**Gas exchange**

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| 1 | Surface area: volume ratio | The important relationship between the surface area of a biological unit such as a cell or a whole animal, and its overall volume, which affects many aspects of its biochemistry. As the size of the unit increases, its surface area grows relatively more slowly than its volume. |
| 2 | Exchange surface | Surfaces across which substances could be transferred. To allow exchange to be efficient, surfaces will often have a large surface area:volume ratio, be very thin and selectively permeable. There will also often be movement of the environmental medium and a transport system to ensure the movement of the internal medium. |
| 3 | Concentration gradient | The difference between the concentration of a gas or substance inside and outside of the cell. The steeper the concentration gradient, the faster the rate of diffusion. |
| 4 | Tracheae | A large internal network of tubes in insects with supported rings to prevent them collapsing. |
| 5 | Tracheoles | These tubes extend from the tracheae and extend throughout all the body tissues of the insect to allow atmospheric air to be brought directly to respiring tissues. |
| 6 | Spiracle | Tiny pores that allow gases to enter and leave the tracheae (and water vapour to leave as well). They are opened and closed by a valve. |
| 7 | Gill | Located within the body of the fish, behind the head. |
| 8 | Gill filaments | Make up the gills of a fish – they are stacked up in a pile. |
| 9 | Gill lamellae | At right angle to gill filaments, which increase the surface area of the gills. |
| 10 | Countercurrent flow | Describes how the flow of water over the fill lamellae and the flow of blood within them are in opposite directions. Allows a diffusion gradient to be maintained all the way across the gill lamellae. |
| 11 | Stomata | Minute pores that occur mainly on the leaves, especially on the underside. They allow gaseous exchange (and water vapour to leave as well). They are opened and closed by guard cells. |
| 12 | Guard cells | Control the opening and closing of stomata. |
| 13 | Spongy mesophyll | Tissue in the leaf, which has large air spaces so gases can readily come into contact with mesophyll cells and large surface area of mesophyll cells for rapid diffusion. |
| 14 | Xerophyte | Plants which have a restricted supply of water which have evolved a range of adaptations to limit water loss through transpiration. |
| 15 | Lungs | A pair of lobe structures made up of a series of highly branched tubules called bronchioles, which end in tiny air sacs called alveoli. |
| 16 | Ventilation | The process in which air is constantly moved in and out of the lungs to maintain diffusion of gases across the alveolar epithelium. Also known as breathing. |
| 17 | Trachea | A flexible airway that is supported by rings of cartilage which prevent it collapsing as the air pressure inside falls when breathing in. Its walls are made up of muscle, lined with ciliated epithelium and goblet cells. |
| 18 | Bronchi | Two divisions of the trachea each leading to one lung. Amount of cartilage reduces as they get smaller. Also produce mucus to trap dirt particles and cilia that move this towards the throat. |
| 19 | Bronchioles | A series of branching subdivisions of the bronchi whose walls are made up of muscle (which constricts to control the flow of air in and out of the alveoli) lined with epithelial cells. |
| 20 | Alveoli | Minute air-sacs with a diameter of between 100µm and 300µm at the end of the bronchioles. They are lined with epithelium. Between the alveoli there are some collagen and elastic fibres. |
| 21 | Inspiration | An active process when external intercostal muscles contract, internal intercostal muscles relax, ribs are pulled upwards and outwards and the diaphragm muscles contract causing it to flatten, increasing the volume of the thorax, which reduces the pressure. |
| 22 | Expiration | A largely passive process when external intercostal muscles relax, internal intercostal muscles contract, ribs move downwards and inwards and the diaphragm muscles relax, decreasing the volume of the thorax, which increases the pressure. |
| 23 | Diaphragm | A sheet of muscle that separates the thorax from the abdomen. |
| 24 | Rib cage | the bony frame formed by the ribs round the chest |
| 25 | Intercostal muscles | Lie between the ribs. Two sets – internal whose contraction leads to expiration and external whose contraction leads to inspiration. |

**Digestion**

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| 26 | Enzyme | A protein that acts as a catalyst and so lowers the activation energy needed for a reaction. |
| 27 | Absorption | Movement of digested food molecules through the wall of the intestine into the blood or lymph |
| 28 | Oesophagus | Muscular tube which carries food from the mouth to the stomach |
| 29 | Stomach | A muscular sac with an inner layer that produces enzymes. Its role is so store and digest food, especially proteins. |
| 30 | Ileum | A long muscular tube where food is further digested. Enzymes are produced by its walls and by glands that pour their secretions into it. Inner walls are folded into villi which gives them a large surface area. Where products of digestion are absorbed into the bloodstream. |
| 31 | Large intestine | Where water is absorbed. |
| 32 | Rectum | The final section of the intestines where the faeces is stored before being egested by the anus. |
| 33 | Salivary glands | Situated near the mouth. They pass their secretions via a duct into the mouth which contain salivary amylase which hydrolyses starch into maltose. |
| 34 | Pancreas | A large gland situated below the stomach. It produces a secretion called pancreatic juice, which contains proteases to hydrolyse proteins, lipase to hydrolyse lipids and amylase to hydrolyse starch. |
| 35 | Hydrolysis | How digestive enzymes function – the splitting up of molecules by adding water to the chemical bonds that hold them together. |
| 36 | Carbohydrases | Type of digestive enzyme which hydrolyse carbohydrates, ultimately to monosaccharides. |
| 37 | Lipases | Type of digestive enzyme which hydrolyse lipids (fats and oils) into glycerol and fatty acids. |
| 38 | Proteases | Type of digestive enzyme which hydrolyse proteins, ultimately into amino acids. |
| 39 | Salivary amylase | Produced by the salivary glands and released into the mouth and starts hydrolysing starch in food to maltose. |
| 40 | Pancreatic amylase | Produced by the pancreas and released into the small intestine where it continues the hydrolysis of starch to maltose. |
| 41 | Maltase | Produced by the epithelial lining and is a membrane-bound disaccharidase which breaks down maltose into glucose. |
| 42 | Membrane-bound disaccharidase | An enzyme which is not released into the lumen of the ileum but is part of the cell-surface membranes of the epithelial cells that line the ileum. E.g. maltase |
| 43 | Sucrase | Produced by the epithelial lining and is a membrane-bound disaccharidase which breaks down sucrose into the monosaccharides glucose and fructose. |
| 44 | Lactase | Produced by the epithelial lining and is a membrane-bound disaccharidase which breaks down lactose into the monosaccharides glucose and galactose. |
| 45 | Bile salt | Produced by the liver and split up lipids into tiny droplets called micelles. |
| 46 | Emulsification | The process by which lipids are split up into tiny droplets called micelles by bile salts, which are produced by the liver. It increases the surface area of the lipids so that the action of lipases is sped up. |
| 47 | Micelles | Tiny structures (4-7nm in diameter) formed when monoglycerides and fatty acids remain in association with the bile salts that initially emulsified the lipid droplets. They break down as they come into contact with the epithelial cells lining the villi of the ileum and release the monoglycerides and fatty acids which diffuse across the cell membrane into the epithelial cells. |
| 48 | Chylomicrons | A structure formed when triglycerides associate with cholesterol and lipoproteins, which are adapted for the transport of lipids. Start forming in the endoplasmic reticulum and continuing in the Golgi apparatus. |
| 49 | Lacteals | Lymphatic capillaries that are found in the centre of each villus, where chylomicrons pass into and then enter the bloodstream. |
| 50 | Exocytosis | The outward bulk transport of materials through the cell-surface membrane. How chylomicrons move out of the epithelial cells by this process. |
| 51 | Endopeptidases | A type of protease which hydrolyses the peptide bonds between amino acids in the central region of a protein molecule forming a series of peptide molecules. |
| 52 | Exopeptidases | A type of protease which hydrolyses the peptide bonds on the terminal amino acids of the peptide molecules formed by endopeptidases. They progressively release dipeptides and single amino acids. |
| 53 | Dipeptidases | A type of protease which hydrolyse the bond between the two amino acids of a dipeptide. Dipeptidases are membrane-bound, being part of the cell-surface membrane of the epithelial cells lining the ileum. |
| 54 | Lumen | The cavity of the intestines |
| 55 | Villi | Folded finger-like projections of the ileum wall, about 1mm long, which are increase the surface area of the ileum and therefore accelerate the rate of absorption. |
| 56 | Microvilli | Tiny finger-like projections from the cell-surface membrane of some animal cells. |

**Mass Transport**

**Blood**

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| 57 | Haemoglobins | A group of chemically similar molecules found in a wide variety of organisms. Protein molecules with a quaternary structure that has evolved to make it efficient at loading oxygen under one set of conditions but unloading it under a different set of conditions. It has four polypeptide chains which are linked together to form a spherical molecule – each polypeptide is associated with a haem group which contains a ferrous (Fe2+) ion which can combine with an oxygen molecule (O2). |
| 58 | Oxygen loading | The process by which haemoglobin binds with oxygen is called loading or associating. In humans this takes place in the lungs. |
| 59 | Oxygen unloading | The process by which haemoglobin releases its oxygen is called unloading or dissociating. In humans this takes place in the tissues. |
| 60 | High affinity | Haemoglobins with this for oxygen take up oxygen more easily, but release it less easily. |
| 61 | Low affinity | Haemoglobins with this for oxygen take up oxygen less easily, but release it more easily. |
| 62 | Oxygen dissociation curve | The graph of the relationship between the saturation of haemoglobin with oxygen and the partial pressure of oxygen. Shows how at low oxygen concentrations little oxygen binds to haemoglobin (shallow gradient initially). After the first oxygen molecule binding the quaternary structure of the haemoglobin molecule changes, making it easier for the other subunits to bind an oxygen molecule, therefore it takes a smaller increase in the partial pressure of oxygen to bind the second molecule and third molecule so the gradient steepens. After the binding of the third molecule, it is less likely that a single oxygen molecule will find an empty site to bind to so the gradient of the curve reduces and the graph flattens off. |
| 63 | Positive cooperativity | Binding of the first molecule makes binding of the second easier and so on, so the gradient of the curve steepens. |
| 64 | Partial Pressure | The amount of a gas that is present in a mixture of gases is measured by the pressure it contributes to the total pressure of the gas mixture. |
| 65 | Bohr Shift | The greater the concentration of carbon dioxide the more readily the haemoglobin releases its oxygen because the more carbon dioxide there is, the lower the pH, the greater the haemoglobin shape change, the more readily oxygen is unloaded, the more oxygen is available for respiration. |
| 66 | Transport System | Required to take materials from cells to exchange surfaces and from exchange surfaces to cells. They must have a suitable medium to carry materials, a form of mass transport in which the transport medium is moved around in bulk over large distance, a closed system of tubular vessels and a mechanism for moving the transport medium within vessels. |
| 67 | Circulatory System | Contains a pump (heart), vessels (arteries, capillaries and arteries) and a medium (blood) to transport substances around the body. |
| 68 | Double circulatory system | Blood is confined to vessels and passes twice through the heart for each complete circuit of the body (to the lungs and tissues). |
| 69 | Heart | A muscular organ that lies in the thoracic cavity behind the sternum. It operates continuously and tirelessly throughout the life of the organism. Made of four chambers – left and right atria and left and right ventricle. |
| 70 | Atria | The upper chambers of the heart which are thin-walled and elastic and stretches as it collects blood. |
| 71 | Ventricles | The lower chambers of the heart which have a much thicker muscular wall as it has to contract strongly to pump blood some distance, the left side to the rest of the body (and therefore has a thicker muscular wall) and the right side to the lungs. |
| 72 | Vena Cava | A vein connected to the right atrium and brings deoxygenated blood back from the tissues of the body (except the lungs). |
| 73 | Pulmonary Artery | An artery connected to the right ventricle which carries deoxygenated blood to the lungs where its oxygen is replenished and its carbon dioxide is removed. |
| 74 | Pulmonary Vein | A vein which is connected to the left atrium and brings oxygenated blood back from the lungs. |
| 75 | Aorta | An artery which is connected to the left ventricle and carries oxygenated blood to all parts of the body except the lungs. |
| 76 | Atrioventricular Valves | The valves found between the atrium and ventricle which prevent the backflow of blood into the atria when the ventricles contract and the ventricular pressure exceeds atrial pressure. The left is also known as the bicuspid and the right is also known as the tricuspid. |
| 77 | Semilunar valves | The valves found in the aorta and pulmonary artery which prevent the backflow of blood into the ventricles when the pressure in these vessels exceeds that in the ventricles. |
| 78 | Coronary Artery | The blood vessels which branch off the aorta and supply the heart muscle with oxygenated blood. |
| 79 | Myocardial infarction | Blockage of these coronary arteries (for example by a blood clot) leads to this. Also known as a heart attack. |
| 80 | Diastole | Stage of the cardiac cycle when the atria and ventricles are relaxed. Blood returns to the atria of the heart. Atrial pressure increases as they fill with blood, causing the atrioventricular valves to open, which allows blood to flow into the ventricles. The semi-lunar valves are closed (‘dub’) because the pressure in the ventricles is lower than that in the aorta and the pulmonary artery. |
| 81 | Atrial systole | A stage of the cardiac cycle when the atrial walls contract, forcing the remaining blood into the ventricles from the atria. Ventricle walls remain relaxed. |
| 82 | Ventricular systole | A stage of the cardiac cycle when the ventricle walls contract simultaneously (after a short delay to allow the ventricles to fill with blood) which increases the blood pressure and causes the atrioventricular valves to shut (‘lub’). Ventricle pressure rises further and forces the semilunar valves open as pressure exceeds that in the aorta and the pulmonary artery, allowing blood to be pumped blood into these vessels. |
| 83 | Heart rate | The rate at which the heart beats in beats per minute. |
| 84 | Stroke volume | The volume of blood pumped out at each beat measured in dm3. |
| 85 | Cardiac output | The volume of blood pumped by one ventricle of the heart in one minute. It is usually measured in dm3min-1. |
| 86 | Arteries | Carry blood away from the heart and into arterioles. They have a thicker muscular layer, thicker elastic layer and overall thicker wall than veins. They also do not contain valves (apart from the aorta and pulmonary artery). |
| 87 | Arterioles | Smaller arteries that control blood flow from arteries to capillaries. Their muscular layer is relatively thicker than in arteries and elastic layer is relatively thinner than in arteries. |
| 88 | Capillaries | Tiny vessels that link arterioles to veins. Their walls consist mostly of the lining layer making them extremely thin, they are numerous and highly branched, they have a narrow diameter and narrow lumen and there are spaces between the lining (endothelial) cells. |
| 89 | Veins | Carry blood from capillaries back to the heart. They have a thinner muscular layer, thinner elastic layer and overall thinner wall than arteries. They contain valves at intervals throughout to ensure that blood does not flow backwards. |
| 90 | Valves | Ensure that blood does not flow backwards and that when body muscles contract, compressing veins, pressurising the blood within them, they ensure the blood flows in one direction only: towards the heart. |
| 91 | Lumen | The central cavity of the blood vessel through which the blood flows. |
| 92 | Tough fibrous outer layer | Resists pressure changes from both within and outside arteries, arterioles and veins. |
| 93 | Elastic Layer | Helps to maintain blood pressure by stretching and recoiling (springing back) in arteries, arterioles and veins. |
| 94 | Muscle layer | Can contract and so control the flow of blood in arteries, arterioles and veins. |
| 95 | Endothelium | Thin inner lining which is smooth to reduce friction in all vessels. |
| 96 | Plasma | Yellow liquid inside blood vessels, which carries red blood cells, platelets, white blood cells and also dissolved substances such as proteins, water, glucose, amino acids and hormones. Composition is controlled by various homeostatic systems. |
| 97 | Tissue fluid | A watery liquid that contains glucose, amino acids, fatty acids, ions in solution and oxygen. It supplies all of these substances to the tissues and receives carbon dioxide and other waste materials from tissues. It is the means by which materials are exchanged between blood and cells and bathes the cells of the body. It is formed from blood plasma. |
| 98 | Ultrafiltration | Filtration under pressure at the arterial end, assisted by blood pressure (a hydrostatic pressure) which causes small molecules to be forced out of the capillaries, leaving all cells and proteins in the blood because they are too large to cross the membranes. |
| 99 | Lymphatic system | A system of vessels which begin in the tissues. Initially they resemble capillaries (except that they have dead ends), but they gradually merge into larger vessels that form a network throughout the body. These larger vessels then drain their contents back into the bloodstream via two ducts that join veins close to the heart. It is how the remainder of tissue fluid (which cannot return to the capillaries) is carried back. |

**Plant transport**

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| 100 | Xylem vessels | Hollow thick-walled tubes which transport water through flowering plants. |
| 101 | Transpiration | The main force that pulls water through the xylem vessels in the stem of a plant is the evaporation of water from leaves through stomata. |
| 102 | Stomata | Tiny pores which guard cells control the opening and closing of. If the stomata are open, water vapour molecules diffused out of the air spaces into the surrounding air. |
| 103 | Cohesion | Attraction between molecules of the same type - how water molecules form hydrogen bonds between one another and hence tend to stick together. |
| 104 | Transpiration pull | How a column of water is pulled up the xylem as a result of transpiration. |
| 105 | Cohesion-tension theory | The main factor that is responsible for the movement of water up the xylem, from the roots to the leaves. Transpiration pull puts the xylem under tension (there is negative pressure within the xylem) and because of the cohesive nature of water (due to hydrogen bonds between water molecules) there is a continuous stream of water being pulled across the mesophyll cells and up the xylem. |
| 106 | Potometer | A piece of apparatus which enables the rate of water loss in a plant to be measured. |
| 107 | Phloem | The tissue which transports biological molecules in flowering plants. It is made up of sieve tube elements, long thin structures arranged end to end. Their end walls are perforated to form sieve plates. Associated with the sieve tube elements are cells called companion cells. |
| 108 | Translocation | The process by which organic molecules and some mineral ions are transported from one part of a plant to another. |
| 109 | Sieve tube element | These are living, tubular cells that are connected end to end. The end cell walls have perforations in them to make sieve plates. The cytoplasm is present but in small amounts and in a layer next to the cell wall. It lacks a nucleus and most organelles so there is more space for solutes to move. The cell walls are made of cellulose so solutes can move laterally as well as vertically. Next to each sieve tube element is a companion cell. |
| 110 | Companion cell | Since the sieve tube element lacks organelles, the companion cell with its nucleus, mitochondria, ribosomes, enzymes etc., controls the movement of solutes and provides ATP for active transport in the sieve tube element. Strands of cytoplasm called plasmodesmata connect the sieve tube element and companion cell. |
| 111 | Mass-flow theory | The bulk movement of a substance through a given channel or area in a specified time. Sucrose is transferred into sieve elements from photosynthesising tissue and there can be mass flow of sucrose solution down a hydrostatic gradient in sieve tubes (caused by active transport of sucrose into sieve tubes at the source and out of sieve tubes at the sink, and osmosis – movement of water into sieve tubes near source and out of sieve tubes near sink). |
| 112 | Ringing | An experiment when a section of outer layers (protective layer and phloem) is removed around the complete circumference of a woody stem while it is still attached to the rest of the plant. This results in the region of the stem immediately above the missing ring of tissue swelling because the sugars of the phloem accumulate above the ring and it leads to tissues dying below the ring because of the interruption of flow of sugars to this region. It shows that the phloem is responsible for translocating sugars. |
| 113 | Tracer | Radioactive isotopes can be used to trace the movement of substances in plants. 14CO2 is used so plants incorporate this isotope into the sugars produced during photosynthesis. These radioactive sugars can then be traced as they move within the plant using autoradiography. This shows that sugars are found where phloem tissue is in the stem. |