St. Ambrose College

A Level Biology (Year 12)

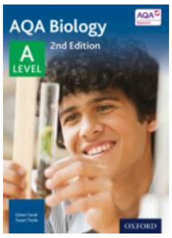
Knowledge Organiser: Unit 1 Biomolecules (1.5-1.8)

1.5 Nucleic acids
1.6 ATP
1.7 Water
1.8 Inorganic ions

For every 1 hour A Level Biology lesson you are expected to spend at least 1 hour independently reviewing the subject content. The following resources should be referred to regularly to support your independent work.

You have been provided with a printed copy of the full subject specification (also available on the AQA website https://www.aqa.org.uk/subjects/science/as-and-a-level/biology-7401-7402/specification-at-a-glance). Use this to follow the learning in lessons…track your progress and be aware of what is still to come.

kerboodle



Use the textbook on www.kerboodle.com after every lesson to develop your understanding. Read the relevant pages, add detail to your class notes and complete the summary tasks. Create your own summary notes/flashcards for future use in the run up to exams.

Unit 1 Biomolecules pg4-55 Nucleic acids (pg36-45) ATP (pg46-47) Water + ions (pg 48-49)

SENECA www.senecalearning.com

Use regularly between lessons to review basic content and to become more familiar with key terminology. https://senecalearning.com/en-GB/

PMT •resources•tuition•courses

Access detailed revision notes, key definitions, flash cards, past paper questions and mark schemes. https://www.physicsandmathstutor.com/biology-revision/a-level-aqa/

As an A Level student you are expected to take a proactive approach to your studies; arrive to lessons fully equipped and prepared for what you will be learning about (read ahead in the specification/textbook), focus and participate in lessons, ask for help/clarification when you are unsure and spend time after the lesson consolidating/embedding new learning.

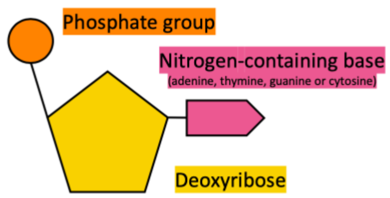
1.5.1 Nucleic acids: structure of DNA & RNA

Function of DNA & RNA

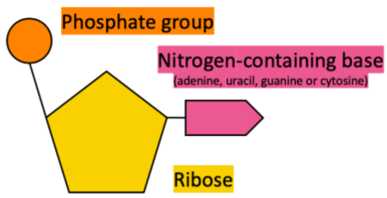
- Deoxyribonucleic acid (DNA) holds **genetic information**
- Ribonucleic acid (RNA) **transfers genetic information from DNA to ribosomes** Ribosomes are formed from RNA and proteins

Structure of DNA & RNA nucleotides and polymers

Single DNA nucleotide (monomer)



Single RNA nucleotide (monomer)

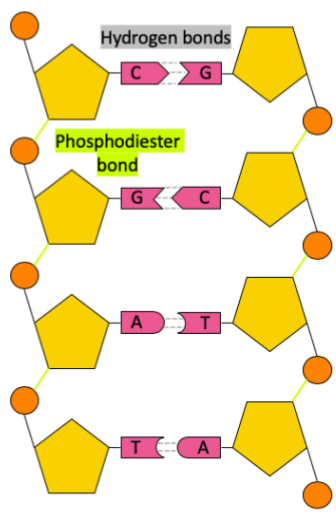


- Nucleotides contain a pentose sugar, a nitrogenous base and a phosphate group
- Nucleotides (monomers) make DNA or RNA which are nucleic acids (polymers)
- DNA or RNA nucleotides are joined together by condensation reactions forming **phosphodiester bonds**
- DNA: 2 strands joined in anti-parallel, held together by hydrogen bonds between specific complementary base pairs (A-T and C-G), twisting into a double helix
- RNA: singe RNA polynucleotide strand

The differences between DNA and RNA nucleotides

- DNA nucleotides have the pentose sugar **deoxyribose**, whereas RNA nucleotides have the pentose sugar **ribose**
- DNA nucleotides can have the base **thymine**, whereas RNA nucleotides have **uracil** instead

DNA molecule (polynucleotide chain)



The differences between DNA and RNA molecules

- DNA molecules are **double stranded** (double helix), whereas RNA molecules are single stranded
- DNA is **longer** whereas RNA is shorter

Exam tip: *examiners can be picky when it comes to* ***comparison*** *questions.*

*To get the marks, try and include '**whereas**' to ensure you have covered both sides*

Structure of DNA related to its functions

- Double stranded → both strands can act as templates for semi-conservative replication
- Weak hydrogen bonds between bases → can be unzipped for replication
- Complementary base pairing → accurate replication
- Many hydrogen bonds between bases → stable / strong molecule
- Double helix with sugar phosphate backbone → protects bases / H bonds
- Long molecule → store lots of (genetic) information (that codes for polypeptides)
- Double helix (coiled) → compact

Exam tip: *you can use incomplete information about the frequency of bases on DNA strands to find the frequency of other bases by remembering the base pairing rule. 100% = all bases.* ***% guanine = % cytosine*** *and* ***% adenine = % thymine.***

1.5.2 Nucleic acids: DNA replication

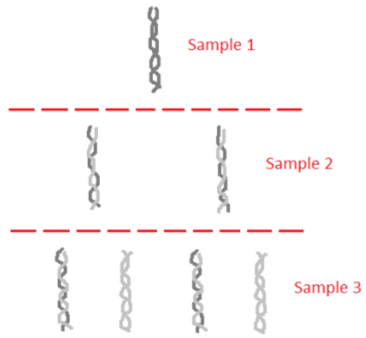
Process of DNA replication

1. **DNA Helicase breaks hydrogen bonds** between bases, **unwinds** double helix
2. = two strands which both act as **templates**
3. **Free floating DNA nucleotides** attracted to exposed bases via **specific complementary base pairing**, **hydrogen bonds** form (**adenine-guanine; guanine-cytosine**)
4. **DNA polymerase joins adjacent nucleotides** on new strand by condensation, forming **phosphodiester bonds** (= sugar phosphate backbone)
5. Replication is **semi-conservative** – each new strand formed contains one original / template strand and one new strand
6. Ensures **genetic continuity** between generations of cells

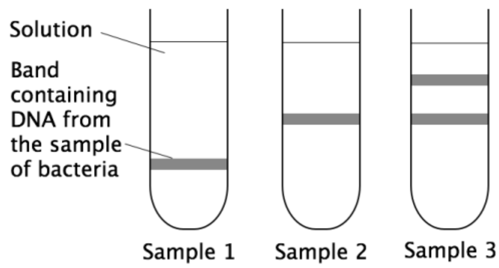
DNA polymerase moves in opposite directions along the DNA strands

- DNA has **antiparallel** strands
- DNA polymerase is an enzyme with a **specific shaped active site** which can only bind to substrate with a complementary shape
- Can only bind to and add nucleotides to the **phosphate (3') end** of the developing strand (so works in a 5' to 3' direction)
- Note - 5' ("5 prime") and 3' ("3 prime") indicate the carbon numbers in DNA's sugar backbone; 5' carbon has a phosphate group attached and 3' carbon has a hydroxyl (-OH) group

Evidence for semi-conservative replication (Meselson and Stahl)



- Bacteria grown in a nutrient solution containing **heavy nitrogen (^{15}N)** for several generations
- Nitrogen **incorporated into bacterial DNA bases**
- Bacteria then transferred to a nutrient solution containing **light nitrogen (^{14}N)** and allowed to **grow and divide twice**
- During this process, DNA from different samples of bacteria was extracted, suspended in a solution in separate tubes and **spun in a centrifuge**



Sample 1. DNA from bacteria grown for several generations in a nutrient solution containing **^{15}N**
→ DNA molecules contain **2 'heavy' strands**

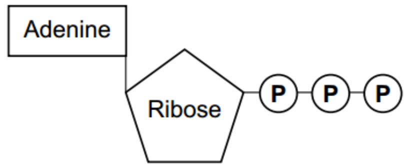
Sample 2. DNA from bacteria grown originally in a nutrient solution containing **^{15}N**, then transferred for **one division** to a solution containing **^{14}N**
→ DNA molecules contain **1 original 'heavy' and 1 new 'light strand**

Sample 3. DNA from bacteria grown originally in a nutrient solution **^{15}N,** then transferred for **two divisions** to a solution containing **^{14}N**
→ **50%** DNA molecules contain **1 original 'heavy' and 1 new 'light' strand**, **50%** contain **both 'light' strands**

1.6 ATP

The structure of adenosine trisphosphate (ATP)

- **Ribose**, a molecule of **adenine**, **3 phosphate groups**
- **Nucleotide derivative** (modified form of nucleotide)
- The structure of ADP (adenosine diphosphate) is the same as ATP, minus a phosphate



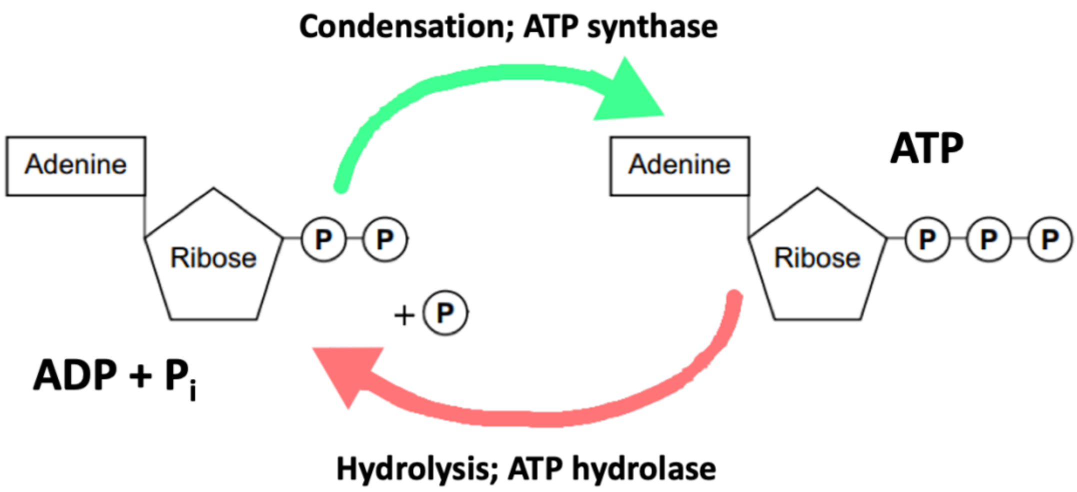
ATP/ADP hydrolysis and condensation

ATP hydrolysis (ATP → ADP + Pi)

- Catalysed by the enzyme **ATP hydrolase**
- Can be coupled to energy requiring reactions within cells, to provide **energy** for active transport, protein synthesis, etc. (energy released when bonds between inorganic phosphate groups are broken)
- The inorganic phosphate released can be used to **phosphorylate** other compounds e.g. glucose, often making them **more reactive** (i.e. lowers activation energy)

ATP condensation (ADP + Pi → ATP)

- Catalysed by the enzyme **ATP synthase**
- Happens during **respiration** or **photosynthesis**
- Also called phosphorylation of ADP



The properties of ATP make it a suitable immediate source of energy

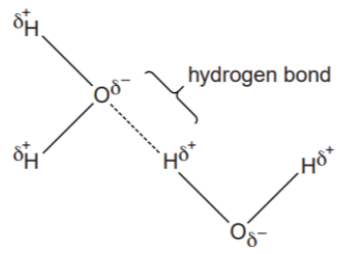
Important – ATP cannot me stored

- ATP releases energy in **small, manageable amounts** (so no energy wasted)
- Only **one bond is hydrolysed** (single reaction) to release energy (which is why energy release is immediate)

1.7 Water

How hydrogen bonding occurs between water molecules

- Water is a **polar** molecule (oxygen molecule has a partial negative charge; hydrogen atoms have a partial positive charge)
- Slightly negatively charged oxygen atoms **attract** slightly positively charged hydrogen atoms of other water molecules
- So **hydrogen bonds** (weak attractive force) form between water molecules



Properties of water that are important in biology

Property	Explanation of property	Importance in biology
High specific heat capacity	• **Polar** so many H bonds form between water molecules • These allow water to absorb a relatively large amount of heat energy **before its temperature changes**	• Good **habitat** for aquatic organisms e.g. lakes as **temperature more stable** than land • Organisms mostly made of water so helps maintain a **constant internal body temperature** – important as temperature affects enzyme activity
High latent heat of evaporation	• **Polar** so many H bonds form between water molecules • These can absorb a lot of energy **before breaking**, when water evaporates	• Evaporation of small amount of water (e.g. sweat) is an efficient **cooling** mechanism • Helping organisms maintain a constant body temperature
Cohesive	• **Polar** so many H bonds form between water molecules • So water molecules tend to stick together	• Column of water doesn't break when pulled up a narrow tube e.g. **xylem** during **transpiration** • Produces **surface tension** at an air-water surface so invertebrates can walk on water e.g. pond skaters
Solvent	• **Polar** (has a slightly positive and negative ends) • Can separate (**dissolve**) ionic compounds e.g. NaCl as +ve end **attracted** to -ve ion (Cl-) and negative end attracted to positive ion (Na+)	Can dissolve other substances e.g. inorganic ions, enzymes, urea, etc. so water… • Acts as a medium for **metabolic reactions** (which can happen in water) • **Acts as a transport medium** e.g. in xylem to transport nitrates which are needed to make amino acids
Metabolite	• Water is **reactive**	**Condensation** releases H_2O and forms a chemical bond; **hydrolysis** requires H_2O to break a bond; e.g. amino acids joined by condensation reactions to form polypeptides

1.8 Inorganic ions

- Occur in solution in the cytoplasm and body fluids of organisms
- Some in high concentrations and others in very low concentrations
- Each type of ion has a specific role, depending on its properties and these roles are relevant in a range of topics across the A Level

Ion	Chemical symbol	Role
Phosphate	PO_4^{3-}	Attached to other molecules as a phosphate group, for example: • in DNA nucleotides, enabling nucleotides to join together forming phosphodiester bonds • in ATP – bonds between these store / release energy
Hydrogen	H^+	Maintain pH levels in the body • Too much H^+ = acidic (low pH) • Too little H^+ = alkaline (high pH) • Affects rate of enzyme-controlled reactions as can cause enzymes to denature
Iron	Fe^{2+}	• Component of (haem group of) haemoglobin which is contained in red blood cells • Transports oxygen around the body – oxygen temporarily binds to it, so it becomes Fe^{3+}
Sodium	Na^+	• Co transport of glucose and amino acids across cell membranes • Involved in generating nerve impulses and muscle contraction