OCR (A) Biology A-level

Topic 2.3: Nucleotides and nucleic acids

Notes

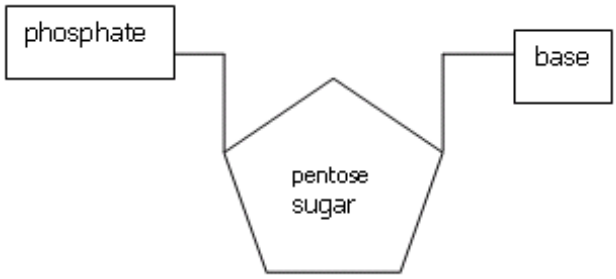


Figure: Royal Society of Chemistry

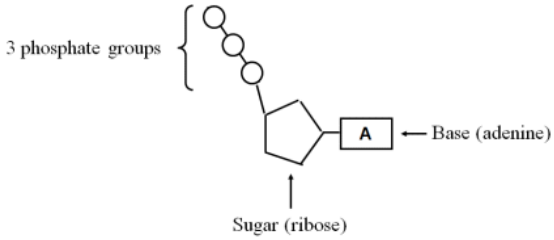
Both **DNA** and **RNA** carry information, for instance DNA holds genetic information whereas RNA then transfers this genetic information from DNA to **ribosomes** made of RNA and proteins. Both deoxyribonucleic and ribonucleic acid are **polymers of nucleotides**. **Nucleotides** consist of **pentose** which is a 5 carbon sugar, a nitrogen containing **organic base** and a **phosphate group:**

- The components of a **DNA** nucleotide are **deoxyribose, a phosphate group and one of the organic bases adenine, cytosine, guanine or thymine.**
- The components of an **RNA** nucleotide are **ribose, a phosphate group and one of the organic bases adenine, cytosine, guanine or uracil**.
- Nucleotides join together by **phosphodiester bonds** formed in **condensation reactions**.

A DNA molecule is a **double helix** composed of two polynucleotides joined together by **hydrogen bonds** between complementary bases whereas **RNA is a relatively short single polynucleotide chain.**

ATP

Adenosine triphosphate is a nucleotide derivative and consists of **ribose, adenine and three phosphate groups**.



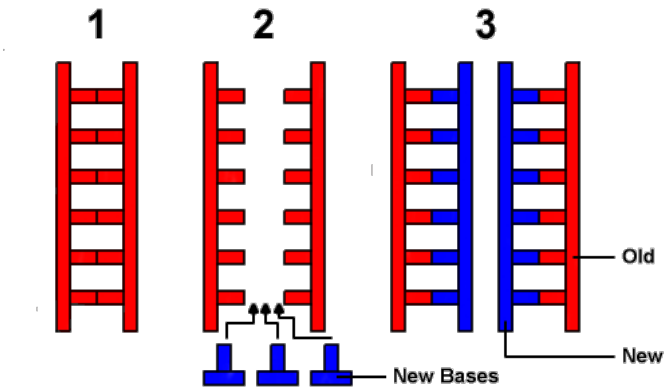
- **Energy is released when ATP is hydrolysed** to form **ADP and a phosphate molecule**. This process is catalysed by **ATP hydrolase**.
- The **inorganic phosphate can be used to phosphorylate other compounds**, as a result making them more reactive.
- **Condensation of ADP and inorganic phosphate catalysed by ATP synthase produces ATP** during photosynthesis and respiration.

DNA replication

The **semi-conservative replication** of DNA ensures genetic continuity between generations of cells meaning that genetic information is passed on from one generation from the next.

The steps of semi conservative replication of DNA are as following:

- The **double helix unwinds** and the **hydrogen bonds between the complementary bases break** using **DNA helicase** thus separating the two strands of DNA



- Both strands are used as **templates** and **complementary base pairing occurs** between the template strands and **free nucleotides**

- Adjacent nucleotides are joined by **phosphodiester bonds** formed in condensation reactions using **DNA polymerase**

Genetic code

The order of bases on DNA is called the **genetic code** which consists of **triplets of bases**, each triplet of bases codes for a particular amino acids and is known as a **codon**. The amino acids are then joined together by **peptide bonds** and form a polypeptide chain. Therefore, a **gene** is a sequence of bases on a DNA molecule coding for a sequence of amino acids in a polypeptide chain. However, not all the genome codes for proteins – the non-coding sections of DNA are called **introns** and the coding regions are called **exons**.

Features of the genetic code:

- The genetic code is **non-overlapping** meaning that each triplet is only read once and triplets don't share any bases.

- Genetic code is also **degenerate** meaning that more than one triplet codes for the same amino acids, this reduces the phenotypic effect of **mutations** (which are mistakes in the base sequence such as **base deletion, insertion or substitution)**. A change in the base sequence of DNA may alter the amino acid sequence and the protein therefore it can have various effects. Some mutations are harmful such as the mutation which leads to production of sticky mucus and causes cystic fibrosis or sickle cell anaemia in which a mutated form of haemoglobin distorts the shape of red blood cells

- The genetic code contains **start and stop codons** which either start or stop protein synthesis

Protein synthesis

There are two stages of **protein synthesis**. **Transcription** which occurs in the nucleus and involves **DNA and mRNA** and **translation** which involves **mRNA, tRNA and ribosomes**. During transcription, DNA strand is transcribed into mRNA and translation is the process during which the amino acids are assembled together to form a polypeptide chain/protein.

Transcription:

During transcription, a molecule of mRNA is made in the nucleus:

- The **hydrogen bonds** between the complementary bases break and the **DNA uncoils** thus separating the two strands
- One of the DNA strands is used as a **template** by RNA polymerase to make the mRNA molecule. the DNA template is called the **antisense strand**
- **Free nucleotides** line up by **complementary base pairing** and adjacent nucleotides are joined by phosphodiester bonds made by RNA polymerase thus forming a single stranded molecule of mRNA
- mRNA then moves out of the nucleus through a **pore** and attaches to a **ribosome** in the cytoplasm which is the site of next stage of protein synthesis called **translation**

Translation:

During translation amino acids join together to form a polypeptide chain.

- **mRNA** attaches to a ribosome and **transfer RNA** collects amino acids from the cytoplasm and carries them to the ribosome. tRNA is a **single stranded** molecule with a **binding site** at one end thus it can only carry one type of amino acid, and a **triplet of bases** at the other
- **tRNA** attaches itself to mRNA by **complementary base pairing** – two molecules attach to mRNA at a time
- The amino acids attached to two tRNA molecules join by a **peptide bond** and then **tRNA molecules detach** themselves from the amino acids, leaving them behind
- This process is repeated thus leading to the formation of a **polypeptide chain** until a **stop codon** is reached on mRNA and ends the process of protein synthesis