

OCR (B) Biology A-level

Topic 4.1 - Energy, Metabolism and Exercise

Definitions and Concepts

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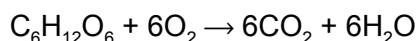


4.1.1 Cellular respiration

Acetyl coenzyme A (acetyl CoA) - A two-carbon molecule formed in oxidative decarboxylation when an acetyl group is bound by coenzyme A. It is oxidised in the Krebs cycle.

Adenosine triphosphate (ATP) - A nucleotide derivative consisting of a molecule of ribose joined to the nitrogenous base adenine and three phosphate groups which acts as the main energy currency in cells.

Aerobic respiration - A form of cellular respiration that takes place in the presence of oxygen and produces carbon dioxide, water and ATP. Overall:



Alcoholic fermentation - A type of fermentation that takes place in plant root cells and yeast cells, and produces ethanol and carbon dioxide.

Anaerobic respiration - A form of cellular respiration that takes place in the absence of oxygen. It produces less ATP than in aerobic respiration.

ATP synthase - An enzyme found embedded in cellular membranes that phosphorylates ADP to form ATP as protons flow through it.

Chemiosmotic theory - The synthesis of ATP through the movement of protons down their concentration gradient across a semipermeable membrane, catalysed by ATP synthase.

Decarboxylation - The removal of a carbon dioxide molecule.

Dehydrogenase - An enzyme that catalyses dehydrogenation.

Dehydrogenation - The removal of a hydrogen atom.

Electron carriers - Protein molecules that accept and release electrons, e.g. NAD.

Electron transport chain - A series of electron carrier proteins that transfer electrons in a chain of oxidation-reduction reactions.

Ethanol - A two-carbon alcohol produced during fermentation in plants and microorganisms.

FAD - A coenzyme that gets reduced when it takes up hydrogen atoms during the Krebs cycle, forming reduced FAD.

Glucose - A hexose monosaccharide that is the main respiratory substrate in eukaryotes.

Glycolysis - An anaerobic process that takes place in the cytosol of the cell and breaks down glucose into two molecules of pyruvate. Two molecules of ATP and two molecules of reduced NAD are also formed.



Krebs cycle - A series of oxidation-reduction reactions in the matrix of the mitochondria in which acetyl coenzyme A is oxidised, generating reduced NAD, reduced FAD, ATP and carbon dioxide.

Lactate - A substance produced when reduced NAD is re-oxidised during anaerobic respiration in animals.

Link reaction - The first stage of aerobic respiration (also known as the 'link reaction') that takes place in the mitochondrial matrix and converts pyruvate into acetyl coenzyme A and carbon dioxide. Reduced NAD is also formed. Overall:



Mitochondrial cristae - Folds of the inner mitochondrial membrane that provide a large surface area for oxidative phosphorylation.

Mitochondrion (pl mitochondria) - An organelle found in eukaryotic cells that is the site of aerobic respiration.

NAD - A coenzyme that becomes reduced when it takes up hydrogen atoms during aerobic respiration, forming reduced NAD.

Oxaloacetate - A four-carbon molecule that combines with acetyl coenzyme A to produce six-carbon citrate in the first stage of the Krebs cycle. It is eventually regenerated, allowing the cycle to continue.

Oxidative phosphorylation - The synthesis of ATP from reduced coenzymes and oxygen in the electron transport chain of aerobic respiration.

Pyruvate - A three-carbon molecule produced in glycolysis. In the link reaction of aerobic respiration, it is oxidised to acetate. During fermentation, it is converted to lactate (animals) or ethanol and carbon dioxide (plants and microorganisms).

Respiratory quotient (RQ) - The ratio of carbon dioxide produced to oxygen consumed during respiration. Calculated using:

$$\text{RQ} = \frac{\text{CO}_2 \text{ produced}}{\text{O}_2 \text{ consumed}}$$

Respiratory substrate - An organic molecule that can be broken down via the respiratory pathways to produce ATP.

Respirometer - A device used to determine respiration rate in living organisms by measuring the change in volume of oxygen or carbon dioxide.

Substrate level phosphorylation - The synthesis of ATP by the transfer of a phosphate group from a phosphorylated intermediate to ADP.



Triose phosphate (TP) - A three-carbon compound formed in glycolysis when a molecule of hexose bisphosphate splits.

4.1.2 Metabolism and exercise

Acetylcholine - A type of neurotransmitter present at cholinergic synapses.

Actin - A type of protein filament found in myofibrils. It forms thin filaments consisting of two long twisted chains.

Actin-myosin binding site - A site on actin that is normally blocked by tropomyosin. During muscle contraction, it becomes exposed, allowing a myosin head to attach.

Actin-myosin crossbridge - The cross-bridge formed when a myosin head attaches to the myosin binding site on an actin filament.

Aerobic fitness - Measures ability to use atmospheric oxygen in aerobic respiration to release energy for muscle cells. Affects a person's heart rate, breathing rate & recovery time.

Anabolic steroids - A class of performance enhancing drugs that are structurally similar to testosterone and are used illegally by athletes to promote muscle growth.

Anisotropic bands (A bands) - The darker bands in a myofibril, which consist of overlapping actin and myosin filaments.

Blood doping - Blood transfusion increases the number of red blood cells so more oxygen is supplied to tissues, delaying anaerobic respiration in endurance events. Transfusion may use blood from a compatible donor or an athlete's own blood which was collected and stored.

Carbohydrate loading - Increases glycogen level in muscle cells by increasing carbohydrate intake and reducing exercise for up to 6 days.

Carbonic anhydrase - An enzyme that catalyses the reversible reaction between water and carbon dioxide to produce carbonic acid.

Endomysium - Loose connective tissue with many capillaries that surrounds myofibrils.

Excess Post-exercise Oxygen Consumption (EPOC) - The amount of additional O_2 needed after exercise to return body systems to their previous state.

Fetal haemoglobin - Has higher oxygen affinity than adult haemoglobin because $p(O_2)$ is low by the time it reaches the fetus.

F.I.T.T. factors - Frequency, intensity, time and type of exercise need to be considered when designing an effective training program to improve aerobic fitness.



Glycogen - A highly branched polysaccharide that is used as the main energy storage molecule in animals and is made up of alpha glucose monomers joined by α -1,4 glycosidic bonds.

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.

Histology - The use of microscopes to study ultrastructure.

H-zone - The lighter region in the centre of each A band.

Isotropic bands (I bands) - The lighter bands in a myofibril, which consist of non-overlapping actin and myosin filaments.

Minute ventilation - The volume of air that can be exhaled or inhaled in a minute.

Myofibrils - Tiny contractile muscle fibres which group together. Numerous myofibril bundles constitute muscles. Myofibrils consist of two protein filaments: actin and myosin.

Myoglobin - A respiratory pigment found in muscle cells of mammals with high metabolic demands which only has one haem group and has a very high affinity for oxygen even at low partial pressures.

Myosin - A type of protein filament found in myofibrils. It forms thick filaments, consisting of long tails with bulbous heads, positioned to the side.

Neuromuscular junction - An excitatory synapse formed between a motor neuron and a muscle fibre that uses the neurotransmitter, acetylcholine.

Oxygen debt - See 'Excess Post-exercise Oxygen Consumption'.

Oxygen deficit - Volume of O_2 required during exercise minus volume of O_2 obtained.

Oxygen dissociation curve - A graph that describes the relationship between the partial pressure of oxygen and the percentage saturation of haemoglobin in the blood.

Power stroke - The myosin head changes shape and loses ADP, pulling actin over myosin.

Recombinant erythropoietin (RhEPO) - Injecting RhEPO hormone stimulates bone marrow to produce red blood cells.

Respiratory pigment - Conjugated protein with a prosthetic group that enables oxygen binding.

Sarcolemma - A structure in skeletal muscle that folds inwards towards sarcoplasm to form transverse (T) tubules.

Sarcoplasm - The cytoplasm shared by muscle fibres. It consists of a high concentration of mitochondria and endoplasmic reticulum.



Skeletal muscle - A voluntary muscle responsible for movement. It makes up the majority of body muscle and is attached to the skeleton by tendons.

Sliding filament theory - The mechanism by which a muscle contracts. During contraction, myosin filaments pull actin filaments to the centre of the sarcomere. The actin filaments slide along the myosin filaments. The sarcomere is shortened and the muscle length is reduced.

Stroke volume - The volume of blood pumped by the left ventricle of the heart in a single contraction.

Tidal volume - The volume of air that moves into and out of the lungs during a normal breath.

Transverse tubules (T tubules) - Tubules which run through striated muscle fibres and transmit the action potential.

Tropomyosin - A protein found in muscles that forms a fibrous strand wrapped around an actin filament.

Troponin - A protein which regulates the position of tropomyosin. When calcium ions bind to troponin, it changes conformation and causes tropomyosin to move.

VO₂ max - A measure of aerobic fitness which represents the maximum rate of oxygen being absorbed into the blood, transported & used by cells.

Z-line - The line in the centre of each I band.

