin made in the pancreas and secreted into SI) hydrolyse peptide bonds WITHIN an amino acid chain.
2. **Exopeptidases** (e.g. aminopeptidase) hydrolyse the peptide bonds at the ends on the amino acid chain

Endo & exopeptidases together produce **dipeptides and amino acids**.**Dipeptidases** hydrolyse **dipeptides** into individual **amino acids**. These are found on the cell surface membrane of the epithelial cells in the SI* Lipids are broken down by Lipase enzyme into Fatty acids and (mono)glycerides
* Lipases are made in the pancreas but work in the small intestine
* Bile salts are made in the liver and emulsify lipids. They also help us to absorb fat-soluble vitamins like A, D, E, and K
* Several lipid droplets have a larger surface area for lipase to act
* Monoglycerides and fatty acids then stick to the bile salts forming micelles
* **Micelles** are lipid molecules that arrange themselves in a spherical form in aqueous solutions. They have a hydrophobic core and a hydrophilic shell.
 |  | HydrolysisPeptidases (exo/endo)MonosaccharidesDisaccharidesMicellesChylomicron |
| **Haemoglobin** | Haemoglobin is a protein making up 95% of the dry mass of a Erythrocyte. Its job is to transport oxygen .Haemoglobin is a large protein with a **quaternary structure** (made up of four polypeptide chains) each bound to one haem group which contains an iron ion (Fe2+)Each haem group can combine with one oxygen molecule, so that one molecule of haemoglobin can combine with a maximum of four oxygen molecules. This forms oxyhaemoglobin.* Globular proteins – these are round, compact and easily soluble so they can be transported in fluids. Examples are haemoglobin and enzymes.

Oxyhaemoglobin forms in the lungs, this reaction is reversed near the body cells* Oxygen joining to haemoglobin =

OXYGEN LOADING* Oxygen leaving haemoglobin =

OXYGEN DISSOCIATION (unloading)**Affinity for Oxygen**“The tendency a molecule has to bind to Oxygen”**Partial pressure of Oxygen (pO2)**“A measure of oxygen concentration”- The greater the concentration of dissolved oxygen in cells, the greater the partial pressure.The more oxygen dissolved in the cells, the greater the partial pressure. Oxygen binds to haemoglobin when oxygen is at a high concentration, and dissociates from haemoglobin when oxygen is at a low concentration. * If every haemoglobin molecule is carrying the maximum of 4 Oxygen molecules, it is 100% SATURATED
* If haemoglobin molecules are carrying no Oxygen molecules, they are 0% SATURATED

Animals living in low Oxygen environments have haemoglobin with a higher affinity for oxygen. When there isn’t much oxygen available, Hb has to be good at loading.Animals with high activity levels have a higher oxygen demand. Their Hb has a lower affinity for oxygen so it unloads easily to respiring cellsSmall animals have high SA:vol so lose heat quickly. They have a high metabolic rate to keep them warm so high oxygen demand. They have Hb with a lower affinity for oxygen so it can unload easily | Students will already know that red blood cells are adapted to carry oxygen by containing haemoglobin. Students should already know these key facts about proteins:* Proteins are made up of C, H, O, N and some S and P
* Transport proteins such as haemoglobin carry oxygen.
* The monomer molecules making up proteins are called amino acids.
* There are 20 different naturally occurring amino acids.

All amino acids have the same general structure:* A carboxyl group (-COOH)
* An amino group (-NH2) attached to a C atom
* A variable group called R
 | QuaternaryOxygen Loading Oxygen UnloadingMyoglobinBohr effectSaturationPartial PressureDissociation curves |
| **Structure and Function of the circulatory system**  | Be able to describe the function of the circulatory system and that it is used to transport raw materials around their body (Respiratory gases, products of digestion, metabolic wastes and hormones).The circulatory system is made up of the heart, pulmonary vein, pulmonary artery, Aorta, Vena Cava, Renal artery, Coronary arteries and Renal veins.Humans have closed double circulatory system. Animals such as arthropods and molluscs have an open circulatory system. | Students will know the main structures of the circulatory system including the hear and blood vessels. They will know that the job of the circulatory system is to transport glucose and oxygen around the body to the cells for repiration | Open Circulatory SystemClosed systemEndothelial cells |
| **Structure and function of blood vessels** | The different structure of blood vessels is related to their function.The different structures of the Arteries, Arterioles, Veins and capillaries. The the Arteries, Arterioles, Veins and capillaries all have different functions.  | Students will know that the circulatory system is made up of different blood vessels.Students will know that arteries, veins and capillaries have specific structures for their functions.  | ArteryVeinCapillaryArteriolesVenulesValves |
| **Tissue Fluid** | Tissue fluid is the fluid which surrounds cells in tissueTissue fluid is made up of small molecules that leave blood plasma (Oxygen, water and nutrients).When blood is at the arteriole end of a capillary, the hydrostatic pressure is great enough to push molecules out of the capillaryProteins remain in the blood; the increased protein content creates a water potential between the capillary and the tissue fluid.Some tissue fluid re-enters the capillaries while some enters the lymph capillaries.The blood from the arteries is pumped into narrower and narrower vessels, creating a pressure called **hydrostatic pressure** at the arterial end. This forces tissue fluid out of the blood plasma. High hydrostatic pressure forces tissue fluid out of the capillaries, into the space around the cells leaving RB cells and proteins in the blood. This filtration under pressure is called **ultrafiltration**. (High pressure filtration)* Oedema can occur as a result of gravity, especially from sitting or standing in one place for too long. Water naturally gets pulled down into your legs and feet.

Oedema can happen from a weakening in the valves of the veins in the legs | Capillaries have thin walls to allow the exchange of substances. | Lymphatic vessels |
| **The structure of the heart** | The 4 chambers of the heart are separated by a structure called the septum.The septum is important is keeping oxygenated and deoxygenated blood separate.The chambers of the heart are separated by valves (Bicuspid, Tricuspid, Pulmonary and Aortic).Coronary arteries supply the heart muscle with oxygenated blood.The walls of the 4 chambers vary in according with their function. The left ventricle has a much thicker muscle wall in order to allow greater pressure when pumping the blood out of the heart into the aorta. The left ventricle has a thinner wall as less pressure is needed to pump the blood to the lungs through the pulmonary artery.Heart dissection. | The human heart is made up of 4 chambers (Right and left ventricle & Left and right atrium). | Tricuspid valveBicuspid valveMiteral valveSemilunar valvesAtrioventricular valves |
| **Cardiac cycle & Interpreting Data on the Cardiac cycle** | The contraction of the heart is called systole, while the relaxation of the heart is called diastoleAtrial systole is the period when the atria are contracting and ventricular systole is when the ventricles are contracting. Students will know how to interpret a cardiac cycle graph, be able to identify when diastole and systole are occurring and when the cardiac valves are open and closed.On the cardiac cycle graph students should be able to identify the different pressures in the chambers on the heart which results in valves opening and closing. Stage 1 - Atrial SystoleBlood enters the atria from pulmonary vein and vena cava. The atria contract which decreases the volume of the chambers and increases the pressure inside. This pushes blood through the AV valves and into the ventricles.The volume of the ventricle chambers increases slightly as does the pressure. Stage 2 – Ventricular SystoleAtria relax and ventricles contract decreasing the volume so increasing the pressure.Higher pressure in the ventricles than the atria causes the AV valves to close to prevent backflow. The pressure inside the ventricles becomes higher than that of the aorta and pulmonary artery, forcing the SL valves to open and blood moves out.Stage 3- DiastoleThe ventricles relax. The pressure is higher in the pulmonary artery and aorta so forces the SL valves to close. Blood returns to the heart and the atria fill again since the pressure is lower inside the chambers. Pressure increases slightly in the atria forcing the AV valves to open and then blood trickles into the ventricles since pressure is lower. (passive) The atria contract and the whole process starts again. |  | Atrioventricular valveUnidirectionalAortic pressureVentricular pressure |
| **Cardiovascular disease** | * Students will learn that
* Atheroma formation- If the smooth epithelium gets damaged, **white blood cells** and **lipids** clump together under the lining to form fatty streaks.
* Over time this hardens and to form a **fibrous plaque** called an **atheroma.** This then partially blocks the lumen and restricts blood flow.
* If the atheroma breaks through the endothelium (cells lining the inside of the artery) it forms a rough surface Platelets and fibrin accumulate to form a **thrombus**.
* The thrombus may block the blood vessel reducing or preventing blood supply to the tissues (cardiac muscle) or it could become dislodged and move to another blood vessel in the body.
* Aneurysm
* The plaque weakens the wall of the artery. The weakened points swell to form a balloon-like structure called an **aneurysm**.
* If the wall is particularly weak and high pressure blood travels though, it may burst causing a haemorrhage or blood loss and possibly death.
	+ Myocardial infarction
* The heart is supplied with blood by the coronary arteries bringing oxygen fro respiration. If the artery becomes completely blocked, an area of the Heart will receive no blood so no oxygen- this will cause Myocardial infarction (heart attack)
* The severity of the heart attack depends on how far along the coronary artery the thrombosis is.
 | Students will already know that Coronary heart disease is caused by a build-up of cholesterol on the inside of the coronary artery which is the artery which brings blood to the heart muscle so the heart can contractStudents will already know that if the coronary artery gets completely blocked, this would result in a heart attackStudents will already know that obesity and smoking are risk factors for heart disease | ThrombosisRisk factorsAneurismCoronary Heart Disease |
| **Transport in plants****Xylem and cohesion tension theory** | Students will learn that the xylem is a Long tubeTube like structure made of dead cells (Vessel Elements)No end walls so continuous, uninterrupted flowThick cellulose cell walls strengthened by lignin (polymer)Impermeable cell wallsFlow is unidirectionalWater in the xylem vessels is pulled (therefore under **tension**) towards the leaves because of the transpiration (transpiration pull).Water molecules attract each other, because they are dipolar molecules (slight positive on H and slight negative on O). Hydrogen bonds form between water molecules. This provides cohesion (stickiness) of the molecules, so the uninterrupted column of water is pulled upwards.Students will learn the following sequence in order to describe cohesion tension theory:1. Water evaporates from the stomata in the leaves. 2. This lowers the water potential in the mesophyll cells 3.Water will move from higher water potential in xylem to lower water potential in cells4. This creates a negative pressure (tension) 5. Cohesive forces between the water molecules means water is pulled up the column. Adhesion pulls the walls inwards narrowing the xylem Students will describe the use of a potometer in order to investigate factors affecting rate of transpiration. | Students will recall from GCSE that the xylem carries water from the roots up the stem and out through the stomata in the leaves in a process called transpiration | Vascular BundleWater potentialCohesionTranspiration stream |
| **Transport in plants Phloem and mass flow hypothesis** | Students will learn that the phloem transports Phloem transports:Sucrose (soluble carbohydrate)Amino acidsHormonesMinerals* Translocation is the movement of solutes around the plant (Requires Energy)
* Examples of solutes include Amino Acids, sucrose
* Solutes are dissolved substances and are also known as ‘assimilates’
* Sieve tube elements are living cells. No nucleus and few organelles so need companion cells which carry out the living functions for sieve cells (Eg energy for active transport of solutes)

There is evidence for mass flow hypothesis:* Remove a ring of bark from a woody stem (only remove the bark and the phloem, leave the xylem)
* Radioactive tracer used to track movement of solutes
* Metabolic inhibitor inhibits ATP so translocation stops
* Aphids piece the phloem and sap flows out quicker near the leaves.

Student will learn the following sequence in order to describe mass flow hypothesis:Translocation moves solutes from source (leaves) to sink (storage)Active transport is used to actively load solutes from companion cells into sieve tubes of the phloem at the source.This lowers the water potential in the sieve tubes so water enters the tubes by osmosis from the xylem.Hydrostatic pressure increases in the sieve tubes at the source end of the phloem. At the sink end, solutes are removed from the phloem to be used up. This increases the water potential inside the sieve tubes so water leaves by osmosis. This lowers the pressure inside the sieve tubes.The result is the pressure gradient from the source end to the sink endThis gradient pushes solutes along the sieve tubes towards the sink where it is used up (eg respiration) or stored.  | Students will recall from GCSE that the phloem carries food for the plant in a process called translocation | Sieve tube elementTranslocationSourceSinkPotometerRadioactive Tracer |