National 5 Biology - Unit 1 Cell Biology

Key Area	Key Terms	Summary of topic
1. Cell Structure	cell cell wall chloroplast nucleus organelles chromosomes vacuole mitochondria plasmid ultrastructure fungus bacterium plant cell animal cell ribosome circular chromosome unicellular organisms	• Cells are the basic unit of life • Stains can be used to make cell structures visible • Organelles are present in cell cytoplasm and carry out a specialised function • Animal, plant and fungal cells contain a nucleus that contains chromosomes • A bacterium does not have a nucleus it has a large circular chromosome and smaller plasmids. • ultrastructure of cells o plant – nucleus, cell membrane, cytoplasm, ribosomes, mitochondria, cell wall, vacuole, chloroplasts o animal – nucleus, cell membrane, cytoplasm, ribosomes, mitochondria o bacterial – cell wall, cell membrane, plasmid, circular chromosome, ribosome o fungal cells - nucleus, cell membrane, cytoplasm, ribosomes, mitochondria, cell wall, central vacuole • cell organelles o nucleus – contains chromosomes, controls the cells activities o cell membrane – controls the entry and exit of substances o cytoplasm – site of chemical reactions o mitochondria – contains the enzymes for aerobic respiration o ribosome – site of protein synthesis o central vacuole – contains water and solutes (cell sap) o cell wall – supports the cell; plant cell walls are made of cellulose o chloroplast – site of photosynthesis, contains chlorophyll o circular chromosome – controls cell activities (bacterial cells only) o plasmid – controls cell activities, transfer of genetic material from cell to cell

Key Area	Key Terms		Summary of topic
2. Transport across cell membranes	cell membrane phospholipid protein diffusion osmosis LWC HWC turgid plasmolysis crenate burst carrier molecules energy iodine	fluid mosaic model high concentration low concentration concentration gradient unicellular organisms multicellular organisms high water concentration low water concentration selectively permeable water concentration gradient osmotic power plant desalination active transport sodium/potassium pump	• The cell membrane is selectively permeable and controls the entry and exit of substances from the cell • The structure of the cell membrane is known as the fluid mosaic model, made up of a double layer of phospholipids and a mosaic of protein molecules. • Substances can cross the cell membrane by osmosis, diffusion or active transport. • Diffusion and osmosis are passive processes, they do not require energy • Active transport requires energy from respiration • Diffusion is the net movement of a substance from a region of its high concentration to a region of its low concentration, until the concentrations become equal • Diffusion in unicellular organisms (paramecium) o There is a difference in concentration between the inside of a cell and its external environment o Oxygen diffuses into cells, Carbon dioxide diffuses out of cells • Diffusion in multicellular organisms o Exchange of respiratory gases in alveoli and body tissues (see unit 2: need for transport) • Osmosis is the net movement of water from a region of high water concentration to a region of low water concentration across a selectively permeable membrane. • Osmosis practical o Sugar concentration and potato cylinders o Water and concentrated syrup on eggs o Model cells • Osmosis in cells o Plants (cell wall) – turgid / plasmolysed o animal cells – burst / shrink o unicellular organisms – contractile vacuoles • Active transport is movement of ions from a low concentration to a high concentration, against a concentration gradient. Uses energy from respiration. • Active transport carrier proteins are called pumps o E.g. Sodium potassium pump o Condition required for protein pumps – temperature, oxygen, food • Iodine – brown seaweeds actively transport iodine into their cells. Iodine concentration in cell sap is thousands of time greater than in sea water.

Key Area	Key Terms		Summary of topic
3. Producing new cells	growth cell number dry mass fresh mass cell division chromosomes chromosome complement nucleus diploid haploid mitosis sigmoid growth curve accelerating growth steady rapid growth decelerating growth airborne micro-organisms inoculating loop growth medium contaminants	chromatid centromere spindle fibres equator poles daughter cells replication growth curve growth spurts cell culture aseptic sterile microbiology autoclave nutrient agar petri dish disinfectant flaming fermenters	• Growth is the irreversible increase in the dry mass of an organism, accompanied by an increase in cell number. • Cell division o Animal cell – nucleus divides, cytoplasm divides, two daughter cells form o Plant cell – nucleus divides, new cell wall forms, two daughter cells form • Chromosomes – thread-like structure, made from DNA, contains genetic information • Chromosome complement – characteristic number of chromosomes for each species e.g. humans 46, fruit fly 8 • Diploid – 2 identical matching sets of chromosomes • Haploid – single set of chromosomes • Mitosis – division of the nucleus into two genetically identical daughter nuclei • Stages of mitosis o Chromosomes shorten and thicken and seen as a double thread - two chromatids attached by a centromere o Nuclear membrane disappears o Spindle forms o Chromosomes line up on equator attached to spindle fibres by centromere o Spindle fibre contracts, chromatids pulled apart o Chromatids move towards opposite poles o Nuclear membrane forms around each set of chromosomes • After mitosis, cytoplasm divides – two genetically identical daughter cells • Mitosis maintains the continuity of diploid chromosome complement, this is important for growth and development. • Growth is measured using fresh mass, height or cell number over a period of time • Growth curve – 4 phases 1. Period of accelerating growth: 2. Period of rapid steady growth: 3. Period of decelerating growth: 4. Period of no growth. • Growth curves – plant height; human growth curve (2 growth spurts) • Culturing cells o Aseptic techniques to prevent contamination by airborne spores o Cell culture requirements – sterile environment free from contaminants, growth medium, controlled environment with optimum levels of oxygen concentration, pH and temperature. • Fermenters can be used to culture cells on a vast scale.

Key Area	Key Terms	Summary of topic
4. DNA and the production of proteins	DNA double helix bases adenine thymine guanine cytosine gene complementary base pairs genetic code messenger RNA ribosome amino acid banding pattern chromosomes	• DNA (deoxyribonucleic acid) is a double helix • There are 4 DNA bases – Adenine (A), Thymine (T), Guanine (G) and Cytosine (C) • Complementary base pairing exists between the two strands – A -- T and G – C (therefore the ratio of bases A:T is 1:1 and the ratio of bases G:C is 1:1) • The sequence of DNA bases contains the genetic instructions that control inherited characteristics. This is an organism's genetic code. • A gene is a region of DNA that codes for the sequence of amino acids in a protein. • Genetic code o every three bases in DNA codes for one amino acid o This is known as the triplet code. • In protein production o mRNA is made complementary to a DNA strand; o mRNA carries the genetic code from the DNA in the nucleus to the ribosome; o at the ribosome, amino acids are assembled in the correct sequence to make a protein. • The sequence of amino acids in a protein determines the structure and function of that protein.

Key Area	Key Terms		Summary of topic

5. Proteins and enzymes	protein
	sequence
	structural proteins
	enzymes
	active site
	hormones
	metabolism
	antibodies
	specific
	denatured
		amino acid
		biological catalysts
		experimental control
		enzyme-substrate complex
		complementary
		catalase
		amylase
		catalyst
		optimum temperature
		optimum pH
			• Amino acids are the subunits of a protein, there are 20 different types of amino acid. The sequence of amino acids determines protein structure and function; bonds form between certain amino acids, this makes the protein fold in a characteristic way
			• Molecular shape of proteins; Fibrous proteins – form long fibres e.g. collagen and other proteins in bone and connective tissue; Globular proteins – form a more globe (spherical) shape e.g. antibodies (Y-shaped), enzymes and hormones
			• Functions of proteins; In enzymes the active site is specific to a substrate molecule; Structural proteins are found in the fluid-mosaic model of cell membranes; Hormones regulate growth and metabolism; Antibodies are specific to antigens on disease-causing organisms
			• Biological catalysts (enzymes) speed up the rate of all biochemical reactions but remain unchanged. The shape of the active site is determined by the sequence of, and bonding between amino acids. The active site is specific (complementary) to the substrate molecule. When the substrate enters the active site the chemical reaction can take place.
			• Factors affecting enzyme activity
			  o Effect of temperature – enzymes are inactive at low temperatures, as temperature increases they move around more and the rate of reaction increases. At the optimum temperature, the rate of reaction is at its best. At high temperatures, the shape of the active site becomes altered and the enzyme is denatured.
			  o Effect of pH – enzymes work best at their optimum pH. If the pH is too low or too high the enzyme becomes denatured.
			• Enzyme experiments can investigate the effect of temperature, pH, substrate concentration and enzyme concentration on the rate of a reaction. The investigation is valid if only one variable is studied at a time.
			• A control is a copy of the experiment where all factors are kept the same but the enzyme is boiled and cooled. This allows you to conclude that any changes in the investigation were caused by an active enzyme.

Key Area	Key Terms	Summary of topic
6. Genetic engineering	genetic material genetic engineering genetically modified medical applications multicellular GM organism blight-resistance golden rice chromosome plasmid products insulin vitamin A gene	• A bacterium has a large circular chromosome and smaller circular plasmids • transferring genetic material o Plasmids can pass between bacterial cells (acts as vectors) o Viruses can insert their DNA into a host cell o DNA can be transferred artificially by genetic engineering • Organisms which contain DNA from another organism are said to be transformed and are called genetically modified (GM) organisms • Using GM bacteria as a chemical factory – Insulin production 1. Identification of the insulin gene 2. Cutting the insulin gene out of the chromosome with an enzyme 3. Extraction of a plasmid 4. Cutting open of the plasmid using the same enzyme 5. Sealing the insulin gene into the plasmid using a different enzyme 6. Insertion of the plasmid into a bacterial cell 7. Growth of transformed bacteria 8. Formation of duplicate plasmids containing insulin gene 9. Production of insulin 10. Extraction and purification of insulin. • Advantage of using micro-organisms – can be grown quickly, easily and at low cost. In suitable conditions, bacterial cells will produce large quantities of a useful product. • GM multicellular organisms o Golden rice – improved nutritional value o Plants that are resistant to pests e.g. blight-resistant potatoes o Fruit with a longer shelf life

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<tr><th>Key Area</th><th colspan="2">Key Terms</th><th>Summary of topic</th></tr>
<tr><td rowspan="17">7. Respiration</td><td>glucose</td><td></td><td rowspan="17">

- Glucose is an energy-rich sugar and is the main source of chemical energy in a living cell.
- Chemical energy is released rapidly, when food is burnt, as heat energy and light energy. In living cells, chemical energy is released in a series of enzyme-controlled reactions in respiration.
- Adenosine triphosphate (ATP) is an energy-rich chemical compound. The energy is released when the bond attaching the terminal phosphate is broken. ATP links energy requiring and energy releasing reactions.
  - ATP → ADP + Pi releases energy
  - ADP + Pi → ATP requires energy
- The chemical energy released during the respiration of glucose is used to regenerate ATP. This energy is available for energy requiring processes such as muscular contraction, active transport of ions, synthesis of proteins and cell division.
- Biochemistry of respiration involves two main stages
  1. The breakdown of glucose, this is identical for aerobic and anaerobic respiration
  2. The fate of pyruvate, this stage is different for aerobic respiration and the fermentation pathways.
- Glycolysis (the breakdown of glucose) takes place in the cytoplasm of the cell. Glucose (6C) is broken down in a series of enzyme controlled steps to form two molecules of pyruvate (3C). Oxygen does not need to be present and two ATP molecules are produced.
- Aerobic respiration takes place in the mitochondria and involves the breakdown of pyruvate in a series of enzyme controlled steps to release carbon dioxide, water and 18 molecules of ATP per pyruvate molecule. In aerobic respiration a total of 38 ATP molecules are produced for each original glucose molecule.
- Fermentation pathways (anaerobic respiration) only the breakdown of glucose can occur and only two ATP molecules are formed per glucose molecule.
  - Animal cells: glucose → pyruvate → lactic acid; this can cause muscle fatigue and an oxygen debt builds up. This process is reversible.
  - Plant and yeast cells: glucose → pyruvate → ethanol & CO_2; this is an irreversible process.

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<tr><td>energy</td><td>respiration</td></tr>
<tr><td>regenerate</td><td>chemical energy</td></tr>
<tr><td>glycolysis</td><td>adenosine triphosphate (ATP)</td></tr>
<tr><td>pyruvate</td><td>adenosine diphosphate (ADP)</td></tr>
<tr><td>cytoplasm</td><td>inorganic phosphate (Pi)</td></tr>
<tr><td>mitochondria</td><td>high energy state</td></tr>
<tr><td>fermentation</td><td>low energy state</td></tr>
<tr><td>lactic acid</td><td>energy requiring process</td></tr>
<tr><td>ethanol</td><td>energy transfer</td></tr>
<tr><td>reversible</td><td>hydrogen carbonate indicator</td></tr>
<tr><td>irreversible</td><td>large surface area</td></tr>
<tr><td>oxygen debt</td><td>central matrix</td></tr>
<tr><td>muscle fatigue</td><td>inner membrane</td></tr>
<tr><td>carbon dioxide</td><td>outer membrane</td></tr>
<tr><td>oxygen</td><td>breathing rate</td></tr>
<tr><td>water</td><td>respiration rate</td></tr>
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Key Area	Key Terms		Summary of topic
8. Photosynthesis	light- dependent stage carbon fixation temperature dependent stage biochemistry of photosynthesis raw materials by-product food product enzyme-controlled reactions storage carbohydrate structural carbohydrate *Elodea* bubbler experiment limiting factor light intensity carbon dioxide concentration	photosynthesis light energy chlorophyll water carbon dioxide carbohydrate carbon sugar starch cellulose fats proteins iodine solution temperature	• Photosynthesis is a series of enzyme controlled stages that starts with the capture of light energy by chlorophyll (green pigment) in the chloroplast (organelle). Carbohydrates are produced from the raw materials (carbon dioxide and water); oxygen is released as a by-product. • Biochemistry of photosynthesis involves two stages; o Light-dependent stage – light energy is trapped by chlorophyll and converted into the chemical energy of ATP; water is split into hydrogen and oxygen. The H and ATP are used in carbon fixation. o Temperature dependent stage (carbon fixation) occurs in the stroma of the chloroplast – it is a series of enzyme controlled reactions where the hydrogen combines with carbon dioxide to form carbohydrate. ATP provides the energy to drive this process. • The glucose made in photosynthesis can be o Broken down by respiration to supply the cells with energy o Converted into starch grains for energy storage o Converted into cellulose which is the structural carbohydrate in plant cell walls. o Converted into fats and proteins • Factors affecting photosynthesis can be investigated using *Elodea* bubbler experiment. Light intensity can be varied by setting up a lamp at set distances from the plant. • Limiting factors – the factor that slows down a process because it is in short supply. Light intensity, temperature and carbon dioxide concentration are limiting factors in photosynthesis. • Farmers can improve the yield of crop plants by controlling conditions in a glasshouse. If light-intensity, temperature and carbon dioxide concentration are kept at optimum conditions the farmer will maximise crop yield and produce early crops.