Photosynthesis:

The Chloroplast

- Thylakoids increase the surface area for light dependent reactions
- Thylakoid stacks are called grana
- Grana are connected by lamellae
- Light dependent reactions takes place on thylakoid membranes
- Light independent reaction (Calvin Cycle) takes place in he stroma

Function of a chloroplast

- Absorbs/traps/uses light
- For photosynthesis;
- Produces carbohydrates/sugars/lipids/protein.

The Light Dependent Reaction

- Takes place on the thylakoid membranes of the chloroplast
- Chlorophyll absorbs light energy
- Light energy excites / raises energy level of electrons in chlorophyll
- Electrons pass down electron transport chain
- Electrons reduce carriers / passage involves redox reactions
- Electron transfer chain along the thylakoid / grana membranes
- Energy released / carriers at decreasing energy levels
- Energy used to generate ATP from ADP and Pi / phosphorylation of ATP (photophosphorylation)
- Photolysis of water produces protons, electrons and oxygen
- NADP reduced by electrons and protons / hydrogen (from photolysis)
- Useful products are NADPH and ATP (used by Calvin cycle)
- Waste product is Oxygen

The Light Independent Reaction (Calvin Cycle)

- Takes place in the stroma of the cholorplast
- Carbon dioxide combines with ribulose bisphosphate (RuBP)
- Produces two molecules of glycerate-3-phosphate (GP)
- AQA & OCR: GP reduced to triose phosphate
- Edexcel: GP reduced to GALP
- Using reduced NADP (NADPH)
- Using energy from ATP
- Triose phosphate converted to useful organic substances e.g. Glucose / Lipids / Amino Acids
- RuBP is regenerated

Change in carbon dioxide over 24hrs :

- Higher carbon dioxide concentration at night/during darkness
- Photosynthesis only takes place during light
- Photosynthesis removes carbon dioxide and respiration adds carbon dioxide
- Respiration taking place throughout 24 hours
- Compensation point is when the rate of photosynthesis is equal to the rate of respiration

Respiration:

Glycolysis:

- Takes place in the cytoplasm
- Glucose is phosphorylated to form Hexose bisphosphate
- Using 2 molecules of ATP
- Hexose bisphosphate splits into two triose phosphate
- Triose phosphate is oxidised to form pyruvate
- This reduces two NAD to form reduced NAD (NADH)
- Producing 4 ATP
- Net yield is 2 ATP
- Pyruvate is actively transported into the matrix of the mitochondria

Link Reaction:

- Takes place in the matrix of the mitochondria
- Pyruvate is decarboxylated to form acetate
- Produces CO2
- Produces reduced NAD (NADH)
- Acetate combines with coenzyme A to form acetyl coenzyme A

Krebs Cycle AQA & Edexcel:

1. Takes place in the matrix of the mitochondria
2. Acetyl CoA reacts with a 4C molecule to form a 6C molecule
3. Krebs cycle produces reduced NAD (NADH) and reduced FAD (FADH)
4. 6C molecule is decarboxylated to form a 5 C molecule
5. ATP produced in Krebs cycle by substrate level phosphorylation
6. Reduced coenzymes carry / move hydrogen to oxidative phosphorylation

Krebs Cycle OCR:

1. Takes place in the matrix of the mitochondria
2. Acetyl CoA reacts with a oxaloacetate to form citrate
3. Krebs cycle produces reduced NAD (NADH) and reduced FAD (FADH)
4. Citrate is decarboxylated to form a 5 C molecule
5. ATP produced in Krebs cycle by substrate level phosphorylation
6. Reduced coenzymes carry / move hydrogen to oxidative phosphorylation

Oxidative Phosphorylation

- Takes place on the inner membrane (cristae) of the mitochondria
- Electrons released from reduced coenzymes (NADH/FADH)
- Electrons pass along the electron transport chain (ETC)
- In a series of redox reactions
- Energy released from ETC pumps protons (H+) into the inter-membrane space
- Creating a proton gradient
- Protons diffuse back into the matrix through ATP Synthase (chemiosmosis)
- Which joins ADP + Pi to form ATP
- Protons join with electrons and oxygen to form water
- Oxygen is the final electron acceptor
- Respiratory substrate completely respired / oxidised
- Lots of ATP produced

A2 CHEAT SHEET

Respiration:

ATP:

- Releases energy in small / manageable amounts
- Broken down in a one step / single bond broken
- Immediate energy compound / makes energy available rapidly
- Phosphorylates / adds phosphate to other molecules
- Makes phosphorylated substances more reactive
- Reformed / resynthesised / made again

Anaerobic respiration in animals and fungi:

- Takes place in the cytoplasm
- Pyruvate accepts hydrogen from reduced NAD / NADH to become lactate
- NAD is regenerated so it can be re-used
- This allows glycolysis to continue
- Only small amounts of ATP can be produced
- There's no oxygen to act as final electron acceptor
- So link reaction / Krebs cycle / oxidative phosphorylation cannot take place

Anaerobic respiration in plants and yeast:

- Takes place in the cytoplasm
- Pyruvate is decarboxylated to form ethanal (CO_2 is lost)
- Ethanal accepts hydrogen from reduced NAD (NADH) to become ethanol
- NAD is regenerated so it can be re-used
- This allows glycolysis to continue
- Only small amounts of ATP can be produced
- There's no oxygen to act as final electron acceptor
- So link reaction / Krebs cycle / oxidative phosphorylation cannot take place
- Cannot be reversed as carbon dioxide is lost

Homeostasis:

Raising Body Temperature:

- Thermoreceptors in skin stimulated by decrease in external temp
- Blood temperature monitored in hypothalamus / sensory cortex
- Vasoconstriction of arterioles to reduce heat loss
- Prevents heat loss by radiation / conduction / convection
- Increased metabolic rate / metabolism / respiration to generate heat (energy)
- Release of adrenaline / thyroxine
- Shivering to generate heat (energy)
- Erector / hair muscles contract to raise hair / fur
- To trap warmer air / heat close to skin
- No sweating

Cooling Body Temperature:

- Thermoreceptors in skin detect increase in external temp
- Blood temperature monitored in hypothalamus / sensory cortex
- Vasodilation of arterioles to increase heat loss
- Heat loss by radiation / conduction / convection
- Decreased metabolic rate / metabolism / respiration to reduce generating heat (energy)
- No release of adrenaline / thyroxine
- No shivering
- Erector / hair muscles relax – hair/ fur lies flat
- Sweat glands release sweat
- Sweat evaporates which removes heat from the skin

Nerves & Hormones:

Sympathetic Nervous System

- Neurotransmitter is noradrenaline
- Speeds things up
- Increases heart rate / cardiac output / blood pressure
- Increases speed / rate / depth of breathing
- Increases blood flow to skeletal muscle
- Responsible for fight / flight / stress
- Dilates pupils
- Makes liver release glucose (glycogenolysis)

Parasympathetic Nervous System

- Neurotransmitter is acetylcholine (at organ)
- Reduces this heart rate / cardiac output / blood pressure
- Decreases heart rate / cardiac output / blood pressure
- Decreases speed / rate / depth of breathing
- Responsible for rest / relaxation / calm
- Increases blood flow to gut / smooth muscle
- Constricts pupils
- Makes liver store / take up glucose (gylcogenesis)

Hormone and Neurone control of heart rate:

- Adrenaline increases heart rate / stroke volume / cardiac output
- Cardiovascular centre in medulla oblongata
- Has a nervous connection to SAN (sino-atrial node)
- Which controls frequency of waves of excitation / depolarisation
- Parasympathetic nervous system decreases heart rate
- Sympathetic nervous system increases heart rate
- High blood pressure detected by stretch receptors / baroreceptors
- Low blood pH / increased levels of blood CO2 detected by chemoreceptors
- Receptors in aorta / carotid arteries

Resting Potential:

- Sodium-potassium pump
- Pumps sodium ions (Na+) out of neurone
- Pumps potassium ions (K+) into neurone
- By active transport (uses ATP)
- K+ ion channels are open
- Some K+ diffuse back out (of neurone / cell)
- Fewer Na+ channels open, so less Na+ diffuses back in
- Voltage-gated (Na+) channels closed
- Membrane potential approx. -70mV

Threshold & Depolarisation

- Stimulus causes some sodium ion channels to open
- Generator potential - membrane potential changes (makes inside of axon less negative)
- Some voltage-gated Na+ channels open
- Na+ diffuses into of the axon / neurone
- This causes more voltage-gated Na+ channels open (positive feedback)
- Threshold is reached
- All voltage-gated Na+ ion channels open
- Na+ diffuses into of the axon / neurone
- Depolarisation ends at approx. +30mV

Nerves & Hormones:

Repolarisation:

- Voltage-gated K+ ion channels open
- K+ diffuses out of axon / neurone

Hyperpolarisation:

- (Voltage-gated) K+ ion channels are slow to close
- Membrane potential more negative than resting potential
- Resting potential re-established by the sodium-potassium pump

Myleinated Neurones

- Action potential conduction is faster in myelinated neurones
- Schwann cell produces myelin which provide electrical insulation
- Prevents depolarisation / movement of ions (in / out of neurone / axon)
- Depolarisation / action potentials can only occur where Na+ channels are present
- Myelinated neurones have long(er) sections with no Na+ channels present
- Depolarisation / ion movement can only take place at the gaps / nodes of Ranvier
- Saltatory conduction / action potential jumps from node to node

Role of Synapses:

- Allows neurones to communicate / cell signalling
- Ensure transmission between neurons is unidirectional / in one direction (only)
- Allows convergence / impulses from more than one neurone to be passed to a single neurone
- Allows divergence / impulses from a single neurone to be passed to more than one neurone
- Filter out low level stimuli / ensures that only stimulation that is strong enough will be passed on
- Prevents fatigue / prevents over-stimulation
- Allows many low level stimuli to be amplified
- Presence of inhibitory and stimulatory synapses allows impulses to follow specific path
- Allows memory / learning / decision making

Transmission Across A Synapse:

- Action potential arrives at the presynaptic membrane
- Calcium (Ca2+) ion channels open
- Ca2+/ calcium ions diffuse into presynaptic knob
- Acetylcholine / neurotransmitter in vesicles
- Vesicles move towards presynaptic membrane
- Vesicles fuse with membrane
- Release acetylcholine by exocytosis into synaptic cleft
- Acetylcholine / diffuses across the synaptic cleft
- Acetylcholine binds to receptors on the post synaptic membrane
- Receptors cause Na+ channels to open
- Na+ diffuses into post synaptic membrane
- If threshold is reached an action potential is initiated
- Acetylcholine / hydrolysed by acetylcholinesterase
- Products diffuse back across the synaptic cleft to presynaptic knob
- Products re-synthesised into acetylcholine

Nerves & Hormones:

Inhibition of a Synapse:

- Inhibitor binds to / occupies / competes for acetylcholine receptor on postsynaptic membrane.
- This prevents acetylcholine binding / blocks binding site / blocks receptor
- Ion channels / sodium channels do not open / remain closed
- Na+ cannot enter / K+ cannot leave neurone
- No / insufficient depolarisation / excitatory postsynaptic potential / generator potential
- Post synaptic membrane does not reach threshold

Why synapses are unidirectional.

- Acetylcholine released from presynaptic side
- Diffusion from higher concentration to lower concentration
- Receptors only on postsynaptic membrane

Strength of a stimulus

- Only stimuli that reach threshold produce an action potential
- All or nothing law - either an action potential occurs or it does not
- Action potentials are all the same magnitude / size, no matter how strong the stimulus
- A strong stimulus produces many action potentials (in rapid succession)

Muscles

Sliding Filament Theory:

- Cross bridges between actin and myosin
- 'Power stroke' / movement of myosin heads / pulling of actin
- Detachment of myosin heads
- Myosin heads move back/to original position / 'recovery stroke.

Calcium ions and ATP

- Calcium ions diffuse into myofibrils from (sarcoplasmic) reticulum
- Edexcel: Ca2+ binds to troponin which moves the tropomyosin
- AQA & OCR: Calcium ions cause tropomyosin to move
- Exposing the actin-myosin binding sites (on the actin)
- Myosin heads attach to binding sites on actin
- Hydrolysis of ATP releases energy which causes myosin heads to bend (power stroke)
- Actin pulled towards the centre of myosin
- ATP needed to detach myosin heads (break the cross bridge)
- Calcium ions activate ATPase (which hydrolyses ATP to ADP and Pi)
- ATP required to return myosin head back to start position (recovery stroke)

Energy & Ecosystems:

Energy Transfer Through An Ecosystem:

- Efficiency of photosynthesis in plants is low (approximately 2%)
- Some light energy fails to strike / is reflected / not of appropriate wavelength
- Energy loss by respiration
- Energy lost via faeces / undigested food / part of organism not eaten
- Energy lost as heat
- Efficiency of transfer to consumers greater than transfer to producers / approximately 10%
- Efficiency lower in older animals / herbivores / primary consumers / warm blooded animals / homoiotherms
- Carnivores use more of their food than herbivores.

How farming livestock increases net productivity:

- Slaughtered when still growing / before maturity / so more energy transferred to biomass / tissue production
- Fed on controlled diet so higher proportion of food digested
- Lower proportion of energy lost in faeces
- Movement restricted so less respiratory loss / less energy used
- Kept inside / heating/shelter / no predators
- Genetically / artificially selected for high productivity.

Succession:

- Colonisation by pioneer species
- Pioneer species change the environment
- Give example e.g. increase in soil depth / nutrient availability (e.g. Nitrate ions)
- This change enables other species to colonise / survive
- New species outcompetes pioneer species
- Increase in number of species / biodiversity / increase in total amount of living material / biomass / more niches / increase in nutrient availability / change from more extreme conditions / more stability
- Climax community

Climax Community:

- Has high biodiversity / soil depth / nutrient availability
- Balanced / dynamic equilibrium between species
- Has a dominant plant or animal species
- Succession does not continue
- Stable assuming no change to environment / human influence

Limits to population size (carrying capacity)

- Named nutrient availability e.g. nitrate ions
- Numbers of producers providing energy / light intensity affecting the rate of photosynthesis
- Disease killing some members of species / predation
- Number of niches e.g. trees / space for nest building
- Intraspecific competition for a named limited resource
- Interspecific competition explained

Energy & Ecosystems:

Sampling:

- Large sample size improves reliability (reduces sampling error)
- Random sampling to avoid bias
- Control all other variables
- Standardise sampling method
- At least 5 repeats
- Mean value determined
- Standard deviation measures the average variance form the mean
- Sample at different times of day / season / weather conditions
- Replicate the study (same method different location / investigator)
- Perform a statistical test

Reasons Why Field Experimental Results are not fully reliable:

- For results to be scientifically valid
- Only one factor can to be varied / changed at once
- Other factors need to be kept constant
- There are many biotic factors in the field
- These factors are difficult to control

Quadrats:

- Used to record organisms that don't move (or move very slowly)
- Use a grid / split area into squares / sections
- Random coordinates e.g. calculator / computer / random number generator
- Number of individuals in each quadrat counted / recorded
- Calculate mean number (per quadrat / section)

Sympatric Speciation:

- Occurs in the same habitat / environment / population
- Reproductive isolation / gene pools remain separate
- Due to behavioural / seasonal / morphology (anatomy) reasons
- No gene flow between populations
- Different allele(s) passed on / selected
- Change in allele frequency
- Occurs over a long period of time / many generations
- Eventually different species cannot interbreed to produce fertile offspring

Allopatric Speciation:

- Geographical isolation
- Separate gene pools / no interbreeding between populations
- Variation exists in the populations due to mutation
- Different environmental conditions / selection pressures
- Selection for advantageous characteristics / mutation / allele
- Differential reproductive success / better adapted organisms survive and reproduce
- Leads to change in allele frequency
- Occurs over a long period of time / many generations
- Eventually different species cannot interbreed to produce fertile offspring

Energy & Ecosystems:

The Nitrogen Cycle:

- Nitrogen exists in organisms as proteins /amino acids / DNA / RNA
- Proteins /amino acids / DNA / RNA converted (oxidised) into ammonium ions (ammonification)
- By saprobionts (extracellular digestion by enzymes)
- Ammonium ions converted (oxidised) into nitrite (nitrification)
- OCR: by nitrosomonas
- Nitrite converted (oxidised) into nitrate (nitrification)
- OCR: by nitrobacter
- Nitrates absorbed by plants to make proteins /amino acids / DNA / RNA
- Nitrates converted to nitrogen gas (denitrification)
- By bacteria in anaerobic respiration (waterlogged soil)
- Nitrogen gas converted to ammonium ions
- By nitrogen-fixing bacteria (OCR: Rhizobium in legumes and Azotobacter)

Gene Technology:

Restriction Enzymes:

- Use a restriction enzyme / endonuclease
- To cut out / isolate target gene / DNA coding for protein
- Cuts DNA at palindromic recognition sites
- Leaves sticky ends

Gene Machine / Sequence

- Sequence target protein
- Work out the primary structure
- Work out the base code of DNA triplets
- Synthesuse this DNA sequence

Inserting A Target Gene:

- Mix recombinant plasmid with bacteria
- Put into ice cold calcium chloride
- Heat shock
- If recombinant DNA is taken up bacteria are transformed

Reverse transcriptase:

- Obtain mRNA for desired protein
- Use reverse transcriptase
- Makes complimentary DNA (cDNA)
- Complimentary DNA (cDNA) is single standed
- Complimentary DNA (cDNA) does not contain introns

Plasmid Vectors:

- Cut plasmid open
- Using same restriction enzyme
- Complimentary base pairing of sticky ends (annealing)
- Join sugar-phosphate backbones
- Using DNA ligase
- Forming recombinant DNA / vector / plasmid

Marker Genes:

- Used to tell if a target gene has been taken up
- Easily identifiable (fluorescence / antibiotic resistance)

Gene Technology

Electrophoresis:

- DNA sample, e.g. blood, saliva, semen
- Small samples of DNA can be amplified by PCR
- Restriction enzymes to hydrolyse DNA into small pieces
- DNA is negatively charged
- Electric current / charge is applied
- DNA moves towards the positive electrode
- Smaller pieces move faster (therefore further in a given time)
- DNA stained and shows up as bands / bars

DNA Profiling / Fingerprinting

- AQA: DNA contains variable number tandem repeats (VNTR's)
- OCR & Edexcel: DNA contains repetitive non-coding base sequences
- Individuals have different numbers of repeats
- Multiple copies of DNA made from a range of people
- Using PCR / polymerase chain reaction
- Restriction enzymes used to produce DNA fragments
- Electrophoresis to separate the fragments of DNA
- Total number of DNA bands compared
- Position of DNA bands compared
- Individuals can be identified by their DNA profile / fingerprint

Use of DNA Profiling / Fingerprinting to study plants and animals:

- Comparisons made between DNA from fossils and other organisms
- To find genetic relationships / how closely related
- Used in taxonomy / classification
- To understand phylogeny / evolutionary relationships

Polymerase Chain Reaction

- DNA polymerase
- Primers (complimentary to the promoter region)
- Free DNA nucleotides
- Heat to 90-98 oc to separate the double stranded DNA
- Cool to 50-65 oc to allow the primers to bind (anneal)
- Heat to 70-75 oc so DNA polymerase can synthesise new DNA quickly
- Cycle repeated many times

DNA Profiles not 100% conclusive:

- DNA profiling / fingerprinting has several stages
- Artefacts / contamination can arise at any stage
- Only a few sequences / small portion of DNA analysed
- It's possible to get two identical profiles from unrelated individuals
- Identical twins / closely-related individuals may show same profile

Practical Skills

Practical Skills:

- Use a range of at least 5 different independent variables
- Repeat at least 5 times
- Take mean values
- Standardise the source of biotic materials e.g. all from same parent plant, same age
- Control all other variables e.g. temperature / light intensity / pH / duration etc.
- Replicate the study (same method different location / investigator)
- Perform a statistical test