

IB
Biology Notes

NB the 'yellow book' I make constant reference to is "Biology: principles and processes- Roberts, Reiss and Monger"
0-17-544000-X

Topic 1 - Cells

1.1 Cell Theory

1.1.1 See syllabus

1.1.2 Light microscopes- light rays from a source beneath the stage are transmitted through the two glass lenses in series, the objective and the ocular (eyepiece) lenses to provide magnifications.

Advantages of light microscopes:

- When using electron microscopes, the material viewed must be dead and mounted on a vacuum. This can cause some delicate structures to be distorted, causing artefacts (images which aren't real).
- Light microscopes can provide magnifications of between 400 –1500 times. Magnification is when an object is made to appear larger than its actual size by the use of a lens.
- Although there is a limit to the amount of detail which can be seen because light microscopes have a resolving power of 0.2 μm (resolving power/resolution is the minimum distance between 2 points for them to be perceived as 2 separate points rather than a single fused image). Higher magnifications of up to 2000 times can be achieved using a special objective lens with a fluid situated between the lens and the objective.

1.1.3 Electron microscopes- Use an electron beam instead of light, and electromagnets instead of lenses. Electrons are recorded on a photographic plate, which forms an image on screen.

Advantages of electron microscopes:

- Electron microscopes are capable of magnifying objects much more than light microscopes without a loss of clarity because modern electron microscopes have resolving powers up to 1000 times greater than light microscopes- they can give pictures which are magnifications up to 50 000 times and are still clear.
- Various forms of microscopy, such as phase-contrast microscopy and dark-ground illumination can be used in addition to electron microscopes to enable transparent objects to be seen, and are also ideal for studying unstained living cells.

1.1.4 Organelle- a structure inside the cell which carried out a particular function

1.1.5.

| | |
|--------------------------|-------------------|
| Molecules- | 1 nm |
| Cell membrane thickness- | 10 nm |
| Viruses- | 10 nm |
| Bacteria- | 1 μ m |
| Organelles- | up to 10 μ m |
| Cells- | up to 100 μ m |

1.1.6 Mathematical rule- as an object increases in volume, the ratio of its total surface area to its volume decreases, i.e. the larger an object, the smaller its surface-volume ratio. The rate of metabolism of a cell is a function of its mass/volume, whereas the rate of exchange of materials and energy (heat) is a function of its surface area. If the volume gets too big, the surface area can't absorb enough gases/food to penetrate to the centre.

1.2. Prokaryotic cells

1.2.1 Prokaryotic cell

1.2.2. Prokaryotic cells belong to their own kingdom- bacteria and blue-green algae. They have no nucleus (The DNA strand is loose within the cell) and lack membrane-bound organelles.

Ribosomes- synthesise proteins

Mesosomes- site for respiration (formed by the intucking of the plasma membrane)

Slime capsule- gives extra protection against ingestion by phagocytes and helps against drying out.

Cell wall- helps maintain the shape of the cell (unique to bacteria; made of peptidoglycan)

Flagellum- allows movement (propels the cell in a rotating fashion)

Cell surface membrane- allows the passage of materials (made of phospholipids)

Plasmid- small rings of DNA which serve as additional chromosomes. In many disease-carrying bacteria, they are associated with resistance to antibiotics.

Naked nucleic acid- A long strand of DNA (genetic information)

1.3. Eukaryotic cells

1.3.1 The endosymbiotic theory assumes that eukaryotes evolved from prokaryotes, because a prokaryotic cell acquired organelles. It states that it is possible that a heterotrophic prokaryote (one which obtains energy and organic matter from inorganic raw materials and an external energy source) which, instead of being digested, became a symbiont (lived in association with) inside the heterotroph, enabling it to carry out photosynthesis. Equipped with its own DNA, the symbiont may be divided inside the host cell very time the host cell itself divided, and in this way the symbiont may have become a chloroplast inside the host cell.

Evidence:

- Ribosomes in mitochondria and chloroplasts are the same sizes as those found in modern prokaryotes and significantly smaller than those found in the cytosol of a eukaryote.

- The inner membranes of mitochondria and chloroplasts have several enzymes and transport systems which resemble those found in the cell membranes of modern prokaryotes.

- Mitochondria and chloroplasts have their own DNA in the form of a ring, just as in prokaryotes found today.

1.3.2 Generalised Eukaryotic Cell (Animal Cell)

1.3.3 Eukaryotic cells have membrane-bound organelles and perform functions in a similar way to organs in an organism.

Rer (Rough endoplasmic reticulum)- to isolate and transport proteins which have been synthesised by the ribosomes to other cells.

Ribosomes- synthesise proteins

Smooth endoplasmic reticulum- synthesis and transport of lipids and steroids.

Golgi apparatus- assembly point through which raw materials for secretion are funnelled, carbohydrate components are added, and then are shed from the cell.

Lysosomes- destroy unwanted structures (e.g. old mitochondria), or entire cells by the rupturing of the lysosome membrane and the releasing of digestive enzymes (e.g. tadpole tails in frog metamorphosis).

Mitochondria- concerned with the chemical reactions of aerobic respiration; i.e. energy is converted to ATP here (the inner surface is infolded to increase surface area).

Nucleus- contains genetic information (bounded by a nuclear membrane).

Chloroplasts- contain chlorophyll used in photosynthesis

1.3.4. (Choose two)

- DNA (although in some cases enclosed in a nucleus, or in others just in the middle of the cell)

- Ribosomes (structures which synthesise proteins)
- Plasma membrane (infolded in prokaryotic cells)
- Mitochondria
- Chromosomes
- Endoplasmic reticulum

1.3.5.

- DNA is loose in prokaryotic cells, in eukaryotic cells the DNA is contained within a nuclear envelope.
- DNA in prokaryotic cells is circular, in eukaryotic cells it is arranged in chromosomes
- Prokaryotic cells have about 1/1000 as much genetic material.

1.3.6.

| Plant cell | Animal cell |
|---------------------|---------------|
| Cellulose cell wall | Cell membrane |
| Chloroplasts | - |
| Vacuole | - |

1.3.7 A plant's cell wall protects the cell, maintains its shape and prevents an excessive uptake of water.

It is made of a polysaccharide carbohydrate called cellulose (microfibrils) as it is tough and elastic. The cell has primary and secondary walls, and pits are found where only primary wall is present, to allow diffusion.

Ref.- Pg. 167, Fig 10.22, Yellow Book

1.4. Membranes

1.4.1 Learn diagram: Page 169, Fig 10.25 , Yellow Book

This is called a 'cell surface membrane'.

The outside of the cell membrane is called 'the outer face', and links with the protruding proteins.

1.4.2. The plasma membrane contains fats (lipids), and fat solvents make it very permeable. In the arrangement of the lipid molecules, phospholipids have a polar head (water-soluble, glycerol, hydrophilic), and a non-polar tail (insoluble hydrocarbon; hydrophobic).

The water-soluble head is drawn into the water and the hydrocarbon tail points out of the water. This arrangement is called the phospholipid monolayer.

But the plasma membrane can't be a monolayer because the plasma membrane has water on both sides, so the 2 monolayers come together and the non-polar tails are attracted to each other to form the bilayer.

See Pg. 168, Fig 10.24 Yellow Book

1.4.3. Diffusion- The passive movement of particles from a region of higher concentration to a region of lower concentration (Ref.; Pg. 192 Fig 12.1, Yellow Book).

1.4.4. Osmosis- the passive movement of water molecules across a semi-permeable membrane (a membrane only soluble to solutes and water) from a region of lower solute concentration to a region of higher solute concentration.

1.4.5. When materials move across cell surface membranes via passive transport, the materials will continue to move from an area of high to low concentration until the particles reach a state of equilibrium (i.e. they are uniformly distributed throughout the system). This process takes place by random thermal motion and does not require energy. Therefore, it can occur in living and non-living systems.

- Osmosis is carried out via passive transport
- Passive transport is used for oxygen/Carbon dioxide gas movement.
- Passive transport is less selective than active transport.

1.4.6

Carrier-assisted transport- the diffusing molecule or ion combines with the protein and is carried across the membrane and deposited on the other side. This movement is passive and goes with the concentration gradient. Active transport is selective.

Active transport- is the movement against the concentration gradient (low to high). Example: some seaweeds take up iodide ions so vigorously that they are 2 million times more concentrated inside the cell than in sea water.

Active transport takes place in a living system which transfers energy by respiration. Anything which stops ATP production (e.g. cyanide), will stop active transport have large numbers of mitochondria.

Carrier proteins and an energy source transport the molecules across the membrane. The energy source is ATP and the carrier protein is ATPase, an enzyme which is the hydrolysis of ATP. .

Active transport is an important because it allows cells to take up nutrients even when the concentration outside the cell is very low (e.g. animal cells contain high concentrations of potassium ions and low sodium ions. A sodium/potassium pump moves these rows in opposite directions. A pump/carrier is always used in active transport and the process is interdependent. Active transport is also used for ion movements.

Ref./diag- Page 194, Fig 12.4, Yellow Book

1.4.7. Endocytosis is the process of molecules taken into the cell. The plasma membrane enters to form a flask-shaped depression which envelops material. The neck of the flask closes and the invagination is sealed so it becomes a vesicle which moves into the body of the cell.

Pinocytosis, aka cell drinking, is a part of endocytosis. At the surface of a cell, tiny channels are continually being formed at the surface by the invagination of the plasma membrane. At the inner end of the channels small vesicles are pinched off and move to the centre of the cell. Vesicles may be pinched off by the larger ones and move to different parts of the cells. These are known as pinocytic vesicles and provide a means by which liquids can be brought into the body of the cell, and their breaking up into smaller (and numerous) vesicles aids distribution and increases the surface area across which absorption can take place.

Phagocytosis, aka cell eating is also part of endocytosis. In this process, certain cells take in larger particles. The plasma membrane invaginates and forms a vesicle enclosing the particles. The particles are then digested by enzymes shed into the vesicle from neighbouring lysosomes. The soluble products of digestion (glucose, amino acids etc) are then absorbed across the lining of the vesicle into the surrounding cytoplasm. Any indigestible material may be got rid of by the vesicle moving to the surface of the cell and fusing with the plasma membrane (exocytosis). Phagocytosis occurs in white blood cells which ingest bacteria and other foreign bodies, and helps the body protect from disease.

Exocytosis provides a means by which means enzymes, hormones, antibodies, and cell wall precursors are released from cells. This occurs when the vesicle containing the materials travels towards the surface of the cell and fuses with the plasma membrane. The vesicle releases all its materials, which leave the cell.

1.5 Cell Division- Mitosis

1.5.1. All cells arise from the division of other cells. Discovered by Virchow in 1855 (see 1.1.1)

1.5.2. The sequence of events which takes place in a cell between one cell division and the next comprises the cell cycle. The cell cycle is an alternation between interphase and mitosis. The mitotic phase consists of nuclear division (mitosis) and cytoplasmic division. During this phase, cells make few new chemicals (i.e. have a low rate of synthesis). After the mitotic phase, the daughter cells enter interphase, where firstly there is a great increase in the rate at which new cell components are made, then DNA synthesis occurs, and then the cells undergo a period of further growth. After this interphase stage, the mitotic phase is entered again.

1.5.3. Interphase is an active period in the life of a cell where many biochemical reactions, DNA transcription and DNA replication occur. Also, during interphase, a cell builds up sufficiently large stores of energy to carry it through mitosis. The mitotic phase only lasts 1-2 hrs, and the interphase makes up 95% of the remaining time.

1.5.4 Learn Fig 31.5, Page 554, Yellow Book
The chromosomes are moved apart by microtubules.

1.5.5 The products of mitosis are 2 genetically identical nuclei.

1.5.6 Tumours (cancers) are the result of uncontrolled cell division (mitosis), and can occur in any organ.

Topic 2- The Chemistry of Life

2.1. The elements of life

2.1.1 The 3 commonest of life are carbon, hydrogen and oxygen.

2.1.2. A variety of other elements are needed by living organisms, such as nitrogen, sulphur, phosphorous, iron and potassium.

2.1.3

Nitrogen- a constituent of proteins, nucleic acids, porphyrins etc, Used by both plants and animals.

Sulphur- constituent of certain proteins and vitamins- used by both plants and animals.

Phosphorus- required for phosphorylation also found in teeth and bones- both plants and animals.

Iron- involved in electron transfer; constituent of haemoglobin.

Potassium- activates many enzymes and is involved in stimulate openings.

2.1.4

Atoms are neutral (they have equal numbers of protons and electrons).

Ions are charged particles (with extra or missing electrons, making them either positive or negative)

2.1.5 Chemical compounds are divided into 2 groups; organic and inorganic

Organic- all the complex compound of carbon. Organic compounds include carbohydrates, fats, proteins and nucleic acids.

Inorganic- water and minerals (i.e. anything not organic)

Both are found in living things.

2.1.6. Water is a solvent, a polar molecule. This is due to an unequal distribution of charge, which makes water an excellent solvent.

The negative ends of water molecules are attracted to positive ions:

The positive ends of water molecules are attracted to negative ions:

Surface tension- Water molecules attract each other and weak bonds between the molecules, i.e. oxygen atoms are attracted to hydrogen atoms. The bonds between the water molecule and other molecules are stronger than is usually found in other liquids, they are called 'hydrogen bonds'.

Cohesion- the cohesive force which results from this bonding is very important, e.g. pondskaters and other insects survive on the surface of still water. Also, movement of water, through plants (capillary action in xylem vessels) depends on surface tension.

Transparency- Photosynthesis in water is the basis of all aquatic food chains. Any colouration or turbidity would affect a plant's ability to photosynthesise. Also, aquatic animals need clear conditions to see, and land animals rely on clear water in their eyes to see.

Thermal capacity- Specific heat capacity = no. of joules of energy required to heat one gram through one degree centigrade. Water has a high heat capacity; i.e. it needs a lot of energy to heat it up. This means water is good at maintaining its temperature and therefore provides a stable environment.

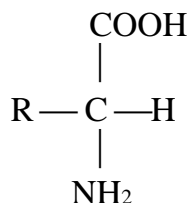
Freezing- Ice floats because it is less dense than water. Therefore there is always 'warm' water at the bottom of oceans and ponds in which organisms can survive the winter.

Solvent properties- The fact that water is capable of dissolving many organic and inorganic particles.

2.1.7 See above. E.g. water is an effective transport medium because of its solvent properties (the fact that water is capable of dissolving many organic and inorganic particles) and a good coolant because of its specific heat capacity.

2.2 Carbohydrates, Lipids and Proteins

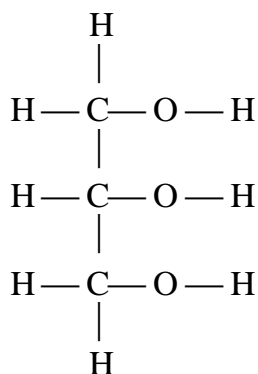
2.2.1 Basic structure of a generalised amino acid



There are about 100 amino acids, which vary according to what you find at the R. The simplest amino acid is glycine where the R group is hydrogen.

2.2.2 It is the specific relationship between the carbon atoms and the side groups which determines the nature of the sugar and its properties. Many forms of glucose can be made by swapping the groups at each carbon atom. These are called ISOMERS, and although they have the same $\text{C}_6\text{H}_{12}\text{O}_6$ formula, they all have different properties.

2.2.3 $\text{C}_3\text{H}_8\text{O}_3$ - Glycerol



Natural fats and oils are compounds of glycerol and fatty acids.

Lipids are insoluble in water, but soluble in organic solvents. They contain carbon, hydrogen and oxygen (with less oxygen than carbohydrates).

They may also contain other elements (e.g. phosphorus). There is only one kind of glycerol but lots of fatty acids.

Fatty acids- The general formula is $C_nH_{2n}O_n$ or $CH_3(CH_2)_nCOOH$, where (n) varies, but is usually between 14-22. The central part is a hydrocarbon (CH_2) and the end $COOH$ is a carboxyl group. This can therefore form hydrogen bonds with water but overall the molecule is insoluble because of the numbers of CH_2 groups.

Ref.: Fig. 9.17, Page 133, Yellow Book

2.2.4 Monosaccharides and Disaccharides

This combination of 2 monosaccharides into a disaccharide is a condensation reaction. As a result, a covalent bond is established (a glycosidic link) which joins the two monosaccharides.

Ref.: Fig. 9.8, Page 127, Yellow Book

Fatty acids- fatty acids and glycerol are the sub-units of fats and oil. In the synthesis of a fat or oil, 3 fatty acid molecules combine with a glycerol to form a triglyceride. This is a condensation reaction, in which the water is lost. Each OH (hydroxyl) group in the glycerol molecule reacts with the $COOH$ (carboxyl group) of a fatty acid. An oxygen bond (or ester bond) is established. As glycerol has 3 hydroxyl groups, 3 fatty acids attach to it and 3 molecules of water are lost.

N.B. When fats are respired, enough water is produced to maintain some desert animals.

For glycerol and triglycerides: Fig. 9.18, Page 134, Yellow Book

For amino acids and dipeptides and polypeptides: Fig 9.24, Page 137

2.2.5 Generalised dipeptide

2.2.6 Most lipids are generally insoluble in water due to the long hydrocarbon chain (hydrophobic). Carbohydrates are generally more soluble due to the presence of OH groups, i.e. hydrogen bonding. Proteins are generally soluble for the same reason; i.e. hydrogen bonds. Solubility is inclined to decrease with increasing molecule size.

2.2.7

Fat (lipid)- 38.5 Kj per gram

Protein- 22.2 Kj per gram

Carbohydrate- 17.2 Kj per gram

(Lipids gave about twice the energy content of both carbohydrates and proteins).

2.2.8/2.2.9

Monosaccharides- glucose and fructose- easy metabolism to form energy

Disaccharides- sucrose and lactose- carbohydrate, transport in plants

Polysaccharides- starch (storage- hydrolysis reaction breaks it down)

Cellulose (indigestible in humans; forms fibres)

2.2.10 Three functions of lipids:

They supply energy

They conduct heat slowly and therefore are good insulators.

They are a source of metabolic water (think camels).

2.3 Enzymes

2.3.1 Enzyme- a globular protein functioning as a biological catalyst. They are protein molecules which speed up chemical reactions in cells. Their main properties of enzymes are:

- They work rapidly
- They are destroyed by the reaction which they catalyse
- They are inactivated by high temperatures (denatured)
- They are sensitive to pH
- They are specific to certain reactions

2.3.2 Active site- The site on the surface of an enzyme to which a substrate or substrates bind.

2.3.3 In an enzyme-controlled reaction, the substrate molecules combine with the enzyme to form an enzyme-substrate complex. The substrate molecules then react together, and the product leaves the enzyme.

Enzyme + substrate → enzyme-substrate complex → enzyme + product

Each enzyme molecule has a precise place on its surface to which the substrate molecules become attached. This is called the active site. It has a particular configuration and the positions of various chemical groups and bonds in it ensure that only the substrate molecules will fit.

The lock and key mechanism proposes that
The substrate fits into an active site on the
Surface of the enzyme, where the reaction
Takes place (Pg 220, Fig 13.10)

2.3.4/5 3 factors affecting enzyme activity

1) High Temperatures

Up to 40 C, the increase is smooth, every 10 C increase doubles the rate of reaction. Above 40 C, the rate declines, and by 60 C, it has ceased. The enzymes are denatured, which means that the links in their polypeptide chains are broken, and they become randomly arranged, therefore the active site is changed.

2) Substrate Concentration

The reaction rate increases with substrate concentration up to a point, and then levels off. Substrate molecules collide with the enzyme molecules and join onto them; the more substrate, the more chances of collision but at some point, all the enzyme is 'occupied', and to increase the reaction, more enzymes need to be added.

3) pH values

Enzymes are sensitive to pH, and every enzyme has its own range of pH in which it functions best. Most intracellular enzymes have optimum function at around neutral, and excessive alkalinity/acidity denatures them and renders them inactive. Digestive enzymes behave differently; some of them work optimally in a distinctly acid or alkaline environment,

2.3.6 Denaturation- a structural change in protein (or nucleic acid) that results in a loss (temporary or permanent) of its biological properties.

2.3.7 2 functions of Enzyme Biotechnology

Washing powder- contains proteases which remove food and blood. They are effective at low temperatures and are therefore energy-saving and gentler on clothes.

Tenderising meat- Proteases are added to meat products to tenderise them (pre-digested food).

Main advantages of using enzymes:

- They are specific in their action and are therefore less likely to produce unwanted by-products.
- They are biodegradable and therefore cause less environmental pollution
- They work in 'mild' conditions, low temperatures, neutral pH and normal atmosphere pressures and therefore causing energy saving.

2.4 DNA Structure

2.4.1/2/3 Genes help to determine an organism's characteristics. Genes, therefore, carry information. They must be able to replicate without losing the information. Nucleic acids carry this information. Nucleic acids occur in all living cells- two types are found: DNA, deoxyribonucleic acid and RNA ribonucleic acid.

The building blocks of nucleic acids are called nucleotides. These consist of 3 molecules linked together:

- A pentose sugar
- An organic base

- Phosphoric acid (phosphate)

a) Pentose Sugar

b) Phosphoric acid

c) Organic bases (They are all ring structures)

Adenine – Thymine

Cytosine - Guanine

These link together by a condensation reaction to form a nucleotide. Nucleic acids form when nucleotides are strung together- another condensation reaction. Pg 711, Fig 39.2, Yellow Book

The sugar and phosphate groups are identical all the way along. The bases, however, vary.

2.4.4 DNA Formation

DNA consists of 2 chains twisted together and around each other to form a double helix. These chains are cross-linked at regular intervals and there are 10 nucleotides for one turn of the helix. DNA is a kind of twisted ladder, with the two uprights consisting of chains of alternating sugar and phosphate groups, and the rungs as pairs of bases sticking inwards towards each other and linked in a specific relationship. Adenine with Thymine, Cytosine with Guanine. The position of the hydrogen atoms in relation to the shape of the molecule ensures that Adenine and Thymine, and Cytosine and Guanine link together.

2.4.5 Learn Fig 39.6, Page 713 Yellow Book

2.5 DNA Replication (also known as DNA synthesis)

2.5.1 DNA replication is semi-conservative. This means that the 2 strands unzip and the nucleotides come into position in relation to each of the strands. The result is that the daughter DNA molecules never contain precisely the same nucleotides as the parent DNA.

2.5.2/3 In DNA replication, the 2 chains separate from each other like a zip unfastening as the hydrogen bonds, which link the bases of one chain with the bases of the other, are not very strong. Any free nucleotides then come along

and form hydrogen bonds with each of the 2 chains. These nucleotides then join together through their sugar and phosphate groups; and 2 DNA molecules result. The complementary relationship between the bases ensure that each of the DNA molecules are identical to the original one.

Because the sequence of the bases in the 2 daughter molecules is exactly the same in the parent molecule (i.e. A to T and C to G), accurate replication occurs. The enzyme that joins the nucleotides together is called DNA polymerase.

Ref: Fig 39.9, Pg 715 Yellow Book

2.6 Transcription and translation

2.6.1. RNA differs from DNA in four ways:

- It contains the sugar ribose instead of deoxyribose
- It is single-stranded rather than double-stranded
- It contains the base uracil instead of thymine
- It is much shorter than DNA, usually containing fewer than 1000 nucleotides.

2.6.2. Messenger RNA conveys the instructions needed for protein synthesis from the nucleus to the cytoplasm.

Transfer DNA transfers amino acids to ribosomes.

2.6.3. DNA Transcription

The double-stranded DNA untwists and then unzips in the relevant region. Free RNA nucleotides then align themselves opposite one of the two strands. All the bases from the DNA and free nucleotides then join up:

C to G

G to C

T to A

A to U (Uracil because it's RNA)

An enzyme called RNA polymerase then joins these together, resulting in the synthesis of messenger RNA. Once assembled, the messenger RNA peels off its DNA template and moves out of the cytoplasm via the pores in the nuclear envelope.

2.6.4. Three bases is sufficient to specify a single amino acid, for $4 \times 4 \times 4 = 64$ bases can be specified, more than enough to account for the 20 different amino acids commonly found in cells. So 3 is the minimum number of bases which between them can specify an amino acid, and so a combination of 3 bases codes for one amino acid. A triplet of bases is called a codon, and these codons form the basis of the genetic code.

2.6.5. Translation- the synthesis of proteins from messenger RNA

Ref.: Fig 39.17, Pg. 721 Yellow Book

The amino acid binding site of the transfer RNA is attached by an enzyme to a specific amino acid. The transfer RNA and accompanying amino acid then move to the messenger RNA binding site then form hydrogen bonds with the appropriate three bases in the messenger RNA molecule. The 3 bases in the messenger RNA are the codon, and the corresponding bases in the transfer RNA comprise the anticodon.

In the way the amino acids are linked up in an order corresponding to the sequence of base triplets in the messenger RNA. As the latter is determined by the sequence of base triplets in the original DNA, it follows that the base sequence in the DNA determines the order in which amino acids line up on the ribosome.

Once aligned, peptide bonds are formed sequentially between adjacent amino acids and a polypeptide chain is eventually formed. The process of assembly starts at one end of the chain, the end with a free amino group, and proceeds, amino acid by amino acid, to the other end- the end with a free carboxyl group. As the amino acids join up, the completed polypeptide chain peels off from the transfer RNA molecules.

2.6.6.

Degeneracy- containing more potential information than is actually used (having one more base triplet to code for one amino acid).

Universal- found in all living organisms.

2.6.7. The one gene- one polypeptide hypothesis

This hypothesis, put forward by Beadle and Tatum in the 1940s states that a single gene controls the production of a single enzyme. Systematic testing showed that organisms can not grow on minimal mediums as they acquire an inability to synthesise specific organic compounds if they lack specific enzymes.

2.7. Genetic Engineering, DNA fingerprinting, gene therapy

2.7.1. Genetic material can be transferred between species because the genetic code is universal.

Universality- a close resemblance among all species- as opposed to degeneracy

2.7.2. Gene transfer

A short piece of foreign DNA is inserted into the DNA of a host organism (usually a bacterium). This host organism then acquires the ability to synthesise certain proteins characteristic of the donor. In practical terms, the technique involves breaking open the DNA ring of bacterial plasmid and inserting a piece of DNA from a donor species into it. This procedure is called gene splicing. Gene splicing relies on an important group of naturally occurring enzymes called restriction endonucleases. A given restriction endonuclease cuts the bacterial plasmid open at a specific site which is determined by the sequence of bases in that region. The same enzyme will cut foreign DNA wherever an

identical base sequence occurs. It is also characteristic of most restriction endonucleases to cut the 2 strands of DNA at slightly different points. The result is that the 2 ends of the foreign DNA segment have a short row of unpaired bases which match the complementary bases at the 2 ends of the opened-up plasmid. (these are referred to as 'sticky ends'). In suitable conditions, the unpaired bases of the foreign DNA and plasmid join up, and so the foreign DNA gets incorporated into the plasmid. The bonding is made secure by another enzyme; DNA ligase. Once in position, the foreign DNA replicates along with the rest of the plasmid every time the bacterial cell divides.

Ref./diag- Pg. 743, Fig. 40.13 Yellow Book

2.7.3.

- In the manufacture of insulin and growth hormones (by the use of bacteria)
- Improved crop and animal breeds by increased disease resistance.

2.7.4

- With the release of genetically engineered organisms in the environment, they could spread and compete with the naturally occurring varieties.
- People eating genetically engineered material that contains substances they are allergic to.

2.7.5 PCR (Polymerase chain reaction) copies and simplifies minute quantities of nucleic acid.

2.7.6. Gel electrophoresis involves the separation of fragmented pieces of DNA according to their charge and size.

2.7.7 Gel electrophoresis of DNA is used in DNA profiling.

2.7.8. To carry out this procedure, DNA is taken from one person and cut up into smaller pieces with restriction endonucleases. These enzymes recognise specific sequences in the DNA. Because each of us has a unique sequence of nucleotides in our DNA, the lengths of these pieces will vary from person to person. Electrophoresis is then used to separate out these bits according to their size and charge. The net result is a pattern unique to each of us

Two applications of DNA profiling/fingerprinting:

- Used to find criminals from blood/semen samples (in cases of rape/murder)
- Used in paternity suits (a la Steven Tyler)

2.7.9. The process of gene therapy involves the replacement of defective genes. White blood cells or bone marrow cells are removed, and by means of a vector, the normal gene is introduced and inserted into the chromosome. The cells are replaced in the patient so that the normal gene can be expressed. An example of gene therapy is for cystic fibrosis.

Topic 3 Genetics

3.1 Chromosomes, genes and alleles

3.1.1 An eukaryote chromosome is made of DNA and protein

3.1.2. Chromosomes can be stained to show banding (the pattern of regions on a chromosome)

3.1.3. The chromosome structure and banding can be used to arrange the chromosomes in their pairs.

Karyotyping can be done in this way by using enlarged photocopies of chromosomes. Need to organise chromosomes into homologous pairs by staining them and using the bands to match them up.

3.1.4 Karyotyping can be used to see if chromosomal defects (such as down's syndrome) are present in unborn babies. It can also be used to identify characteristics of the organism that the cell came from.

3.1.5. Gene- an heritable factor that controls a specific characteristic, consisting of a length of DNA occupying a position on a chromosome known as a locus.

3.1.6. Allele- One specific form of gene, differing from other alleles by one or a few bases only and occupying the same gene locus as other alleles of a gene.

3.1.7. Genome- The total genetic material of an organelle, cell or organism.

3.2. Gene mutation

3.2.1. There are 2 types of mutation:

Gene mutation- a rare change in the DNA of genes that ultimately creates genetic diversity.

Chromosome mutation- changes in the gross structure of the chromosome. An alteration in the sequence of nucleotides in the part of the DNA molecule that

corresponds to a particular gene may change the order of amino acids making up a protein.

3.2.2

Insertion is where a base may be added to a sequence:

E.g. Please say where you are
Please **st**ay where you are

Deletion is where a base is missed out

E.g. I will send a **fr**riend to collect you
I will send a fiend to collect you

3.2.3. Gene mutation

Base substitutions (aka point mutations) occur when 1 base on a DNA strand is replaced with a different one. This can affect the resulting protein in various ways. Great distortions can arise because during transcription and translation, the DNA that is being read is wrong, and thus do not correctly produce a needed protein. An incorrect sequence of amino acids may alter the shape of the protein, the most important characteristic that defines a protein's function. In the case of sickle cell anaemia, the haemoglobin molecule is crystalline and makes the red blood cell crescent-shaped. Even a slight change in the sequence may be enough to completely alter the information-

3.3 Meiosis

3.3.1 Meiosis is a reduction division in terms of diploid and haploid number of chromosomes.

3.3.2. In meiosis, the number of chromosomes is halved, the daughter cells receiving only one of each type of chromosome instead of two. It occurs in the formation of gametes (sex cells).

In the diploid parent cell, chromosomes occur in homologous pairs (the same size). The parent splits in two (1st meiotic division), and the homologous chromosomes of each pair line up together and then get separated from one another and go into different cells. The products then divide again (2nd meiotic division, and the chromatids are separated and a total of 4 daughter cells result (see syllabus diagrams).

3.3.3. Meiosis promotes genetic variation, partly because each chromosome in the homologous pair carries different genetic material, and also because the homologous pairs are separated independently of each other ('independent assortment) so that the daughter cells contain different combinations of chromosomes. The number of possible different combinations depends on how many pairs of chromosome there are in the parent cell. The number of different combinations depends on how many pairs of chromosomes there are in the

parent cell. The number of different combinations that can occur is 2^n (to the power of n, where n = the number of haploid chromosomes).

3.3.4. Non-disjunction is a chromosome abnormality which is caused by the addition or loss of one or more whole chromosomes. On some occasions during meiosis, the homologous chromosomes go into the same cell instead of separating. This results in the formation of 2 types of gametes in equal proportions one type has 2 of the chromosomes whilst the other type has none. The fusion of the first kind of gamete with a normal gamete gives a zygote with 3 such chromosomes; this is known as trisomy. This causes Dow's Syndrome in humans.

See Figure 43.11, page 789 Yellow Book.

3.3.5. Mendel's Law of Segregation- An organism's characteristics are determined by internal 'factors' which occur in pairs (alleles). Of a pair of such alleles only one can be carried in a single gamete.

3.3.6. Meiosis is the process that separates allele pairs to create the gametes (sex cells; sperm, egg) that later fuse together during fertilisation.

3.4. Theoretical genetics

3.4.1. Genotype- the alleles possessed by an organism

3.4.2. Phenotype- all the characteristics of an organism

3.4.3. Dominant allele- an allele which has the same effect on the phenotype whether it is present in the homozygous or heterozygous state.

3.4.4. Recessive allele- an allele which only has an effect on the phenotype when present in homozygous state.

3.4.5. Co-dominant allele- alleles which have a partial effect in the phenotype when in the heterozygous state but a greater effect in homozygotes.

3.4.6. Locus- the particular position on homologous chromosomes of a gene.

3.4.7. Homozygous- having the 2 identical alleles of a gene

3.4.8. Heterozygous- having 2 different alleles of a gene.

3.4.9. Carrier- an individual that has a recessive allele of a gene that does not have an effect on the phenotype.

3.4.10 Test cross- testing a suspected heterozygote by crossing with a known homozygous recessive

3.4.11 See Pg 679, Yellow Book

3.4.12 See Pg 271, Green GCSE Book

3.4.13 Some genes have more than 2 alleles. These are known as multiple alleles.

3.4.14 Co-dominant alleles- alleles which have a partial effect on the phenotype when present in heterozygous state but have a greater effect in homozygotes.

An example is in the alleles controlling the BO blood group system in humans. The ABO system is controlled by 3 alleles; I^A, I^B and I^O.

I^A produces A antigens

I^B produces B antigens

I^O produces no antigens

There are 2 such alleles present in each person and therefore 6 combinations, which are:

I^A I^A = A

I^B I^B = B

I^A I^B = AB

I^A I^O = A

I^B I^O = B

I^O I^O = O

The I^A and I^B alleles show equal dominance with respect to one another (i.e. they are co-dominant), but each is dominant to I^O. Inheritance follows normal Mendelian patterns.

3.4.15 Sex is determined by sex chromosomes; Female = both X

Male = X and Y

Therefore, during gamete formation, the female will only pass on an X chromosome. A male can either pass the X or the Y chromosome, thus determining the sex of the new individual.

The sex chromosomes are called heterosomes.

See Pg 692, Yellow Book

3.4.16 Some genes are present on the X chromosome and absent from the shorter Y chromosome in humans.

3.4.17 Sex linkage- genes carried on sex chromosomes

3.4.18

- Haemophilia (inability to clot) is a sex-linked recessive trait (found on X chromosome).
- Muscular dystrophy (weakening of muscle and loss of co-ordination) is also a sex-linked trait (on X chromosome).

3.4.19 A human female can be homozygous or heterozygous, with respect to sex-linked genes.

3.4.20 They are carriers because they only have the X-linked allele on one X chromosome.

3.4.21 Monohybrid crosses involve one pair of genes
E.g. Red flowers x white (where white is recessive to red)
Let R = red, r = white

RR x rr =

All heterozygous in genotype. All red in phenotype.

When incomplete or co-dominance occurs, all heterozygous individuals would be pink and when bred together give rise to a 1:2:1 ratio.

- 1) RR x rr = red
- 2) Rr x rr = 1:1 ratio (dominant to recessive)

3.4.22 See syllabus

3.5 Applied genetics

3.5.1 Genetic screening- testing a population for the presence or absence of a gene.

3.5.2 1) Prenatal diagnosis of genetic diseases

- 2) Confirmation of animal pedigree
- 3) Paternity suits

3.5.3 The Human genome Project is an international co-operative venture to sequence the complete human genome.

3.5.4.

- It will lead to the production of pharmaceuticals based on DNA sequences
- It will lead to the understanding of many genetic diseases, genome libraries and the production of gene probes to detect sufferers and carriers of genetic diseases.

3.5.5 Clone- a group of organisms of identical genotype.

3.5.6 Early divisions of a fertilised egg produce 8 cells, each of which could give rise to an embryo (totipotency). After in vitro processes, the 8 resultant separated embryos can be transferred to surrogate mothers (e.g. cattle and sheep to continue using selected prime animals for the productive of more gametes (At present it is used for cloning genetically manipulated animals to produce pharmaceutical bio-chemicals).

3.5.7.

- People believe that scientists shouldn't 'play God'.
- This would lead to a 'super-race' with ordinary people dying out.
- Dictators and people like Hitler could be cloned
- Who decides who is fit to be cloned?

However, cloning happens naturally in monozygotic (identical) twins.

3.5.8 Modern Agricultural biological techniques

- Breeding for disease resistance
- Increased food production
- High yield of stuff (e.g. milk etc.)
- Breeding plants to select those that can spread to extend the range of species.

Topic 4 Ecology

4.1. Communities and Ecosystems

4.1.1 Ecology- the study of relationships between living organisms and their environment.

4.1.2. Ecosystem- a community and its abiotic environment.

4.1.3. Population- a group of organisms of the same species living in the same area at the same time and capable of interbreeding.

4.1.4. Community- a group of organisms living and interacting with each other in a habitat.

4.1.5 Species- a group of organisms which can interbreed and produce fertile offspring.

4.1.6. Habitat- the environment in which a species normally lives.

4.1.7. The biosphere is the part of the Earth and its atmosphere that is inhabited by living things. It is a self-contained community where different species live together and integrate.

4.1.8. Food chain- the nutrient sequence that leads from producers to top carnivores.

PLANT → 1ST CONSUMER → 2ND CONSUMER → TERTIARY CONSUMER → TOP CARNIVORE

E.g. Algae → Fish → Seal → Shark → Human

4.1.9. Food web- shows feeding interrelationships within a community. See page 35, Yellow Book.

4.1.10 *Trophic level*- the position that an organism occupies in a food chain or a group of organisms in a community which occupy the same position in food chains.

4.1.11/12 See Pgs 34- 37, Yellow Book

4.1.13 *Autotroph (consumer)*- an organism that produces organic matter from inorganic raw materials and an external energy source; (e.g. photosynthesis → all plants).

4.1.14 *Heterotroph (consumer)*- an organism that obtains energy and organic matter from other organisms (e.g. feeding in animals).

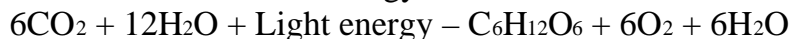
4.1.15 *Detritivore (decomposer)*- an organism that ingests dead organic matter. They are important in nitrogen and carbon cycles (e.g. bacteria).

4.1.16 *Saprotroph (decomposer)*- an organism that feeds on dead organic matter using extra-cellular digestion (e.g. flies, funghi).

4.2 Photosynthesis, respiration and energy relationships

4.2.1 Light is the initial energy source for almost all communities. Through photosynthesis, light energy is able to nourish almost all of the living world directly or indirectly.

4.2.2 Photosynthesis involves an energy conversion in which light energy is converted to chemical energy.



4.2.3. White light from the sun is made up from a range of wavelengths or colours. The light is electromagnetic energy, or radiation.

4.2.4 Chlorophyll is actually a mixture of different pigments; chlorophylls are the main photosynthetic pigments. More than one form of chlorophyll commonly exists.

4.2.5 Chlorophyll absorbs light, but following the rules of colour. Leaves appear green because the colour is reflected. Low wavelength colours are absorbed, e.g. ultra-violet, violet and blue at 400-500/nm. The greater the intensity, the more energy that falls on it and is absorbed by the pigment. The wavelength determines the frequency with which the light waves strike the pigment. Red light, as well as blue, are the most effective wavelengths in photosynthesis. Red light is absorbed, but not as much as blue light.

4.2.6 Light energy is used to split water molecules to produce oxygen and hydrogen and to produce ATP (this is a redox reaction called photolysis).

4.2.7 The ATP and hydrogen derived from the photolysis of water are used to fix CO₂ to make organic molecules. This is an enzyme-controlled reaction.

4.2.8 Photosynthesis is a 3 stage procedure. Light is captured, electrons are transported (and ATP and reduced NADP) are formed), and CO₂ is reduced (energy from this comes from electron transfer). Stages 1 and 2 occur in the light, stage 3 occurs without light. Photosynthesis can be monitored by O₂ production, which is easily monitored. The uptake of CO₂ and increase in biomass and are also indicators, though are more difficult to monitor. The measuring of the input/output of gases such as CO₂ can produce changes such as in pH value- and this is regarded as a direct means. Biomass is an indirect means.

4.2.9 The factors which affect photosynthesis are:

- Temperature
- Light intensity
- Light quality (wavelength, colour filters)
- CO₂ concentration

4.2.10 Respiration involves the breakdown of organic molecules to release energy stored by photosynthesis.

4.2.11 The CO₂ fixed by the photosynthesis is released by respiration.

4.2.12. The energy released during breakdown/respiration of complex compounds in an organism is used within an organism to do work or is lost as heat.

4.2.13. Biomass- the total mass of organic matter in organisms or ecosystems (water is not organic matter and so is not included).

4.2.14 Pyramids of numbers- see Pg. 36 Yellow Book

Pyramids of biomass- see Pg. 37 Yellow Book

The greatest mass of organisms are the producers supporting a smaller mass of herbivores and a smaller mass of carnivores, and although top carnivores are often large (e.g. wolves), they are few in number and therefore have a low biomass.

Biomass refers to what is happening at a given moment, and therefore sometimes the pyramid does not work due to migration or seasonal flux of species.

The energy between each trophic level decreases because:

- Some is excreted as waste
- Radiation of heat energy (waste)
- It is used by organism for growth and repair.

4.2.15 When energy transformations occur, including those in living organism, the process is never 100% efficient, often being 10 – 20%.

4.2.16 - See Pg. 37, Yellow Book

Pyramids of energy are pyramids which show the energy transfer between trophic levels. Units = Kj m yr.

Energy taken in by producers for photosynthesis has 3 possible pathways:

- Respired by the producer
- Passed on to the herbivore
- Passed on to the decomposers

Energy from the herbivore can also follow the same 3 pathways. Thus the energy available to each trophic level above it decreases. This is the law of the conservation of energy (Energy can not be created or destroyed, but simply changes form).

4.2.1.7 A pyramid of energy shows the transfer of energy through a community, and shows the rate at which energy is transferred from one trophic level to another.

e.g.

The units of energy per area per time are expressed as kJoules $m^{-2} yr^{-1}$. The energy flowing through each trophic level decreases as you go up a food chain. This is due to this energy being lost, for example, by being given off as heat, excreted, or used by the organisms for growth and repair.

4.2.1.8 Energy leaves and enters an ecosystem, but nutrients must be recycled. In order for organisms to maintain themselves, grow and reproduce, they need a supply of the elements of which they are made, and they receive this from the cycling of nutrients.

4.2.1.9. The Carbon Cycle

4.2.20 Saprotrophs (aka saprobionts) are responsible for breaking down the organic waste products and dead remains of organisms into the inorganic substances needed by the producers. These inorganic materials are rebuilt into organic compounds by the synthetic activities of the producers. Decomposers mainly comprise bacteria and fungi.

4.3. Populations, natural selection and evolution

4.3.1. Population- the number of individuals of an organism/species; there must be a potential of interbreeding.

Population increase is brought about by natality (birth rate) and immigration.

Population decrease is brought about by emigration and mortality.

4.3.2 See Pg. 58, Yellow Book

This is the Sigmoid (s-shaped) population growth curve.

4.3.3. Stages: 1) Lag phase (settling in)

2) Exponential growth (population grows geometrically)

3) Transitional phase (environmental resistance causes this)

4) Plateau phase (population constant)

Exponential growth ceases as environmental resistance builds up, and the population reaches its maximum size. This is its 'carrying capacity' for that particular environment where the population is found.

Exponential growth- represents a high growth rate under environmental conditions that permit population growth- little competition for food and the effect of predation and disease are slight; i.e. species realise their full reproductive potential.

Transitional phase- Environmental resistance due to:

- lack of food and water
- lack of light (particularly plants)

- lack of oxygen (particularly aquatic species)
- predators and parasites
- disease (spread rapidly through individuals of the same species living closely together)
- lack of shelter
- build up of toxic waste (CO₂, nitrogenous waste, etc.)
- stress (overcrowding leads to abnormal behaviour)
- weather and catastrophes; freezing of lakes/ fire on Heathland

Plateau phase- where births and deaths balance, the carrying capacity has been reached.

4.3.4. Carrying capacity- the maximum number of a species that can be sustainably supported by the environment.

4.3.5. Factors limiting population growth: see “Transitional Phase” 4.3.3.

4.3.6. Populations tend to produce more offspring than the environment can support.

4.3.7. The consequences of the potential overproduction of offspring is a struggle for survival. An increased mortality rate occurs as individuals who are least adapted for survival die first; aka Differential Mortality, and it perpetuates beneficial characteristics.

4.3.8. The members of a species show variation.

4.3.9. Life can survive through natural selection. This is done in different ways. With stabilising selection, nature acts against the extreme phenotypes and favours the more intermediate variants (this is why most heads are one average size). There is also directional selection, which is most common during periods of environmental change or when members of a population migrate to some new habitat with different environmental conditions. There is also diversifying selection, which occurs when environmental conditions are varied in a way that favours individuals on both extremes of a phenotypic range over intermediate phenotypes (i.e. prefers both extremes rather than the average).

4.3.10 Any process that encourages the transmission of favourable alleles and hinders the transmission of unfavourable ones contributes towards evolution. Given enough time, an allele which is associated with only a very slight reduction in viability and fertility usually being eliminated from the population.

4.3.11 If the environment should change, selection responds by favouring genotypes adapted to new conditions (eg peppered/white moths).

4.4 Human Impact

4.4.1. The Greenhouse effect- the way in which the atmosphere helps to keep the earth warm by trapping the sun's radiation. Carbon Dioxide, now in excessive production due to the combustion of fossil fuels contributes to this, Matters are also made worse by the mass destruction of natural vegetation which would normally absorb the extra carbon dioxide. The greenhouse effect is a natural phenomenon, without it organisms may have evolved differently. Other gases than Carbon dioxide, such as CFCs, contribute to the problem.

The Ozone layer- The ozone layer filters out some of the harmful UV radiation from the sun. A hole has been found, and is constantly growing in size due to the increased use of CFCs. These stay in the atmosphere for a long time, and over the years, slowly diffuse upwards until they reach the stratosphere, where they react with ozone and destroy it. In the lower atmosphere (troposphere), the influence of ozone is negative, it causes pollution problems.

4.4.2 The Greenhouse effect- From between 500 BC and 1880 AD, The CO₂ concentration was 270 ppm (parts per million), now it has reached 350+ ppm. This is an increase of 30%.

Effects- Average world temperatures have risen by 0.5 – 1 C, and are predicted to rise by another 1-5 C over the next few decades .

Ice at the north and south poles will melt

Flooding of coastal and lowland

More droughts in sub-tropical latitudes

Ozone layer- CFCs break down in the atmosphere, releasing chlorine atoms. These react with ozone, producing ClO, which then reacts with oxygen atoms. Chlorine atoms catalyse the destruction of ozone.

Effects- a rise in skin cancer cases, especially in countries close to Antarctica, as more UV radiation reaches ground level.

4.4.3.

Greenhouse effect-

- More nuclear/renewable power used instead of fossil fuels
- More energy saving methods introduced
- Afforestation to provide more trees to use carbon dioxide
- Nutrient enrichment of the oceans might encourage algal blooms which would trap carbon dioxide in organic matter

Ozone layer-

- Reduction in the use of CFCs by lessening their presence in aerosols, refrigerators and fast-food packaging and using other substances instead.

4.5. Ecological Techniques

4.5.1. See Heathland experiment

4.5.2 Random sample- a method used to ensure that every individual in a population had an equal chance of being observed.

4.5.3 Lincoln Index is used to estimate the population size of an animal species based on a capture-mark-release-recapture method.

$$\text{Population size} = \frac{n_1 \times n_2}{n_3}$$

where n_1 = number initially caught, marked and released.

n_2 = total number of individuals caught in the 2nd sample

n_3 = number of marked individuals in the 2nd sample.

4.5.4 see Heathland experiment.

4.5.5 You can do this.

4.5.6 Mean- the 'average' value obtained by dividing the total of a set of values by the number of values.

4.5.7. Mode- The most frequent value in a set of observations.

4.5.8 Median- the central value in a set of observations arranged in order.

4.5.9 The term standard deviation is used to summarise the spread of variables around the mean and that 68% of the values fall within one standard deviation of the mean (plus and minus).

4.5.10.

4.5.11 Standard deviation is useful in comparing the means and spread of ecological data between 2 or more sites. A small SD indicates that the data is clustered closely around the mean value; a large SD indicates a wider spread around the mean. The size of a SD might be the result of genetic or environmental factors (or both). When comparing 2 samples from 2 different populations, the closer the means and SD. The more likely the samples are drawn from a similar (the same) population. The bigger the difference, the less likely that this is so. This is dependant on sample size- larger samples make more reliable results.

Option G- Ecology and Conservation

G.1.1. Factors which affect plant species distribution:

Temperature- few organisms can grow in temperatures outside the range of 0 – 40 C (enzyme activity is stopped)

Water- necessary for life. Usually, areas with higher rainfall levels have more growth.

Light- vital for photosynthesis.

Soil pH- certain plants favour acidic soils, others alkaline (bog stuff)

Salinity- excessive salinity is not favoured by plants

Mineral nutrients- without many minerals, especially in areas where minerals are leached downslope, plant distribution decreases.

G.1.2. Factors which affect animal species distribution:

Temperature- few organisms can grow in temperatures outside the range of 0 – 40 C. Most animals have physiological / behavioural adaptations to avoid extremes of temperature.

Water- vital for life. Animals who live in dry areas usually have specialised mechanisms for water loss.

Territory- can allow exclusive access to food. Also allow one sex (usually male) to defend an area to which the opposite sex is attracted for mating.

Breeding sites

Food Supply- more distribution where much food is found.

G.1.3 –

- = mean
- = standard deviation
- = number of entries in a set of data
- = variance
- =the *positive* difference between the 2 means

The t-test is used to compare 2 sets of data and measure the amount of overlap.

Factors of concern:

- Nearness of the mean values of the 2 sets
- Size of the variance (how tightly clustered the data is)

Large t-values = little overlap and therefore a difference between the 2 sets of data.

Small t-values = Much overlap and probably no difference

A probability of 0.05 = significant and a critical value read off from a table.

This test should be used on normally distributed data, ideally with large samples. The value of 't' should be compared with the critical value at ∞ degrees of freedom. For sample sizes lower than 30, the t-value is only approximate and the degrees of freedom is $n_1 + n_2 - 2$. If t is equal to or larger than the critical value, then it is possible to reject the null hypothesis.

G.1.4/5 The competitive exclusion principle states that 2 species can not coexist unless there are significant differences in their ecologies; i.e. 'Each species has its own unique niche'. The niche of an organism is its role in the community, the habitat of an organism is where it lives. The feeding niche focuses on what the animal eats etc.

Fundamental niche- the niche a species would occupy in the absence of any competitors, predators or parasites.

Realised niche- the niche a species actually occupies.

G.2. The ecology of communities

G.2.1

Competition- where species are both predators of the same food
e.g. tigers/hyenas and owls/weasels

Herbivory- feeding solely on plants
e.g. slugs/snails and cows/sheep

Predation- animals which kill their prey before eating it
e.g. lions/tigers and wolves/foxes

Parasitism- where one organism (the parasite) lives in or on another (the host)
e.g. hedgehogs/ticks and dogs/fleas

Mutualism- where two members of different species benefit and neither suffers
e.g. rumen bacteria/ protozoa and chlorella/ chlorohydra

G.2.2. Gross production- the amount of organic matter produced by photosynthesis in plants.

G.2.3 Net production – The part of gross production that is not used in plant respiration

G.2.4 Gross production – respiration = Net production

Supplementary Notes

Plant and Animal Cells

Animal Cells

Diagram - Pg. 151, Yellow Book

Cytoplasm- where complex chemical reactions take place, building up materials and supplying energy for the cell's activities.

Chromatins- condense into chromosomes when the cell undergoes division. Chromosomes carry DNA (hereditary material) which determine the organism's characteristics and transmits these to subsequent generations.

Nucleus- directing cell activities

Centriole- plays an important part in the formation of cilia and flagella ('hairs')

Plant Cells

Diagram- Pg. 152, Yellow Book

Vacuole- contains cell sap (salts and sugars)

Cell wall- made of cellulose. Tough but slightly elastic. Starts as a thin layer of pectin beneath which cellulose, secreted by the outer part of the cytoplasm, is laid down. This constitutes the primary wall, and further layers of cellulose constitute the secondary wall.

Plasmodesma- fine strands of cytoplasm which facilitate the movement of materials between cells.

Starch grains- major form of storage carbohydrate.

Chloroplast- contains pigment chlorophyll; used in photosynthesis.

Miscellaneous Notes

-Chloroplasts do not have membranes

-When mammals respire, air enters the lungs because the air pressure in the lungs becomes lower than the atmospheric pressure.

-A fundamental difference between plants and animals concerns the ability to fix carbon dioxide.

-The source of oxygen in photosynthesis is water.

- DNA duplication occurs during interphase.
- The basic building blocks of nucleic acids are nitrogenous bases.
- A nucleotide of DNA consists of one nitrogenous base, a pentose sugar and a phosphate group.
- The translation phase of protein synthesis takes place on the ribosomes.
- Bacteria in a mutualistic relationship with the roots of leguminous plants are responsible for fixing nitrogen from the surrounding air.
-
- Functions of HCl in digestion:
 - it denatures proteins
 - it stimulates pancreatic secretions
 - it activates enzymes in the stomach

Punnett Square for double heterozygotes/homozygotes.

Example: Female: DdEe
 Male: DdEe

Female

| | DE | De | DE | de |
|----|------|------|------|------|
| DE | DDEE | DDEe | DdEE | DdEe |
| De | DDEe | DDee | DdEe | Ddee |
| DE | DdEE | DdEe | ddEE | ddEe |
| de | DdEe | Ddee | ddEe | ddee |

Male

Revise Heathland project; especially fieldwork methods:

- Quadrats
- Transects
- Capture-mark-release-recapture etc.

Ways in which environmental degradation has occurred due to the use of fossil fuels:

- Greenhouse effect
- Acid rain
- Deforestation
- Increased pollution
- Ozone layer depletion
- Soil degradation

Topic 5- Human health and physiology

5.1 Digestion and nutrition

5.1.1. Digestion- Large, insoluble molecules are turned into small soluble molecules. These molecules are absorbed into the blood stream.

Large complex molecules which are insoluble and relatively inert chemically are of no use to organisms. As these molecules are too large to pass into the cells of an organism, it is essential that digestion occurs so that these molecules are turned into soluble products which can be absorbed.

A proper diet supplies fuel for cellular respiration, and animals are powered by ATP generated from the oxidation of complex organic molecules.

5.1.2 Enzymes are required for digestion as they increase the rate of digestion. The physical action of digestion (e.g. chewing), increases the surface area over which enzymes can act.

5.1.3

| | Source | Substrate | Products | Optimum pH |
|-------------------|-----------------|-----------|--------------------------------|---------------------------|
| Salivary amylase | Salivary glands | Starch | Maltose | Neutral/slightly alkaline |
| Pepsin | Stomach | Protein | Polypeptides | Very acidic |
| Pancreatic lipase | Pancreas | Fats | Monoglycerides and fatty acids | Alkaline |

5.1.4 See and learn Fig 16.16 B Pg 276 Yellow Book

5.1.5. See and learn Fig, 16.27 Pg 285 Yellow Book

5.1.6 Absorption- That taking in of chemical substances through cell membranes or layers of cells.

5.1.7 *Balanced diet*- a diet that provides all nutrients in the necessary proportions; i.e. carbohydrates, fats, proteins, minerals and water.

A balanced diet allows an organism to function efficiently and lead a healthy life. Different people need different things: young, old, sick, active, pregnant and lactating.

A balanced diet:

- Provides fuel for cellular respiration.
- Supplies organic raw materials which animals use to fabricate many of their own molecules
- Supplies essential nutrients that animals cannot make for themselves.

5.1.8 Both vitamins and minerals are required by humans, but only in small amounts. Vitamins serve primarily as co-enzymes or parts of co-enzymes.

Minerals' roles:

Constituents of large and small molecules

Constituents of certain pigment (iron-haemoglobin) and structures (calcium-bones)

Determinants of the anion- cation balance in cells (especially in nerves, muscles and sensory cells)

Determinants of water potential (osmotic pressure)

Vitamins- cause deficiency diseases when not taken. They have different functions, varying from prevention of rickets, blindness, etc. Water-soluble vitamins are essential for the functioning of certain enzymes (and are also known as co-enzymes).

5.1.9. Obesity is a health problem concerned with malnutrition.

5.1 The transport system

5.2.1 In mammals, with double circulation, the heart is divided into right and left sides with 2 atria and 2 ventricles. This division of the heart prevents the oxygenated blood on the left side from mixing with the deoxygenated blood on the right side.

The muscular heart pumps the blood into a system of arteries, which branch into arterioles. Within the tissues the arterioles branch into capillaries where exchange of materials between blood cells takes place. From the capillaries blood is collected up into a series of venules which join up to form veins which the blood returns to the heart.

Blood returning to the heart from all parts of the body, except the lungs, enters the right atrium, whence it passes into the right ventricle, and then via the pulmonary artery to the lungs. The walls of the arteries and veins are elastic,

and the heart and veins are equipped with valves which prevent blood flowing in the wrong directions.

Blood returning via the venae cavae enters the right atrium. The resulting pressure in this chamber forces open the flaps of the tricuspid valve. The result is that blood flows through the tricuspid opening into the right ventricle.

When the atrium and ventricle are full of blood, the atrium suddenly contracts, propelling the blood into the ventricle. The contraction spreads from the right atrium over the rest of the heart. Atrial systole is relatively weak but the ventricles, whose thick walls are especially well endowed with muscle, contract more powerfully. As a result, blood is forced from the right ventricle into the pulmonary artery.

5.2.2.

5.2.3 Cardiac muscle (i.e. the heart) is myogenic: its rhythmical contractions arise from within the muscle tissue itself.

The heart is made to slow up or down, under involuntary control, by means of nerves and hormones.

Myogenic means that cardiac cells are self-excitabile: they can contract without any signal from the nervous system.

The sinoatrial (SA) node/pacemaker is located in the wall of the right atrium. It is composed of specialised muscle tissue. Each time the SA node contracts, it

initiates a wave of excitation that travels through the wall of the heart; the two atria contract in unison.

The atrioventricular node is located at the bottom of the wall separating the 2 atria. When the wave of excitation reaches the AV node, it is delayed for about 1 second. After this delay, the wave of excitation spreads upward through the ventricular walls.

The pacemaker is controlled by both nerves and hormones. The hormones are secreted into the blood by the glands.

5.2.4. See and learn Fig 19.18 Pg 329 and Fig 19.20 Pg 330 Yellow Book.

Arteries- Carry oxygenated blood from the heart. Blood is expelled from the heart only when it contracts. Blood flow through the arteries is therefore intermittent, the blood flowing rapidly during systole and slowing down during diastole. However, by the time the blood reaches the capillaries it is flowing evenly. The gradual change from intermittent to even flow is made possible by the elasticity of the arterial walls which contain much elastic tissue and smooth muscle.

Veins- Carry deoxygenated blood from the heart. Veins have thinner walls and a larger lumen than arteries. Blood flow through them is assisted by the contraction of skeletal muscles which squeezes the blood along. Back-flow is prevented by valves, and by the large diameter of the veins which minimises the resistance to flow. Contraction of the smooth muscle in the walls of the veins can also increase the return of the blood to the heart.

Capillaries- Capillaries are narrow (average 10 μm diameter) and thin-walled. The wall consists of a single layer of very thin pavement epithelium which allow rapid diffusion of dissolved substances into or out of the capillary. The cells are bathed in tissue fluid derived from the blood plasma which provide a medium through which diffusion can take place. The close proximity between which the capillaries and the tissue cells, and the thinness of the barrier between them, facilitates this exchange of materials.

5.2.5. Blood is composed of plasma, erythrocytes, leucocytes and platelets.

5.2.6 The following are transported by blood: heat, nutrients, oxygen, carbon dioxide, hormones, antibodies, waste products.

5.2.7 Haemophilia is one health problem concerned with disorders of the transport system.

It is a sex-linked disease and is found in males. It is caused by a recessive allele carried on the X chromosome.

In this condition, the blood takes an abnormally long time to clot, resulting in profuse and prolonged bleeding from even minor knocks and wounds.

Factor VIII is the cure.

5.3. Defence against disease

5.3.1. Disease can be caused by a variety of organisms, especially bacteria, viruses, protoctists and fungi. These organisms are known as pathogens.

5.3.2 The skin acts as a barrier to most micro-organisms (including pathogens) due to its hard, keratinised outer layer which serves as an effective barrier.

Also, micro-organisms and undesirable particles get caught up in mucus secreted by numerous goblet cells and are carried by the beating cilia towards the glottis and thence to the throat where they are swallowed.

5.3.3 Phagocytic leucocytes ingest disease-causing organisms in the blood and body tissues. See and learn Fig. 24.5 Pg 415

5.3.4

Antibody- a globular protein that recognises an antigen

Antigen- A molecule recognised as foreign by the immune system

5.3.5 B- lymphocytes in bone marrow produce, during development, clones of identical cells programmed to secrete a specific antibody when recognising one type of antigen.

Each B cell carries on its surface the same kind of antibodies that it is capable of producing. Their surface antibodies act as receptors. When an appropriate antigen comes along, it combines with one of the receptors. This activates the B cell, causing it to start making the antibodies which are then released into the blood and lymph. There is an antigen binding site.

The type of immunity provided by B lymphocytes and their antibodies is called humoral immunity.

As a result of infection, special memory cells develop from the clone which produces the antibodies, and these memory cells may survive for many months, and even years.

5.3.6 Effects of HIV on the immune system:

AIDS causes a reduction in helper T-cells, which lowers the communication between the cells of the immune system leading to infection by certain bacteria, fungi, protists and viruses.

Immunodeficiency is a state where part of the body's immune defence against disease becomes defective, leading to an increased susceptibility to certain infections.

5.4 Gas Exchange

5.4.1. Four features of alveoli that allows them to carry out gas exchange efficiently:

- Large surface area
- very good blood supply
- very thin wall, exchange is easier
- mucus lined and therefore oxygen is more easily transmitted across.

5.4.2. All animals need oxygen (for energy), so a ventilation system is essential to get oxygen into our systems at cell level.

The body needs oxygen to get rid of hydrogen ions at the end of the electron transport chain.

We can't store large amounts of oxygen in the body for long periods of time due to its oxidative properties which are harmful to tissue. Therefore, we must constantly replace the oxygen as we get rid of it in the form of water.

Also, we need to get rid of carbon dioxide, which forms carbonic acid in solution.

5.4.3. The Human Gas Exchange system – See and Learn Fig 15.13 Page 256 Yellow Book

5.4.4 *Breathing*- the mechanism by which air is drawn into an organism

Respiration- the release of energy at cell level using oxygen. It occurs in the mitochondria.

5.4.5 Exercise improves the functioning of the heart and lungs. This is due to increases in the stroke volume of the heart and increased total volume of the lungs leading to a lowering of rate of both the heart beat and the ventilation rate.

5.4.6 Breathing rate varies with exercise. This is due to the changes in carbon dioxide concentration leading to a lowering of blood pH, which is detected by chemosensors (in the aorta and carotid arteries) that send impulses to the breathing centre of the brain (in the brainstem). This then sends nerve impulses to the diaphragm and intercostals muscles to increase contraction/ relaxation rates. This is under involuntary control, but can be controlled voluntarily to some extent.

5.4.7. Asthma. This is often caused by allergic reactions to allergens such as pollen or dust. Symptoms are constriction and swelling of bronchioles, and thus trouble breathing. The frequency of asthma has been rising dramatically (40% more deaths) in the past 20 yrs, and reasons are unknown (probably due to an increase in motor vehicles??)

5.5. Homeostasis

5.5.1 *Homeostasis*- the maintenance of a constant internal environment which ensures that an organism's cells always experience those conditions which permit effective functioning.

5.5.2 Two of the functions of homeostasis are the maintenance of body temperature (thermoregulation) and blood glucose levels. Most of the mechanisms are involuntary.

Thermoregulation- there is a monitoring of both skin temperature (by thermoreceptors in the skin) and blood temperature (by thermoreceptors) in heat centres in the hypothalamus. Heat can be gained or lost by active mechanisms, most are under control although conscious behavioural mechanisms are important.

Warming-up mechanisms: vasoconstriction, increased cell metabolism, shivering.

Cooling-down mechanisms- vasodilation , sweating, decreased metabolism.

Glucose regulation- chemoreceptors in the pancreas monitor glucose. Levels rise due to diet or release from liver and muscles by demand and falls due to respiration or conversion to other metabolites or for storage (glycogen). If levels are low, the pancreas secretes glucagons which stimulates liver cells to convert (enzymically) glycogen directly to glucose and amino acids indirectly to glucose. If levels are high, other pancreas cell secretes insulin that stimulate cell respiration, increased absorption of glucose by muscle cells, increased conversion of glucose to fat (in adipose tissue) and to glycogen in liver and muscle cells.

5.5.3 *Negative feedback*- The control of a process by the results or effects of the process in such a way that an increase or decrease in the results or effects is always reversed. (Examples are temperature and glucose regulation).

If basically means that when something changes, the opposite effect is produced. For example, in glucose regulation; an increase in the concentration of glucose sets into motion the process which decrease it.

5.5.4 The nerve and the endocrine systems are involved in homeostasis. Temperature regulation (i.e. thermoregulation) controls temperature (its mainly nerves) and hormones secreted from endocrine systems regulate glucose. Thermoregulation is primarily nervous; glucose regulation is mainly hormonal.

5.5.5 The nervous system consists of the central nervous system and peripheral nerves composed of special cells called neurons that can carry electrical impulses rapidly.

5.5.6 The endocrine system consists of glands which release hormones that are transported in the blood. Hormones are secreted directly into the bloodstream. Responses are slower and often permanent (e.g. secondary sexual characteristics).

5.5.7 Excretion- The removal from an organism of the toxic waste products of metabolism.

5.5.8 Osmoregulation- The control of the osmotic and water potential in a cell or inside a living organism.

5.5.9 The functions of the kidney are excretion and osmoregulation.

5.6 Human Reproduction

5.6.1. By sharing alleles through sexual reproduction, a species produces a variety of offspring. Each offspring receives genes from both mother and father and also is subject to crossovers and random mutation, providing variety in a species.

Meiosis promotes genetic variation, partly because each chromosome in the homologous pair carries different genetic material, and also because the homologous pairs are separated independently of each other ('independent assortment') so that the daughter cells contain different combinations of chromosomes. The number of possible different combinations depends on how many pairs of chromosome there are in the parent cell. The number of different combinations depends on how many pairs of chromosomes there are in the parent cell. The number of different combinations that can occur is 2^n (to the power of n, where n = the number of haploid chromosomes).

5.6.2. Yellow Book Pgs 580 & 581

5.6.3 Boys- puberty is brought on by sex hormones secreted by the gonads: androgens (principally testosterone) by the testes. Hormones are produced more or less uniformly in the male.

Females- Puberty is brought on by the sex hormones secreted by the gonads: oestrogen in the ovaries.

The female menstrual cycle

These two hormones are produced in the ovaries and control the main events of the cycle:

Oestrogen- Causes the lining of the uterus to thicken and grow.
Stimulates the release of an egg at day 14.

Progesterone- Maintains the lining of the uterus (the endometrium)
When the level of progesterone falls, the lining of the uterus breaks down.

LH and FSH are also involved. They are produced in the pituitary gland. They travel in the blood to the ovaries.

FSH (Follicle Stimulating Hormone)-

Causes an egg to develop in one of the ovaries.

Stimulates the ovaries to produce oestrogen

LH (Luteinising hormone)- stimulates the release of an egg at day 14.

See Pg 598, Fig. 33.16 Yellow Book.

5.6.4 Males: Bone and muscle growth
Body hair; face, armpits, pubic
Sperm production (nocturnal emissions)
Chest widens

Females: Breast development
Menstruation
Hip development
Body hair; pubic, armpits

5.6.5 Copulation- the act of intercourse

Fertilisation- the joining of the sperm and egg cells.

5.6.6. See Fig 13.12 Pg 590, Yellow Book

Fertilisation occurs about 1/3 of the way along the oviduct. The zygote is then pushed down the oviduct by gentle contractions of the circular muscle in the oviduct wall. It takes about 3 days after fertilisation to reach the uterus. As it moves along, it divides to form a solid ball of cells (blastomeres) called a morula, which then becomes a hollow blastocyst after further divisions. The follicle cells have disappeared by this time but the egg is still surrounded by the jelly and becomes attached to the lining of the uterus (this is called implantation). A wide range of nutrients and other substances are provided to the blastocyst from glands which help it survive and continue its development (one nutrient provided is glucose- energy)/

5.6.7. The fetus is supported and protected by the amniotic sac and amniotic fluid. They act as shock absorbers to protect the fetus, and also act to prevent pathogens from infecting fetus during development.

5.6.8 Materials are exchanged between the maternal and fetal blood in the placenta. The fetal and maternal blood are in close capillaries so that they can osmotic exchange oxygen and food source.

Placenta provides- soluble food / oxygen / water / salts / antibodies

Placenta removes- urea / carbon dioxide.

5.6.9 Birth starts with rhythmic contractions of the uterine muscle. This is known as labour. The amnion then bursts and the amniotic fluid flows out through the vagina ('breaking of water'). The fetus is then forced out through the cervix and the vagina by powerful contractions of the uterine muscle. The placenta comes away from the uterine wall and is expelled as the 'afterbirth'. Birth is hormonally controlled. Oestrogen increases and makes the uterus contract and progesterone declines. Oxytocin is produced by the pituitary gland and also makes the uterus contract. Positive feedback occurs during birth. This where a change triggers more change in the same direction.

5.6.10

Rhythm method: refraining from sex when conception is most likely.

Barrier methods: condoms and diaphragms bar the sperm from meeting the egg.

Intra Uterine Devices (IUD): device that fits into the uterus and impedes the sperm's quest for the egg.

Vasectomy: the cutting of the vas deferens so that sperm cannot travel through the ejaculatory duct.

5.6.11 Abortion is one form of family planning- obvious issues here
The Pope is against contraception; its unnatural
I dunno. Any suggestions? (email me!! Samartyler@aol.com)

5.6.12 In amniocentesis, a syringe is inserted into the amnion through the abdomen. Sample amniotic fluid is then withdrawn. The fetal cells are cultured for 2-4 weeks. The cultured cells can then be karyotyped, and up to 400 chromosomal abnormalities can be detected. The test carries a 1% chance of causing spontaneous abortion.

In chorionic villus sampling, a small piece of tissue is removed from the chorion via the vagina for genetic and metabolic analysis. The test carries a 5-20% risk of spontaneous abortion, but results can be obtained earlier.

5.6.13 IN vitro fertilisation (IVF) can help infertile couples have children.

Removal of the egg- the egg is taken from the Graffian follicle in the ovary. The aim is to collect the egg a few hours before ovulation. To increase the chances of success, doctors arrange for the woman to produce a larger number of eggs than the single one normally formed during each menstrual cycle. She is made to produce many eggs through the use of hormone-based drugs.

Using ultrasound guidance, a hollow needle is inserted into the vagina, and through its wall into one of the follicles. The egg is then sucked out, and placed in a test-tube containing a special medium. This procedure is repeated for the other follicles. The eggs are then maintained in separate test tubes at 37 C in an incubator.

Meanwhile, the sperm are prepared. A few hours after collection, about 100,000 of the prepared sperm are added to each egg in a small petri dish. After

16- 20 hours the eggs are checked to see if they have been fertilised. The embryos are then left to develop for 2-3 days in the incubator. They can then be transplanted back into the uterus.

5.6.14 Not natural, playing god?

Possibility of multiple births?

Surrogacy?

Again, I don't know. But do email me if you do. – samartyler@aol.com

5.6.15

Research on improving methods of storing embryos- Further explanations are aimed at improving the procedures for freezing and storing embryos so that a woman can have the opportunity of receiving an embryo at a later date.

Research on chromosome abnormalities- Careful observation of human embryos created by IVF has revealed that about 1/3 of embryos have an abnormal chromosome content, preventing them from developing into blastocysts capable of implanting, or leading to the births of abnormal babies. It is thought that these sorts of chromosome abnormalities are responsible for about 50% of the 75, 000 miscarriages that occur in the UK each year.

Embryo screening- Diagnosis of many genetic disorders has been possible for some time by the techniques of amniocentesis and chronic villus sampling. The trouble is that these procedures can not be carried out until well into the pregnancy. If the diagnosis of genetic disorders could be carried out before implantation occurs, affected embryos could be discarded and only the healthy ones put back in the uterus.

Couples identified as 'at risk' of passing on genetic defects to their children can now attend for IVF and have their embryos screened.

Techniques are available which make it possible to remove one or more cells at an early stage in development- usually the 8-cell stage three days after fertilisation. The embryo is unharmed by this, In the meantime, the DNA in the isolated cell(s) is amplified by making it replicate repeatedly to a level at which standard methods for diagnosing genetic disorders can be applied. The healthy embryos can be placed in the uterus immediately, or frozen for embryo transfer on a future occasion. Any unhealthy embryos may then be discarded.