BIOLOGY

Cells:

NOTE:::
Polar=water soluble
Non-polar=fat soluble
C1: The cell is the unit of structure and function of most organisms
C1.1: Understand that the cell is the smallest independent unit of life.
MRS GREN

Characteristic of living thing (organism)	Eukaryotic organisms (plants or animals)	Prokaryotic organisms (bacteria)	Viruses
Movement	Yes	Yes (flagellum)	No
Respire	Yes	Yes	No
Stimuli (respond to)	Yes	Yes	No, except recognition of host cell for infection
Grow	Yes	Yes	No
Reproduce	Yes	Yes	No (host reproduces them)
Excrete	Yes	Yes	No
Nutrition (Energy gain, transformation and loss)	Yes	Yes	No

Cell Theory=
- All living things are composed of cells or cell products.
- All cells arise from pre-existing cells through cell division.
- Cells have individual existence and in multicellular organisms.
- Energy flow occurs within cells (e.g. gain, transform and lose energy).

Exceptions: Viruses= a protein coat enclosing gen. mat. (DNA or RNA). Have no cytoplasm or metabolic activity. (reproduced and can evolve)
- Act by infecting a host cell with their gen. mat. Which then joins with the host cell's DNA.
- Re-directs it to produce copies of the virus (e.g. host cell produces the virus.)

SACE SAYS THEY ARE LIVING if so, they are an exception cos they do not have all components of cells. So ARE NOT CELLS OR MADE UP OF CELLS.

Light vs. Electron microscopes:

Characteristic	Compound light microscope	Electron microscope
Magnification	Up to 2,000x (less)	Up to 5,000,000x (more)
Resolution	Poor	Excellent
Mounting medium	Air	Vacuum
Cost	Low	High
Able to view all organelles	No	Yes
Can view: cell wall, cell membrane, nucleus, chloroplasts & mitochondria	Yes	Yes

C1.2: Explain the significance of the surface area-to-volume ratio.
What is SA: VOL? = The amount of SA available for every unit of VOL. (useful when comparing different cells or structures)
- As size increases, the rate of growth of VOL is greater than the rate of growth of SA. The result is the size increases, as the amount of SA per unit of VOL decreases.
- For Fixed Shape: As size inc. SA: VOL dec.
- For varied Shape: As shape becomes more spherical SA: VOL dec.

Cells Exchange (inputs and outputs):
Inputs:
- Water, oxygen (CO_2 for plants)
- Ions
- Organic molecules (glucose, glycerol, fatty acids, amino acids, nucleotides)
- Heat energy

Outputs:
- Water, CO_2, (oxygen for plants)
- Urea (and other nitrogenous wastes)
- Heat energy

Exchange efficiency: directly proportional to SA: VOL. As SA: VOL inc. Exchange efficiency inc.
SA: VOL inc.= good SA: VOL dec=bad
Why SA: VOL limits cell size?
1. Many chemical reactions occur in the cell.
2. The number of reactions inc. as the VOL inc.

∴ - larger cells= more input/output

3. Exchange of raw mat. Can only occur through cell membrane.
4. Greater surface area, greater amount of exchange per unit time.
5. amount of surface area available per unit of volume inc. with inc. in cell siz e.g. SA: VOL dec.
6. SA: VOL gets too small to effectively exchange- means cell cannot get larger.

NOTE: Cell can respond to this by dividing. (inc. cell size can stimulate this)
NOTE: Specialized cells can inc. their SA: VOL by being less spherical. (E.g. RBC, villi)

C2: There are two main types of cell organization.
C2.1: Compare the size and structural organization of prokaryotic and eukaryotic cells.

Prokaryotes	**Eukaryotes**
No nucleus	Nucleus
No membrane bound organelles	Membrane bound organelles
Small cell size 1-10 microns (usually <2)	Relatively large cell size 10-100 microns (us. >5)
Small ribosomes (70S)	Larger ribosomes (80S)
Sing. Circ. Chrom. + plasmid rings (cytoplasm)	Homologous strand-like, linear chrom. (nucleus)
Little internal organization (some infolding of cell membrane may occur)	Lots of internal organization (compartmentalizing metabolic reactions)
e.g. Bacteria only	e.g. animal, plant
All unicellular	Uni/multicellular

(comp. 3) NOTE: because prokaryotes are smaller, they have a large SA: VOL ratio **means:**
- Higher metabolic rate and so faster growth
- Shorter generation times, so reproduce more rapidly

EXAMPLES:
Prokaryotic:
Bacteria (auto/heterotrophic): ALL unicellular, some are motile
Eukaryotic:
Green Plants (autotrophic): uni/multicellular. Produce energy rich, organic molecules by photosynthesis. Few motile.
Animals (heterotrophic): uni/multicellular. Gaining energy rich organic molecules by consuming other organisms. All motile at some stage.

Differences summarized:

Plant Cell	**Animal Cell**
Chloroplasts	No chloroplasts
Large Vacuoles e.g. sap vacuole	Vesicles only (v small vacuoles)
No Centrioles	Centrioles
Cell Wall	No Cell wall

C2.2: Describe the structure and function of the following organelles: nucleus, mitochondrion, chloroplast, vacuole, Golgi body, and endoplasmic reticulum.

Organelle	**Structure**	**Function**
Nucleus (nuclei- plural) (plant/animal cells)	- *Bound by a dbbl. Mem.* - Contains DNA in linear chrom. Long and unwound- chromatin - *Nucleolus* within- darker, denser, has rRNA and ribosomal proteins.	- **Control Centre of the cell** - *DNA determines* which proteins are made and when- controlling: - Cell structure (structural prot.) - Cell behaviour (enzymes, hor.) - *Pores allow:* - Exit of mRNA & ribosomes - Entry of ATP, enzymes, nucleotides and req. proteins - *Nucleolus:* - Involved in formation of ribosomes (subunits). - The subunits are formed and leave by the nuclear pores for final assembly in cytoplasm.
Mitochondrion (Mitochondria-plural) (plant/animal cells)	- Highly variable shape - 1-3 microns' long - *Double membrane bound:* - Outer membrane smooth - Inner membrane highly folded; forming *cristae (crista- sing.)* - *Matrix*=like cytoplasm contains: - Enzymes - Ribosomes (70S like prok. Rib.) - mtDNA (sing. Circ. Chrom.)^	- **Aerobic Cellular Respiration (eq.)** - *Cristae*- inc. SA for enzyme attachment, inc. eff. of ATP synthesis using energy released in the matrix during Kreb's critic acid cycle. - *Matrix*- Enzymes needed to complete breakdown of pyruvic acid are present releasing all of its stored chemical energy. - Cells with higher energy req. will have more mitochondria
Chloroplast (only in photosynthetic plant cells)	- Shaped like hemisphere - *Double membrane bound*	- **Photosynthesis (eq.)** (convert light energy into chemical energy)

	- Numerous *thylakoid* membranes form stacks of enclosed vesicles containing chlorophyll (in *lumen*) and the enzymes needed for photosynthesis called *Grana* (Granum sing.) - Between the grana is the *stroma* (like cytosol) contains: - Enzymes- needed for light independent stage of photosynthesis - Ribosomes-(70S) - DNA- sing. Circ. Chrom. - *Starch grains* (energy store)	- *Grana:* hold and display chlorophyll for max. light absorp. to produce ATP. - *Stroma:* contains the approp. Enzymes and energy (ATP from grana) req. to produce glucose and oxygen from CO_2 and H_2O.
Vesicle (plant and animal cells)	- *Very small mem. bound sacs* - Formed when sections of ER & Golgi bud off, or when the cell mem. invaginates during endocytosis. - Can fuse tog. To form vacuoles.	- **Transport of substances in/out of cells** - (out) e.g. secretory vesicles used in exocytosis. - (in) e.g. pinocytic and phagocytic vesicles are used in endocytosis.
Vacuole (plant and animal cells)	- *Membrane bound sacs* (larger than vesicles) - Generally, very small in animal cells but larger in plant cells. - Formed by fusion of many vesicles.	- **Storage and packaging of substances (Inc. wastes) for export, isolation of toxins.**
Sap Vacuole (plant cells)	- *Very large mem. bound sac* - 30-80% of cells volume - generally central in cytoplasm - usually contains *cell sap*- mainly made of water, glucose, proteins, ions.	- **Maintains turgidity of plant cells and acts as a reservoir of water & ions.** - *Turgidity:* allows soft plant tissues to stand erect in the sun for photosynthesis - *Cytoplasm:* pushed against the cell membrane increases exch. Eff. (O_2/CO_2) - H^+ *ions* can be actively transported in/out of sap vacuole to *reg. the pH of the cytoplasm.*
Endoplasmic Reticulum (ER) (rough) (plant and animal)	- Flattened membrane lined, and interconnected cavities continuous with the *nuclear membrane* - Encrusted with *ribosomes* - Rough ER also connects to smooth ER	- **Protein synthesis, processing & transport** - Ribosomes attached to rough ER translate polypeptides that: - Enter rough ER lumen for further processing (take on final 3D shape) - Travel via vesicles (budding off the rough ER) to the Golgi - Mostly destined for export (e.g. enzyme, hormone secretions) *Cells that produce lots of protein e.g. pancreas- insulin will have more rough ER*
Endoplasmic Reticulum (ER) (smooth) (plant and animal)	- Generally tubular and interconnected membrane lined cavities, continuous with rough ER. - NO RIBOSOME ATATCHED - Enzyme req. for lipid and steroid synthesis are found in smooth ER lumen	- **Synthesis and transport of lipids including phospholipids and steroids** (steroids= lipid based hormones e.g. oestrogen and testosterone.) - Lipids synthesized in the smooth ER: - May be used to create more ER or plasma membrane - Will travel to be used within the cell or may be secreted. *Cells that secrete lipids/steroids have lots of smooth ER (e.g. waxy leaf cuticle cells)
Golgi body/Apparatus/Complex (plant and animals cells)	- Composed of flattened membrane bound cavities or *cisternae* (cisterna-sing) in stacks - Enzymes in each cisterna differ.	- **Modification & packaging of proteins and lipids for export or use within the cell. (also polysaccharides and lysosomes- secretory vesicles)** - Proteins and lipids enter Golgi as vesicles-> fuse with it - Pass from one cisterna to the next- undergoing additional processing at each stage including:

		- Shape modification (prot.) - Addition of polysaccharides to form glycolipids/glycoproteins - Modified prot. and lip. exit the Golgi via vesicles that bud off and travel to: - Form part of the cell membrane - Secretion from the cell via secretory vesicles budding off the Golgi which then fuse with cell membrane. - Move to other parts of cell - As lysosomes in the cell

NOTE: DNA can be found outside the nucleus e.g. mtDNA (an and plants) and cpDNA (in plants).
NOTE: Origin of mitochondria? Dbbl. Membrane, prokaryotic ribosomes, prokaryotic DNA, division by binary fission, suggest origin as a free living prokaryote (theory of embosymbiosis).
NOTE: Origin of chloroplasts? (exact same as above.Ibid.)

C2.3: Understand why even the simplest cell has several hundred genes.
*Because Cells need many 100's of polypeptides and RNA's and genes code for polypeptides and RNA molecule. *
Different polypeptides/RNA molecules for:
- cell structure
- enzyme- catalyse synthetic reactions
- membrane proteins
- detect chemical signals
- cellular recognitions
- ribosomes
- tRNA
- Proteins synthesized by cells catalyse cellular chemical reactions and form cell structures
- At least 100's of different proteins is needed, so at least 100's of different genes are needed.

C3: All cells have a lipoprotein cell membrane. In eukaryotic cells it is attached to the cytoskeleton.
- **Prokaryotic cells:** peptide-glycan cell wall. Inside the cell wall is a lipoprotein cell membrane.
- **Plant cells:** cellulose cell wall- inside this is a lipoprotein cell membrane.
- **Animal cells:** lipoprotein cell membrane

C3.1: Describe the structure and function of the cell membrane in terms of the fluid mosaic model.
Lipo-protein fluid mosaic composed of:
- **Phospholipid bilayer:** layer uniform, made of repeating phospholipid molecules. (hydrophilic out, hydrophobic in)
- **Cholesterol molecules within the bilayer:** help membrane remain fluid at low temperatures.
- **Proteins (some which pass all the way through):** highly variable among cell types. (for active transport, facilitated diffusion, hormone recognition, contact inhibition, cellular recognition)- explains selective permeability and responses to different hormone stimuli.
- Carbohydrate molecules (glycoproteins, glycolipids)

Mosaic= made up of different parts that interlock to some lipids & proteins
Fluid= changeable in shape and composition with proteins 'floating' among the lipids and the membrane is able to break and to then rejoin.

Why are cell membranes semi-permeable?
- **Lipid bi-layer allows** passage of small *uncharged* molecules like- O_2 CO_2 N_2 – some water and lipid soluble molecules (e.g. glycerol and alcohol)
- **Proteins in the membrane can select and allow the passage of** glucose, amino acids, and certain ions

NOTE Different cells have different requirements and so have different membrane transport proteins.

Membrane & Cytoskeleton relationship:
Functions: (cytoskeleton)
- Provides scaffolding for **membrane proteins** to **anchor** to and limits how far they extend within bi-layer.
- Allows formation of **cilia, flagella- microtubule** based extensions covered by the cell membrane.
- Can cause cell to have **particular shape** (e.g. RBC, microvilli)
- Can cause cells to **change shape** (e.g. during endocytosis)

Functions: (membrane)
- **Encloses** cell's contents- prevent entry/exit of unwanted materials, exist as sep. entity
- **Semi-permeable**- selective transport, can maintain optimal nutrient levels, pH, and low levels of waste (sec)
- Allows for **communication** between cells- contact inhibition, hormones, self/non-self recognition
- Assists in some **metabolic reactions**- enzymes embedded in mem.
- Assists in **cell division** with cytoskeleton- ability to break and reform is crucial for **cytokinesis- invagination.**

C3.2: Describe the role of the membrane in endocytosis and exocytosis.
(taking in many large molecules at once)
Define Endocytosis: (cell taking in substances in bulk)
- Phagocytosis (cell eating)- taking in of solid- inc. macromolecules, cells, cell fragments (occurs only in amobae and specialized cells, e.g. WBC)
- Pinocytosis (cell drinking)- taking in of liquids-inc. water and oil droplets. (occurs in most an. cells)

Plasma membrane invaginates to surround material, seals off to form a vesicle. If mat. Is large, it's digested by enzymes after fusion with a lysosome.
Define Exocytosis: (cell eliminating substances in bulk)
Materials to be transported out of cell are enclosed in a **secretory vesicle** (surround by membrane- synth in golgi), vesicles will fuse with the cell membrane and the contents leave.

C3.3: State three functions of the cytoskeleton

3 Functions:
- Anchoring organelles and membrane proteins
- Changing cell shape e.g. amoeboid movement, invagination, the formation of microvilli, maintaining shape of cells like RBC.
- Cytoplasmic streaming that can be seen in cells
- Formation of spindle fibres, cilia, flagella
- Allows movement of organelles in cell (e.g. via motor proteins)

3 components of the cytoskeleton:
- Microfilaments
- Intermediate filaments
- Microtubules

C4: The intracellular environment of cells differs in composition from the extracellular environment of cells.

C4.1: Know that the proportions of chemicals in the intracellular environment of cells are different from those in the extracellular environment of cells.

Intracellular Environment: (more regulated)
- Rich in organic molecules (e.g. carbs, lipids, prot.)
- Rich in water and necessary ions
- Fairly stable in composition and pH
- Cells accumulate (by active transport) and synthesize molecules not made outside of cells.

Extracellular Environment: (less regulated)
- Poor in organic molecules (usually)
- Highly variable in composition
- pH depends on weather
- external environment depends on local conditions

Elemental Composition of intracellular vs. extracellular environments	
Needs to know stats???	

C4.2: Understand why the internal composition of the cell is regulated.

Why?
Enzymes control cell reactions- function eff. need:
- pH
- co-enzymes
- absence of inhibitors

For cells to operate optimally:
- to gain energy rich organic molecules
- (if aerobic) to gain oxygen cellular resp.
- to gain substrates needed to form all of the organic mol. That make them up
- to eliminate toxic wastes (carbon dioxide and urea)
- to maintain water balance
- Regulation of cell, largely achieved by the activities of the cell membrane
- As environmental variability inc. -> the membrane's role in maintaining constancy inc.

How?
- If substrates are in short supply- inc. active transport into cell
- If conc. Of wastes are too high -> inc. active transport out of cell
- If pH is too low -> active transport of H+ out of cell.

C4.3: Explain how selective exchange occurs at the cell membrane

Cell membrane: Lipo-protein fluid mosaic composed of a phospholipid bilayer with a variety of embedded and transmembrane proteins with attached polysaccharides.

Structures within the plasma membrane involved in the transport of molecules: phospholipid bi-layer, channel proteins, carrier proteins, carrier proteins or pumps (transport proteins), receptor molecule, embedded enzymes, glycoprotein/glycolipid (cell recognition, binds cells together).

NOTE: Different cells have different needs and so their membranes differ. All the phospholipid molecules are identical; the variable parts are the proteins (and polysaccharides). Different cell types in an individual have different membrane proteins due to cell differentiation. Cell membranes in different organisms differ due to genetic differences.

ROLE OF MEMBRANE IN SELECTIVE EXCHANGE:				
Structure	Permeable to	Mechanism of transport	Active/passive	selectivity
Phospholipid bilayer	Small mol. That are uncharged and/or lipid sol. (e.g. 02,	Diffusion and osmosis	passive	Selection due to small molecular size,

	co2, H20, urea, alcohol, glycerol			sol. In lipids and being uncharged.
Transport Proteins	Small water sol. Mol., ions, (e.g. H^+, Na^+, K^+, glucose, a.a.	Facilitated diffusion/ active transport	Passive/active	Small molecular size, charge, solubility in water, ability to bind with other transport proteins.
Membrane itself	Macromolecules (liquid/solid), cell fragments, whole cells. (Agar.io)	Endocytosis (pino/phago) Exocytosis	Active	Relatively unselective (any macromolecules, liquid/solid)

NOTE: water channel proteins called Aquaporins.

C5: Movement of substances across membranes may be passive or require the expenditure of energy.
NOTE: Movement of particles is known as Brownian motion. Heat energy provides the energy for this motion. It explains:
- Why substances diffuse
- Why the rate of chemical reactions inc. with higher temp. (inc. mol. coll)

C5.1: Understand that the movement of substances by diffusion and osmosis is passive.
Passive movement across cell membranes occurs when:
- The cell expands no energy in the process
- Substances move with the concentration gradient.

Concentration gradient diagram...

- Passive process involves only Brownian motion, with heat energy supplying the energy for movement. They include, diffusion, facilitated diffusion and osmosis.

Define Diffusion: The net movement of molecules from a region of higher concentration to a region of lower concentration until equilibrium is reached. (this occurs as mol. move according to Brownian motion and straight lines due to heat energy in the environment.
Diffusion occurs within cells, and across the cell membrane at:
- Phospholipid bilayer
- Transport proteins involved in facilitated diffusion.

Efficiency of diffusion: as SA:VOL inc -> Efficiency of diff. inc.
Rate of diffusion: (per micron of surface), not affected by SA: VOL:
- Temperature
- Distance travelled
- Concentration difference/gradient
- Molecular Weight
- Resistance to diffusion

Facilitated Diffusion: Diffusion which is facilitated (assisted by certain membrane proteins. (transport proteins)(relies on conc. grad. & Brownian motion) (some are gated)

Osmosis:
Define Semi-permeable: cell membranes are not equally permeable to all substances. Some substances pass through membranes more easily than others.
Hypertonic: When two solutions are separated by a semi-permeable membrane, the one with the most dissolved solute (and hence the lowest water conc.) is said to be hypertonic to the other.
Hypotonic: When two solutions are separated by a semi-permeable membrane, the one with the least dissolved solute (and hence the highest water conc.) is said to be hypotonic to the other.
Isotonic: When two solutions are separated by a semi-permeable membrane, and their conc. of dissolved solute (and hence their water conc.) are equal, and are said to be isotonic with each other.
Osmotic Pressure: When two solutions are separated by a semi-permeable membrane, the one with the most dissolved solute (and hence the lowest water conc.) is said to exert osmotic pressure on the other (it will gain water from the other)

Osmosis: The diffusion of water molecules across a semi-permeable membrane.
"The movement of water molecules, across a semi-permeable membrane from a region of higher water concentration to a region of lower water concentration."

Examples of Osmosis include:
- Water movement into and out of cells
- Absorption of water in the bloodstream

	Hypotonic	**Isotonic**	**Hypertonic**
Animal Cells	Lysed	Normal	Shriveled
Plant Cells (cell wall prevents bursting)	Turgid (normal)	Flaccid	Plasmolysis

Case: Paramecium (ia-plural)

Unicellular organism that contains specialized vacuoles (contractile vacuoles) that absorb excess water that enters the cell and squirt it out maintaining water balance. Freshwater Paramecia tend to gain water by osmosis and without a mechanism for the removal of excess water, they would swell and burst. As seawater paramecia are isotonic to their environment- they don't need these vacuoles.

Examples of Passive and Active Transport:
- Water going from soil into plant root- osmosis
- Mineral ions going from the soil into a plant root-active transport
- Epithelial cells absorbing small droplets of lipid from the gut- endocytosis (pinocytosis)
- A white blood cell engulfing a bacterium-endocytosis (phagocytosis)
- Oxygen diffuses from lungs into the blood-(diffusion)

C5.2: Understand that the active transport of substances against the concentration gradient requires energy. This energy is supplied by ATP.

Active Transport (active process): The movement of substances against the concentration gradient, requiring energy. (from lower concentrations to higher concentrations). E.g. a molecule to be transported may enter a *carrier protein*, 'dock' on to a complementary binding site and it would then change shape caused by a burst in energy from the breakdown of ATP- pushing the molecule to the other side of the membrane.

C6: All cell require energy.

NOTE: Energy can be gained and transformed but is ultimately LOST as heat energy.

Forms:
- Light
- Kinetic
- Potential (e.g. chemical energy stored in chemical bonds of energy rich organic molecules)
- Heat
- Electrical

NOTE:

Anabolic reactions: (energy needed to form chem. bonds)
- Photosynthesis- light energy used to form chemical bonds that hold elements in glucose together.
- Protein synthesis
- Synthesis of ATP (ADP + P_i + E -> ATP)

Catabolic reactions: (energy released when chem. bonds holding large mol. tog. are broken.)
- Cellular respiration- when glucose is broken down to release energy.
- Breakdown of ATP (ATP -> ADP + P_i + E)
- Oxygen diffuses from lungs into the blood-(diffusion)

C6.1: Know that all living cells use energy for movement, synthesis, and the maintenance of a stable intracellular environment.

Cells use energy:

Energy is used for:	**Examples:**
Movement (kinetic) Organisms convert chemical energy to kinetic energy (e.g. use kJ to run- cell resp.).	- **Of the whole organism** (hunting/evading predators) - **Within organisms** (blood flow in animals) - **Of cells** (e.g. movement of amoebae and white blood cells via contractions/relaxations of the cytoskeleton) - **Within cells** (cytoplasmic streaming in plant cells, movement of chrom. in cell division
Synthesis (chemical energy) Synthesis reactions are anabolic- energy is needed to form bonds.	- **Synthesis of complex organic molecules** (macromolecules) from their monomers - **ATP Synthesis** occurs when energy is avail. in Photosynth. & cell resp.
Maintenance of a stable environment (maintaining optimal conditions in cells requires active processes which use energy)	- **Active Transport** of glucose and amino acids (against a conc. grad) - **Active Transport of req. ions** (inc. H^+ ions to maintain an approp. pH req. energy) - **Heat Production** esp. in warm blooded org. req. energy from cell resp.

NOTE: if diffusion was the only mechanism for maintenance in and out of cells- would always be equilibrium.

C7: Energy is obtained in physical or chemical form from the cell's environment, and energy transformations occur within the cell.

C7.1: Know that the sun is the main source of energy for life.

Autotrophs: (self-feeders)

Organisms that produce energy rich organic molecules like glucose from simple inorganic molecules (carbon dioxide and water). Autotrophs can be subdivided into 2 categories:

Chemo-autotrophs: (EXCEPTION)

Those that access energy from chemical reactions involving inorganic molecules to synthesise organic molecules like glucose. E.g. high temperature tolerant bacteria living around submarine lava flows (in darkness).

Photo-autotrophs:

Those that access energy from sunlight e.g. photosynthetic bacteria, algae and green plants in water and on land. Use light energy to synthesise organic molecules like glucose by photosynthesis.

NOTE: Most autotrophs are photo-trophs so the sun is the major source of energy for life on earth.

C7.2: Understand that light energy can be used by some cells in photosynthesis

Photo-autotrophs use light energy in photosynthesis:

- Sunlight provides the energy needed for the synthesis of (energy rich) organic molecules (light energy is converted to chemical energy stored in bonds in glucose.)
- Chlorophyll is the green pigment that acts as an energy converter (light energy -> chemical energy)

C7.3: Know that some molecules contain energy that can be released when chemical bonds are broken and new bonds are formed.

Organic Molecules: (contain potential energy)

All organic mol. are energy rich with energy stored in the chemical bonds that hold the organic mol. tog. Glucose is a good example of an energy rich mol. (e.g. can be measured by heat energy in a calorimeter)

Breaking down organic mol. releases their stored energy:

Organic mol. are broken down in cell resp. to release energy and is stored in them so that cells can use that energy.

Complementarily of photosynthesis and aerobic cellular respiration:

Photosynthesis: anabolic reaction. Uses energy from sunlight to produce energy rich org. mol (glucose) which store energy.

Aerobic Cellular Respiration: catabolic reaction. Breaks down energy rich glucose to release the stored energy for use by cells. Some of the energy released is lost as heat.

THEREFORE: The substrates of photosynthesis are the products of aerobic cellular respiration and vice versa.

C7.4: Explain how the ATP/ADP conversion provides energy for use in cells.

ATP (Adenosine Tri-phosphate): Is a modified RNA nucleotide which has 3 phosphate groups attached instead of one.

Functions:

-acts as a short-term energy storage compound.
-It is synthesised and stores energy when there is energy available
-broken down (hydrolyzed) to release energy when energy is needed

ATP: In organic mol. energy stored in chem. bonds- in ATP that holds the last phosphate group in place is a weak (high energy) bond and is easily broken- releasing energy when it does. When the bond holding the 3rd phosphate group is broken, ATP releases energy for use by the cell.

ATP -> ADP + P_i + Energy (breakdown)- for synthesis of org. mol. (DNA, prot., glucose in photo.), or movement of mat., nerve impulse transmission.

When energy is needed again, ATP can be re-synthesised.

ADP + P_i + Energy -> ATP (synthesis)
*Energy comes from cell. Resp.
*light energy is converted to chem. energy in the light dependent stage of photosynthesis.

C7.5: Explain why energy pathways involve many small, regulated steps.

Organic mol. provides the mat. that cells need.

When burned in air**,** org. mol. release their energy explosively (in light and heat forms)
e.g. glucose burned in air
Unsuitable for cells.
Results in- gradual release of energy- some of which can be used in the form ATP and some which is lost.
Cells having control over the rate of energy release- maximizing ATP synthesis and minimising overheating.

C7.6: Describe how a metabolic pathway is controlled by a specific enzyme at each step.

Chemical reactions: the formation of a final product occurs in a series of small steps in which intermediate compounds are formed.

Why? because each enzyme is specific for its substrate, and as each intermediate compound is different, a different enzyme is needed for each step in the overall reaction.

NOTE: The absence of any enzymes will halt the overall reaction at that point.
e.g. A mutation in the gene coding for a particular enzyme may result in the absence of that enzyme. This is the basis for some genetic diseases. (like PKU)

C7.7: Understand that each step produces intermediate compounds and loses some energy as heat.

Intermediate compounds: May result due to the many steps involved. These can be used in the production of the final product OR can be used in alternate reactions. This gives cells enormous flexibility.

IN THE PROCESS OF REAC. SOME **E** IS LOST AS HEAT.

Catabolic reactions such as cell. resp. occurs in small steps to:

- increase the cells efficiency in synthesizing ATP
- Allows for manageable dissipation of heat- stop cells overheating (& exploding)

Small Regulated Steps give:
- Control over rate of energy release- maximizing ATP synth. & min. overheating
- More options through use of intermediate compounds.

C8: Cells arise from pre-existing cells, and cell division leads to an increase in cell number.

C8.1: Explain why the amount of DNA in a cell doubles before cell division.
- From the beginning of life- cells have undergone cell division to produce daughter cells which become the next generation.

What does DNA do before cell division? DNA doubles before cell division in both prokaryotic and eukaryotic cells. This is so the daughter cells produced may receive the same amount of DNA as the original parent cell. (so there is no reduction in the amount of DNA) (retains same diploid number). **This means that**, only mutation can chance the genetic material passed onto the daughter cells.

Somatic cell division in prokaryotes is known as binary fission (very efficient can be occur up to once every 20 mins-bacterial populations grow exponentially-food hygiene). In eukaryotes it is known as mitosis.

C8.2: Describe how prokaryotic cells divide by binary fission
- Singular circ. Chrom. attach to the cell mem
- DNA replicates and remains attached to cell mem.
- Cell grows- causes 2 chrom. (sister chromatids) to opp. Sides of cell
- Cell mem. And cell wall grow inwards (septum formation) and divide (cytokinesis) into 2 sep. daughter cells
- **DNA rep. occurs before cell div- each daughter cell is genetically identical to the parent cell. (they are clones)
- (plasmids also replicate and pass on to daughter cells)

C8.3: Illustrate the process of mitosis in eukaryotic cells.

Background:
- Haploid number (n)- of types of chrom. there are in euk. Cells (in humans=23)
- Diploid number (2n)- number of chrom. found in somatic (body cells) of euk. (this is dbll. The haploid number)
- The 2 types of chrom. are called homologous- and in sexual species this means one is maternal and the other, paternal.
- **note: the ends of chrom. are known as telomeres.

What is mitosis? A form of cell division that occurs in eukaryotic cells for:
- Growth (of multicellular organisms)
- Repair (of multicellular organisms)
- Reproduction (of unicellular organisms & some multicellular orgs.)

PICTURE/TABLE THING

Summary of the key events in the cell cycle and Mitosis that are essential to the production of gen. ident. Daughter cells:
- Exact DNA rep.
- Chromosomes line up singly along the metaphase plate
- One of each sister chromatids moves to opposite poles

C8.4: Know that the products of mitotic division or binary fission have the same number and type of chromosomes as the parent.

Mitosis and **binary fission** both result in genetically identical daughter cells (they all have the same number and type of chromosomes as the parent cell).

How?

Binary Fission: DNA rep. (of circ. chrom.) to form 2 genetically identical circular chrom.

Mitosis: DNA rep. occurs in Interphase to form 2 genetically identical sister chromatids.

C9: Division may be regulated by internal and external factors

Some cells won't divide--

Cell Differentiation:
- Different cell types are formed as different cells use different subsets of the genes available and so produce different proteins which leads to different structural and biochemical outcomes.
- Differentiated cells tend to stop dividing (said to be G_0 in the cell cycle)
- Undifferentiated cells (stem cells) continue to undergo cell division and some of their daughter cells then differentiate to form the replacement (e.g. new skin cells)
- (embryonic stem cells can develop into aaany type of body cell)
- Totipotent (all) pluripotent (many)
- Harvesting stem cells from embryos destroys (kills) the embryos (is it ok to kill to heal?)

Contact Inhibition:
- This tends to stop cell division because either sides of the cells make contact (touch) and this halts mitosis. (sometimes called density dependence)

Insufficient Nutrient Availability: tends to stop cell division (nutrient dependence for cell division)

Cell Cycle: includes...
- Growth (I)
- Differentiation and function (I)
- Cell division (PMAT)

DIAGRAM (indicate where the checkpoints are on the cell cycle)

G1: (1st Growth phase) newly formed cell grows, produces more organelles and accumulates energy reserves.
S: (synthesis phase) DNA rep. occurs
G2: (2nd Growth phase) more organelles are produced, cell functions are performed and energy reserves increase.
Mitosis: mitosis occurs followed by cytokinesis of the separation of the cytoplasm.
Stem cell (remains in cycle)
Differentiated cell (doesn't)

Why must cell division be regulated?
- In Unicellular organisms, uncontrolled cell division would result in very small cells with insufficient or accumulated energy reserves to produce viable and functional daughter cells. (likely result in cell death)
- Multicellular organisms, uncontrolled cell division would similarly result in small relatively unviable cells and abnormal growth (e.g. tumors, cancers)

C9.1: Know that the cell produces gene products that regulate the cell cycle.
Proteins=gene products
Gene products regulate the cell cycle: the regulation or control of a cell cycle is achieved via a number of checks which occur at restriction checkpoints. Unless certain criteria are satisfied, the cell will not proceed to the next part of the cell cycle. The checkpoints are controlled by proteins (gene products) which signal cells and bring about changes in cell behaviour in cell division.

Checkpoint		*Checked for*	*Chemical control*
Restriction checkpoint #1 **GF + relay proteins -> DNA rep.**	G1 checkpoint	Sufficient energy reserves and growth	A number of growth factor proteins **(GF's)** (transported in sap (plants) or blood (animals). They affect target tissues that have mature cells with appropriate membrane protein receptor molecules (RM). When specific GF protein binds to a RM, **relay proteins** in the cytoplasm stimulate DNA rep. in the nucleus and the S phase begins.
Restriction checkpoint #2 **Cyclin + Cdk -> MPF**	G2 checkpoint	Successful DNA replication	Once DNA has replicated-**Cyclin** with the aid of **enzymes** such as Cyclin dependent kinases **(Cdk's),** forms mitosis promoting factor (MPF). **MPF** initiates prophase (starts mitosis) chkpt. #2 is passed.
Restriction checkpoint #3 Cyclin↓ -> MPF↓	M checkpoint	Successful attachment of chromosomes to spindle fibres	Once the chrom. attached to the spindle **singly at metaphase,** Cyclin is progressively broken down in the cell which leads to a fall in the concentration of MPF. Lowered levels of MPF bring out anaphase ckpt. #3 is passed.

C9.2: Understand that hormones may regulate cell division.

Growth factor proteins (GF's)- proteins that act like hormones (around 50 types). produced by specialized 'signal' cells.

Growth inhibiting factors- group of proteins stop cell division. Can be involved in DNA damage ckpts. Act by inhibiting cdk and so stopping the cell cycle. Genetically abnormal cells are inhibited from going on with cell division by growth inhibiting factors then die through apoptosis (cell suicide).

Examples:

Erythropoietin (EPO)- stimulates the production of RBC (in sport)

Interleukin 2- stimulates the production of WBC and so boosts immune function

FSH (Follicle stimulating hormone)- stimulates the development of ovarian follicles in females and sperm production in males.

Auxins-in plants stimulate plant cell division and hence plant growth. can be used in herbicides like glyphosphate roundup where over-rapid plant growth leads to plant death.

C9.3: Understand that carcinogens upset the normal controls of cell division by causing mutations.

Carcinogen: any factor that can transform a normal cell into a cancer cell. e.g. chemicals, high energy radiation.

Carcinogens/Mutagens: creosote, UV, X-rays

Uncontrolled cell division results in the formation of a tumour- 2 main types:

Benign- tumours don't spread and can generally be removed fairly easily (surgically)- usually not called cancers.

Malignant- tumours spread to other parts of the body by invading surrounding tissues and spreading via the lymphatic system and bloodstream. (Cancers) dangerous because they occur in many locations and are hard to remove.

Cancer: the uncontrolled growth and spread of cells. Occurs because normal cell regulation over cell division has been lost. Genes controlling cell division have undergone mutation.

How do normal cells become cancerous?

Specific genes control or regulate cell division by coding for proteins that:

- allow cells to pass restriction chkpts
- *or*
- inhibit cell division

Mutant versions of these genes (oncogenes-cancer genes) may result in a cell losing control over cell division by:

- coding for excessive amounts of the growth factor proteins
- *or*
- not coding for proteins that inhibit cell division
- *or*
- those that bring about apoptosis of genetically abnormal cells

Because there are many proteins that regulate cell division, normally takes between 4-7 mutations before a cell becomes cancerous.

Many cancers increase in frequency with age because there is more time for mutations to occur.

C10: Existing cells are the products of evolution

C10.1: Understand that there is evidence that prokaryotic cells existed before eukaryotic cells

Fossil record order of evolution:

i) **Anaerobic bacteria:(prokaryotic)** Early earth did not contain oxygen and all life was anaerobic.

ii) **Photosynthetic bacteria:(prokaryotic)** used the suns energy to photosynthesize. The oxygen produced began to accumulate in the atmosphere. As a result, many species of prokaryote died out as (toxic) oxygen levels increased.

iii) **Aerobic bacteria: (prokaryotic)** able to use toxic oxygen in energy yielding reactions (ATP) and water.

Two keys to their success:

- they oxygen is used up in aerobic cell resp. (so reducing its toxic effects)
- more energy is yielded in aerobic cell. resp. (advantage)

∴ organisms that thrive in an oxygen containing atmosphere were now 'best suited to the environment' so natural selection favored them

iv) **Cells engulf other cells: (eukaryotic cells)** but don't digest them e.g. prokaryote engulfing another prokaryote or pre-eukaryote engulfing a prokaryote.

C10.2: Explain how the ancestry of most existing eukaryotic cells probably involved endosymbiotic events.

Evolution of Eukaryotes:

Endosymbiosis- Cells are engulfed, but not digested. Cells live together in a mutually benefiting relationship.

The Endosymbiotic Theory= first proposed by Lynn Margulis in 1967.

Hypothesis:

- mitochondria are the results of endocytosis of aerobic bacteria.
- chloroplasts are the result of endocytosis of photosynthetic bacteria.
- in both cases endocytosis was by large anaerobic bacteria (could have been prokaryotic or pre-eukaryotic)
- this arrangement became a mutually beneficial relationship for both cells (endosymbiosis) e.g. the aerobic bacterium use up the toxic oxygen for the anaerobic bacterium and the anaerobic bacterium would have ingested food and protected the aerobic "symbiot".

NOTE: plant cells have chloroplasts and mitochondria, while animal cells only have mitochondria.

Evidence that supports endosymbiosis: (3 points)- why it is the most plausible explanation.

1. Similarities between prokaryotic cells and the organelles of eukaryotic cells. - suggesting origin as a phagocytic vesicle.

Feature	Prokaryotes	Eukaryotes	Mitochondria of eukaryotes	Chloroplasts of photosynthetic eukaryotes
DNA	1 sing. circ. chrom.	Lots linear chrom.	1 sing circ. chrom	1 sing. circ. chrom
DNA	No introns	introns	No introns	No introns
Replication	Binary fission	mitosis	Binary fission	Binary fission
Ribosomes	70S	80S	70S	70S
Size (Approx.)	1-10 microns	10-100 microns	1-10 microns	1-10 microns

2. Mitochondria and chloroplasts divide independently of the cell they live in. (can't any longer live outside their host cell). Division by binary fission is similar to that of prokaryotes. - suggesting origin as a phagocytic vesicle.
3. Both mitochondria and chloroplasts are surrounded by a dbll. membrane. Inner mem. resembles prokaryotic mem., while outer mem. is more eukaryotic in nature. - suggesting origin as a phagocytic vesicle.

NOTE: Anaerobic bacteria still exist today- e.g. bacteria deep within the intestines in the digestive system.
NOTE: Amitochondrial eukaryotes- are the exception to the endosymbiosis in the evolution of eukaryotic cells. are anaerobic and have no mitochondria.

C11: Human beings culture cells for a variety of purposes.
Example 1: Yeast: Unicellular fungi occurs naturally in the environment. e.g. beer, wine, bread, vegemite.
Example 2: Bacteria: occur naturally- 2 uses:

- particular bacteria when added to milk make yoghurt, cheese
- others are used in sewage treatment plants to breakdown human waste

C11.1: Understand techniques of cell culture, and discuss some contemporary examples of their use.
Cell cultures can be grown using animal cells, plant cells, yeasts and bacteria.

1. cells are obtained
2. cells are placed in a nutrient medium (solid nutrient agar or liquid nutrient broth)
3. cells are kept in ideal conditions (temp, pH, light)
4. Existing cell cultures can be used to produce the next generation of cell cultures
5. Cells are kept free of pathogens (sterile medium)- no disease causing bacteria

Animal cell cultures: (inc. human)

- grown in flat flasks
- flasks contain cells and a nutrient medium maintained at 37 degrees Celsius
- cells divide by mitosis
- used for research and/or begin the next generation of cells

Hayflick Limit: most cells will only continue to grow for between 30-40 generations. (exception- HeLa cells)
Examples:

- cultured for research purposes- search for cancer cures, and for product and drug testing (minimising testing on animals)
- host cells for viruses for the production of vaccines – viruses cannot be grown independently as they need host cells for their reproduction.
- *Stem cells:* used to find new cell therapies allow us to re-grow damaged heart muscle, mend severed spinal cords and repair damaged brains. (immunosuppressive drugs)
- *ova and sperm:* used in IVF. (production and culturing of embryos for implantation into surrogate mothers or used a source of totipotent embryonic stem cells for stem cell therapies- but die when some are harvested)- legal rights of embryos.
- *3 parent offspring*- have both partner's nuclear DNA placed into a donor ovum (with normal mitochondrial DNA) with its nuclear DNA removed. The offspring has DNA from its mother, father and ovum donor.- what legal rights do all parents have.

Plant cell cultures:

- grown on agar in petri dishes or test tubes
- optimum conditions (auxins- GF prot. that promote cell division), lights, temp.
- cells divide by mitosis and differentiate so whole plants with roots, stems and leaves are formed.
- plantlets are then separated from each other and grown on for research or used in the horticulture industry

Examples:

- plants cultured to create clones of a desirable plant variety- single cell can give rise to a whole plant. Can be beneficial but the production of clones reduces genetic variability, negatively impacting on evolutionary adaptability. used for research, agriculture, horticulture. – can we create synthetic organisms?- clones effect genetic variability.

Bacterial cell cultures:

- grown in solid (agar) or liquid (broth) nutrient medium
- optimum conditions for growth (temp, pH)
- Bacteria divide very rapidly and cheaply
- Different species of bacteria on one agar plate- usually the desired strain/type is isolated and grown as a pure culture e.g. rDNA bacteria that produce human insulin.

Examples:
- Recombinant bacteria- insulin, human growth hormone, manufacture vaccine
- "oil-eating" bacteria- grown for their potential usefulness in cleaning up oil spills so that environmental damage is minimized. (not successful yet)

C12: Chemicals can interfere with cell metabolism.
What are chemicals? A form of matter that has constant chemical composition and characteristic properties. It cannot be separated into components by physical separation methods. (without breaking chem. bonds) e.g. pure water.
C12.1: Discuss possible benefits and/or harmful effects of chemicals that human beings use.
Benefits:
Medicinal drugs: (aim to improve physical and mental health)
- Antibiotics-chemicals produced by organisms that kill bacteria or stop their reproduction. e.g. penicillin
- Pain killers-are used to minimise pain e.g. aspirin, paracetamol, morphine
- Anti-depressants- compounds that help reduce feelings of depression

Fuels:
- wood, coal, oil, petrol- burned to release their stored chemical energy for heating, cooking, transport and generation of electricity

Fertilizers:
- provide plants with necessary elements for healthy plant growth. increase crop growth and hence increase agricultural yield.

Harmful effects:
Medicinal drugs:
- Some prescription drugs are abused with deadly consequences
- Thalidomide- anti-morning sickness drug. many women gave birth to children with shortened or missing limbs.

Recreational drugs:
- Alcohol- addictive- cancer, brain damage, foetal alcohol syndrome
- Nicotine- cancer
- Caffeine- addictive stimulant

Fuels:
- when burned give of carbon dioxide/monoxide which contribute to the enhanced greenhouse effect- likely to contribute to global warming. – effect ecosystems- extinction.

Fertilizers:
- problems if the fertiliser run off into streams and bodies of water where increase the growth of algae and blue-green bacteria- can lead to eutrophication. (excessive richness of nutrients)- can poison native Australian native species.

Formaldehyde:
- used in woodworking and cabinet-making industries- in the glues that bond particle board together. – carcinogen. wood veneer and plastic laminate.

Oestrogen mimicking chemicals:
- BPA- used to manufacture hard clear plastics- used for bottled water and lining for canned foods and drinks.- can negatively impact fertility in males and females.