Edexcel IAL Biology A-level

Topic 2: Membranes, Proteins, DNA and Gene Expression

Definitions and Concepts

2.1-2.5: Gas Exchange and Membrane Transport

Active transport: The active movement of substances from a low concentration to a higher concentration (up their concentration gradient) with the use of energy in the form of ATP.

Adenosine triphosphate (ATP): The universal energy carrier found in all living cells.

Alveoli: Small air sacs found in the lungs at the end of bronchioles which provide a large surface area for gas exchange.

Carrier protein: Protein involved in active transport that uses energy in the form of ATP to change conformation.

Cell membrane: The semi-permeable membrane surrounding a cell's cytoplasm.

Channel protein: A transmembrane protein that can transport large or charged substances. Some are involved in facilitated diffusion and do not use ATP; others are involved in active transport and do require energy in the form of ATP.

Diffusion: The passive spreading out of substances from a high concentration to a lower concentration (down their concentration gradient) without the use of energy.

Endocytosis: The bulk uptake of substances into a cell by invagination of the membrane to form a vesicle trapping the substances inside the cell with the use of energy in the form of ATP.

Exocytosis: The bulk transport of substances out of a cell using a vesicle that fuses with the plasma membrane using energy in the form of ATP.

Facilitated diffusion: The net movement of substances from a high concentration to a lower concentration (down their concentration gradient) through transport proteins without the use of energy.

Fick's Law of Diffusion: The law that relates the rate of diffusion to the concentration difference, surface area and membrane thickness using the following equation:

$$Rate\ of\ diffusion \propto \frac{Membrane\ surface\ area \times Concentration\ difference}{Membrane\ thickness}$$

Fluid mosaic model: A model that describes membrane structure as a sea of mobile phospholipids studded with various proteins.

Osmosis: The net movement of water molecules across a partially permeable membrane from a region of high water concentration to a region of lower water concentration without the use of energy.

Passive transport: A process by which an ion or molecule passes through a cell wall via a

concentration gradient, without the use of energy. This can happen via simple or facilitated diffusion, osmosis, or filtration.

Permeability: The ease with which molecules cross biological membranes.

Water potential: A measure of the tendency of water molecules to move from one area to another measured in kilopascals (kPa) and given the symbol Ψ.

2.6-2.7: Proteins and Enzymes

Activation energy: The minimum amount of energy needed for a reaction to happen.

Active site: A specific region on an enzyme where the substrate binds and the reaction takes place.

Amino acid: The monomers containing an amino group (NH_2), a carboxyl group (COOH) and a variable R group that make up proteins.

Catalysis: Increasing the rate of a chemical reaction via the reduction in activation energy.

Collagen: A type of fibrous protein that provides strength to many different cell types and makes up connective tissues.

Competitive inhibitors: A molecule which binds to the active site of an enzyme and prevents the substrate from binding.

Condensation reaction: A type of reaction that joins two molecules together with the formation of a chemical bond involving the elimination of a molecule of water.

Denaturation: Upon exposure to high temperatures or extremes of pH, the permanent change in the tertiary structure of an enzyme and the shape of its active site, preventing it from carrying out its cellular function.

Enzyme-product complex: The temporary complex formed after the enzyme has catalysed the reaction but before the products have left the active site of the enzyme.

Enzyme-substrate complex: The temporary complex formed when the substrate binds to the active site of the enzyme.

Enzyme: A protein molecule that acts as a biological catalyst, reduces activation energy and increases the rate of biochemical reactions.

Extracellular enzyme: An enzyme which works outside of cells.

Fibrous protein: A class of long chain proteins that are generally insoluble in water and typically have structural roles.

Globular protein: A class of spherical shaped proteins that are generally water soluble and typically have metabolic roles.

Haemoglobin: A type of conjugated globular protein used to transport oxygen that is made up of four polypeptide chains each containing a haem prosthetic group.

Immobilised enzymes: Enzymes which are attached to an inert, insoluble material over which the substrate passes and the reaction takes place.

Induced-fit hypothesis: A model of enzyme action that describes how once a specific substrate binds to the active site, the enzyme undergoes subtle conformational changes to fit the substrate better.

Intracellular enzyme: An enzyme that works within cells.

Lock-and-key hypothesis: A model of enzyme action that describes how the enzyme will only fit a substrate that has the correct complementary shape to the active site.

Metabolism: The sum of all the enzyme controlled chemical reactions taking place in a cell.

Monohybrid inheritance: A genetic cross between two homozygous organisms.

Monomer: An individual unit that can be bonded to other identical monomers to make a polymer.

Non-competitive inhibitors: An inhibitor which binds to a different part of an enzyme known as the allosteric site and prevents the enzyme from functioning.

Peptide bond: A bond formed between the carboxyl group of one amino acid and the amino group of another in a condensation reaction.

pH: A measure of the acidity or alkalinity of a solution based inversely on the concentration of H^+ ions.

Polymer: A molecule made from many repeating monomers joined together.

Polypeptide: Molecules formed by the condensation of many amino acids.

Primary structure: The individual sequence of amino acids in a protein.

Proteins: Polymers of amino acids.

Rate of reaction: The change in concentration of reactants or products over time.

Secondary structure: The local interactions of the amino acids in the polypeptide chain.

Substrate specificity: The ability of an enzyme to catalyse only a specific reaction or set of

reactions which have substrates complementary to the active site of the enzyme.

Substrate: The molecule that is acted upon by an enzyme.

Tertiary structure: The way that the whole protein folds to make a three-dimensional structure.

2.8-2.14: Nucleotides and Nucleic Acids

Anti-sense strand: The strand of DNA which is used as a complementary template and is used for complementary mRNA synthesis.

Anticodon: A sequence of three nucleotide bases at one end of a tRNA molecule that is specific to an mRNA codon.

Coding DNA: The sections of DNA which code for proteins.

Codon: A nucleotide base tripled on messenger RNA that encodes a single amino acid.

Complementary base pairing: Describes how hydrogen bonds form between complementary purine and pyrimidine bases. Two bonds form between A and T in DNA or U in RNA. Three bonds form between G and C.

Degenerate (genetic code): A feature of the genetic code; more than one triplet can code for a particular amino acid.

Deletion mutation: A type of mutation where nucleotide(s) are not incorporated into the chain and are lost which results in a frameshift mutation.

Deoxyribonucleic acid (DNA): A double stranded polynucleotide that contains the genetic material of an organism and is made up of deoxyribonucleotide monomers joined together by phosphodiester bonds.

Deoxyribose: A modified sugar, lacking one oxygen atom.

DNA nucleotide: The monomer that makes up DNA and consists of deoxyribose, a nitrogenous base and a phosphate group.

DNA polymerase: An enzyme that catalyses the formation of phosphodiester bonds between nucleotides during the synthesis of a new DNA strand.

Gene mutation: A change to at least one nucleotide base in DNA or the arrangement of bases. Gene mutations occur spontaneously and may result in harmful or beneficial changes to the genotype.

Gene: A sequence of bases on a DNA molecule that codes for a sequence of amino acids in a polypeptide chain.✢

Genetic code: The rules by which triplets in a DNA base sequence code for the sequence of amino acids in a polypeptide chain. The genetic code is degenerate, universal and non-overlapping.

Helicase: An enzyme that catalyses the unwinding and unzipping of DNA in many processes like replication and transcription.

Hydrogen bond: A type of intermolecular bond between a δ+ hydrogen and a δ- atom such as oxygen or nitrogen which is used to hold together the secondary, tertiary and quaternary structures of proteins.

Insertion mutation: A type of mutation where extra nucleotide(s) are incorporated into the growing DNA chain which results in a frameshift mutation.

Messenger RNA (mRNA): A type of RNA that carries genetic information from the DNA in the nucleus to the ribosomes for translation.

Mononucleotide: A nucleotide consisting of one molecule each of a phosphoric acid, a sugar, and either a purine or a pyrimidine base.

Non-overlapping (genetic code): A feature of the genetic code; each base in a sequence is read once and is only part of one triplet.

Nucleotides: The individual monomers that make up polynucleotides which are composed of a phosphate group, pentose sugar and a nitrogenous base.

Phosphate: A group of molecules composed of one phosphate atom bound to multiple oxygen atoms.

Phosphodiester bond: A type of bond that joins nucleotides together to create polynucleotides.

Polynucleotide: A biopolymer composed of 13 or more nucleotide monomers covalently bonded in a chain.

Purines: A class of nitrogenous bases which are made up of two rings that adenine and guanine are members of.

Ribose: A ‘normal’ sugar, with one oxygen atom attached to each carbon atom.

Ribosomal RNA (rRNA): A type of RNA that makes up ribosomes.

RNA polymerase: An enzyme that catalyses the formation of phosphodiester bonds between nucleotides during the synthesis of a new RNA strand.

Semi-conservative replication: The replication of DNA to produce two new DNA molecules which both contain one new strand and one old strand from the original DNA molecule.

Sickle cell anaemia: A disease characterised by hook-shaped red blood cells. A missense point mutation of GAG to GTG in the HbA (normal) allele for the β-globin polypeptide results in the HbS (sickle cell) allele of the gene.

Start codon: A genetic codon in messenger RNA that stimulates the binding of a transfer RNA which starts protein synthesis.

Stop codon: A genetic codon in messenger RNA that signals the termination of protein synthesis during translation.

Substitution mutation: A type of mutation where the incorrect nucleotide is incorporated into the growing DNA chain.

Thymine: A pyrimidine nucleobase, which pairs with adenine (A), a purine nucleobase.

Transcription: The process of synthesising a new mRNA strand from a molecule of DNA.

Transfer RNA (tRNA): A type of RNA that has three hairpin loops, an anticodon for attachment to the mRNA codon and an amino acid binding site and is used to carry amino acids to the ribosome.

Translation: The process of protein synthesis where complementary tRNAs carrying amino acids are brought to each codon in an mRNA molecule as it moves through a ribosome.

Triplet (genetic code): A specific sequence of three nucleotides on a molecule of DNA or RNA codes for a particular amino acid in protein synthesis.

Universal (genetic code): A term used to describe the fact that the same codons code for the same amino acids in all organisms.

2.15-2.18: Gene Expression and Inheritance

Alleles: Different versions of the same gene.

Amniocentesis: Sampling the amniotic fluid to determine the sex of the foetus or any abnormalities that may be present during development.

Carrier: A person or other organism that has inherited a recessive allele for a genetic trait or mutation but does not usually display that trait or show symptoms of the disease. They can pass the allele onto their offspring, who may then express the genetic trait.

Chorionic villus sampling: Sampling the placenta to test for any genetic diseases that may be present in the developing foetus.

Codominant: When both alleles for a gene in a heterozygous organism equally contribute to

the phenotype.

Cystic fibrosis (CF): An autosomal recessive genetic disorder which causes the production of excess thick mucus.

Directional selection: A type of selection that favours one extreme phenotype and selects against all other phenotypes.

Disruptive selection: A type of selection where multiple extreme phenotypes are advantageous for different reasons and the average phenotype is selected against. This leads to speciation and changes in the population.

Dominant trait: A trait which is present if an individual has at least one copy of the allele.

Founder effect: A type of genetic drift in which a few individuals of a species are geographically isolated from the population and form a new colony. This results in smaller gene pools and an increased frequency of rare alleles.

Genetic drift: A gradual change in allele frequencies in a population over time due to chance.

Genotype: The genetic makeup of an organism.

Hardy-Weinberg principle: A principle that states that the frequency of alleles in a population will not change over time unless evolutionary factors are present. It can be used to calculate the frequencies of the other two genotypes when given the frequency of one genotype using the equation given below:

$$p^2 + 2pq + q^2 = 1$$

$$p^2 = \text{Frequency of homozygous dominant}$$

$$2pq = \text{Frequency of heterozygous}$$

$$q^2 = \text{Frequency of homozygous recessive}$$

Heterozygote: An organism which has two different versions of the same gene.

Homozygote: An organism which has two of the same versions of a gene.

Incomplete dominance: A type of inheritance where a dominant allele does not completely mask the recessive allele and so the trait produced is a combination of both alleles.

Gene mutation: A change to at least one nucleotide base in DNA or the arrangement of bases. Gene mutations can occur spontaneously during DNA replication and may be beneficial, damaging, or neutral.

Phenotype: The observable physical characteristics of an organism which is based on both the genotype and environmental influence.

Population bottlenecks: A significant reduction in population size which reduces the genetic diversity of a population.

Pre-implantation genetic diagnosis (PGD): A method used to diagnose diseases before implantation of the embryo into the uterus.

Prenatal testing: Testing performed before childbirth to determine the overall health of the developing foetus.

Recessive trait: A trait which is only present when an individual has two copies of the allele and can be masked by a dominant allele.

Red-green colour blindness: A perception defect that is caused by a mutation on the X-chromosome.

Selection pressures: Factors which lead to selection and survival of the fittest which drives evolutionary genetic changes over time.

Stabilising selection: A type of selection which selects against extreme phenotypes and produces a population with average phenotypes.

X chromosome: A sex chromosome, two of which are normally present in female cells (designated XX) and only one in male cells (designated XY).

Definitions denoted with a '✢' taken from: Pearson Edexcel International Advanced Subsidiary/Advanced Level in Biology – Specification – Issue 1 (September 2017)