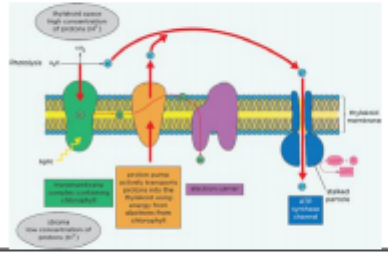
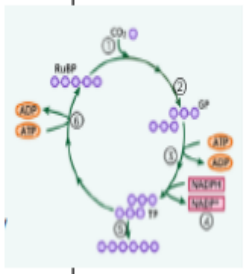
Biology: Energy Transfers Between Organisms

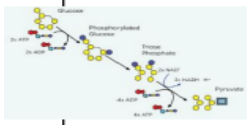
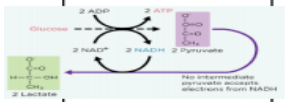
Photosynthesis— Light Dependent Reaction

Where?	Occurs in the thylakoids of the grana in chloroplasts.
Non-cyclic photophosphorylation 	Chlorophyll molecules absorb light energy via photosystem II, exciting a pair of electrons to a higher energy level, leaving the chlorophyll molecules ionized. The electron passes through an electron transfer chain to produce ATP, and reaches photosystem I. The electrons replace the electrons lost in photosystem I when it absorbs light to reduce NADP with the protons created from photolysis ◦ The photoionized chlorophylls electrons in photosystem II are replaced by the electrons from photolysis of water.
Cyclic photophosphorylation	Only uses photosystem I, where the electrons are passed back to photosystem I rather than NADP via electron carriers, producing small amounts of ATP

Photosynthesis— Light Independent Reaction (the Calvin Cycle)

1	Where?	The stroma of chloroplasts
2	Key information 	The Calvin cycle depends on the products from the light dependant stage (reduced NADP and ATP). The fixation of carbon dioxide is catalysed by enzyme Rubisco. Forms GP (glycerate-3-phosphate), which is then reduced to TP (triose phosphate) using ATP. Meanswhile, NADP reoxidises. 5 out of every 6 TP molecules are used to regenerate RuBP. 1 is for producing hexose sugars (e.g. glucose).

Respiration—Anaerobic

1	Glycolysis 	First stage of aerobic and anaerobic respiration. It occurs in the cytoplasm. Glucose is phosphorylated (using 2 ATP) and forms 2 molecules of TP. TP is then oxidised to 2 Pyruvate (NAD is reduced and 4 ATP molecules released by substrate level phosphorylation). There is a net yield of 2 pyruvate, 2 reduced NAD and 2 ATP molecules.
2	Why does it occur?	If oxygen is not available (the final electron acceptor).
3	In mammals – lactate fermentation 	Pyruvate is reduced to lactate using NADH (which becomes reoxidised). Lactate can be converted to glycogen in the liver or oxidized further to release energy, when oxygen is available.
4	In plants and fungi – alcoholic fermentation	Pyruvate + reduced NAD → ethanol + carbon dioxide + oxidised NAD. Not reversible like lactate fermentation.

Key Vocabulary

Photolysis	Light energy splits 2 water molecules into 4 electrons, 4 hydrogen ions (protons) and an oxygen molecule (light-dependent reaction). These electrons replace the electrons lost from a chlorophyll molecule when light strikes it.
Oxidation	Loss of electrons or loss of hydrogen or gain of oxygen with a substance
Reduction	Gain of electrons or gain of hydrogen or loss of oxygen from a substance
Co-enzyme	A non-protein compound that is necessary for the functioning of an enzyme. (NOT AN ENZYME!) Play a huge role in photosynthesis and respiration where they carry hydrogen atoms from one molecule to another. E.g. NAD, FAD and NADP.
Photoionisation	Process by which a chlorophyll molecule becomes ionised. Caused by the chlorophyll molecule absorbing light energy and boosting the energy of a pair of electrons within a chlorophyll molecule, raising them to a higher energy level and they become so energetic they leave the chlorophyll molecule altogether and are taken up by an electron carrier.
Limiting factor	A variable that limits the rate of a chemical reaction e.g. temperature, light intensity and CO_2 availability

Required Practical's 7 and 8

1	RP 7	Chromatography can be used to separate out photosynthetic pigments, identifying them by their *Rf* value.	2	RP 8	Investigating factors affecting dehydrogenase activity in extracts of chloroplasts (DCPIP goes from blue→colourless when reduced).

$$R_f\ value = \frac{Distance\ travelled\ by\ spot}{Distance\ travelled\ by\ solvent}$$

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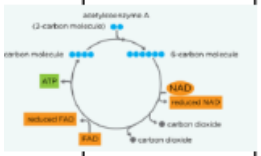
Stages of Respiration—aerobic

1	Following glycolysis – the link reaction	In presence of oxygen, pyruvate is actively transported into mitochondrial matrix. Here it is oxidised to acetate, then combined with coenzyme A to acetyl CoA. (CO_2 is released by decarboxylation).
2	The Kreb's cycle – De Na De Na A Fa Na 	Acetyl CoA combines with oxaloacetate and this compound is oxidised until oxaloacetate reforms. Decarboxylation, dehydrogenation (removal of H atoms) and substrate level phosphorylation occur. This produces 2 CO_2, 2 reduced NAD, 1 reduced FAD and 1 ATP for every turn (2 turns for every glucose due to 2 pyruvate entering link reaction.
3	Electron transport chain	Reduced NAD and FAD donate electrons to the electron transport chain in the inner mitochondrial membrane. Oxidative phosphorylation occurs and chemiosmosis. Oxygen is final electron acceptor as well as the protons to form water.

Required Practical 9

Investigation into the effect of a factor on the rate of respiration of yeast e.g. temperature. Measured by time taken to decolourise methylene blue (faster = greater rate of respiration).

Respiratory substances

Lipid	Hydrolysed to fatty acids and glycerol. Glycerol is phosphorylated and converted to triose phosphate, which enters the glycolysis pathway The fatty acid part is broken down into 2-carbon fragments which are subsequently converted into acetyl CoA, also generating reduce NAD & FAD
Protein	Protein is hydrolysed to amino acids. In the liver, the amino group is removed (deamination), and the amino group is converted to urea and removed in the urine. The remaining amino acid can then be converted to an intermediate

Key Vocabulary Respiration

Phosphorylation	Process which makes glucose more reactive by adding 2 phosphate molecules.
Substrate level phosphorylation	Happens in plant and animal cells when phosphate groups are transferred from donor molecules to ADP to form ATP.
Oxidative phosphorylation	The formation of ATP in the electron transport chain of aerobic respiration. Happens in the mitochondria within the inner folded membrane (cristae). It involves the transfer of electrons down a series of electron carrier molecules.
Chemiosmosis	Theory of oxidative phosphorylation. As electrons flow along the chain, they release energy which causes the active transport of protons across the inner mitochondrial membrane which means a concentration gradient of protons is maintained with a higher concentration of protons in the inter-membranal space than in the mitochondrial matrix. They then diffuse back into the mitochondrial matrix through ATP synthase channels which forms ATP.

Fertilisers

Fertilisers can be used to provide plants with minerals, particularly nitrates, to support their growth In agriculture systems, the harvesting of crops prevents the reintroduction of minerals to the soil.

1 – Leaching (see keyword definitions)

2 – Reduced species diversity: Nitrogen rich soils are only favourable to rapidly growing species

3 – Eutrophication: Nitrate levels increase in rivers and lakes due to leaching. The increased plant growth (usually algae) blocks light from and kills plants below the surface. Increased number of saprobionts are respiring, reducing oxygen levels. This kills aquatic organisms like fish.

Biomass

Definition	The total mass of living material in a specific area at a given time. Usually measured in gm^{-2}. Fresh mass is quite easy to assess, but varies depending on the water content. Measuring dry mass overcomes this problem but the organism must be killed, it is usually only a small sample and may not be representative.
Where does it come from?	Plants synthesise organic compounds from atmospheric, or aquatic, carbon dioxide. Most of the sugars synthesised by plants are used as respiratory substrates. The rest are used to make other groups of biological molecules, forming the biomass of the plant.
Calorimetry	Dry biomass shows the chemical energy store in an organism and can be measured by the process of calorimetry. A dry sample is weighed and burnt in pure oxygen within a sealed chamber, the temperature increase of the fixed volume of water is used to calculate the energy released.

Productivity

Definition	The energy store available in biomass, the more energy, the more productive. Important to increase productivity in agriculture.
Net production	(N) is the total chemical energy consumers store after energy losses to faeces, urine and respiration have been taken away from the chemical energy store of the ingested plant food. **N = I - (F + R)** ◦ Where N is net production, I represents the total chemical energy store in ingested food, F is the energy lost in faeces and urine, and R is energy lost to respiration. All use units (kJ m-2 yr-1)
Primary and secondary	See GPP and NPP
Efficiency	The percentage efficiency of energy transfer from one trophic level to another can be calculated as $\left(\frac{\text{energy available after the transfer}}{\text{energy available before the transfer}}\right) \times 100$
Increasing productivity in farming	Reducing respiratory loses in a human food chain e.g. reduce movement of animals Simplifying food chains to reduce energy loss to non-human food chains e.g. killing weeds and pest using herbicides and insecticides

Key Vocabulary Ecology

Trophic level	Each stage in a food chain
GPP (primary)	Gross primary production which is the total quantity of the chemical energy store in plant biomass, in a given time. Plants use 20-50% of this energy in respiration.
NPP (secondary)	Gross primary production – respiratory losses. The chemical energy store which is left when these losses to respiration have been taken into account. This is available for plant growth and reproduction and available to other trophic levels in the ecosystem (such as consumers and decomposers).
Pyramid of Number	A pyramid drawn with bar lengths proportional to the numbers of organisms present

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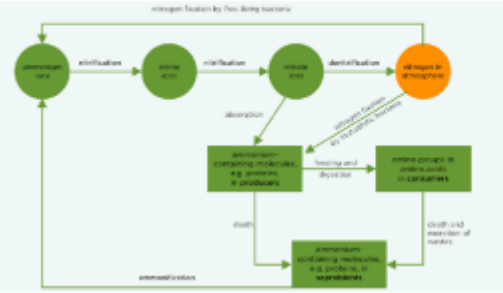
Nutrient Cycles

Nitrogen cycle



Nitrogen fixation – bacteria transform inert (unreactive) nitrogen gas in the atmosphere to ammonium ions. These are either found in soil or on root nodules of leguminous plants. Can also be done chemically by lightning.

Ammonification – decomposers break down proteins and urea in dead plants and animals to produce ammonia containing molecules.

Nitrification – nitrifying bacteria convert ammonium ions first into nitrites and then different nitrifying bacteria convert nitrites to nitrate ions (nitrates). Nitrates are absorbed by plants to make proteins – passed onto animals as they eat plants and use the amino acids to make their own proteins. Mycorrhizae fungi help to increase the surface area of plant roots to aid absorption (this is a symbiotic relationship).

Denitrification – denitrifying bacteria convert nitrates back into atmospheric nitrogen (they work in anaerobic conditions)

Phosphorus cycle

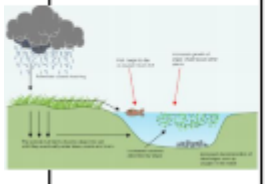
Phosphorus in fertilizer and rocks is distributed by rain to nearby land and bodies of water. Animals eat the plants grown by fertilizer. They expel the phosphorus as waste. It eventually reaches the water as runoff. Phosphorus is cycled through animals that live in water. It is eventually deposited into the ocean floor where it will eventually become sedimentary rock. Erosion of rock restarts the cycle.

Key Vocabulary

Ecosystem	All the living and non-living components of a particular area.
Saprobiontic microorganism	Also known as saprophyte – an organism that obtains its food from the dead or decaying remains (detritus) of other organisms.
Detritrivores	Organisms that help saprophytes do their job. They feed on pieces of dead and decaying material and finely break it up increasing its surface area.
Decomposer	Any organism which breaks down organic matter. Include saprophytes and detritivores.
Symbiotic	When two species live in close proximity. Mutualistic is a type of symbiotic relationship where the relationship is mutually beneficial for two organisms.

Leaching

Leaching



Process by which nutrients are washed from the soil into watercourses. Rainwater will dissolve any soluble nutrients, such as nitrate ions and carry them deep into the soil, eventually beyond the reach of plant roots.