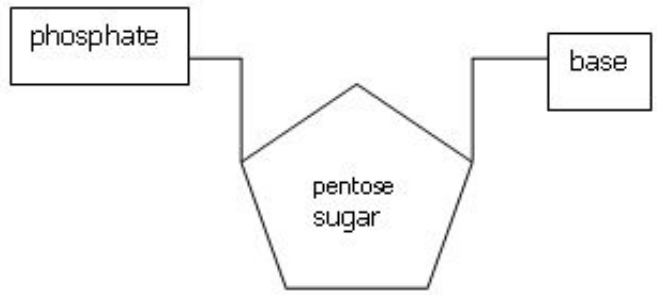
WJEC Biology A-level

Topic 1.5: Nucleotides

Notes

Nucleotides and nucleic acids

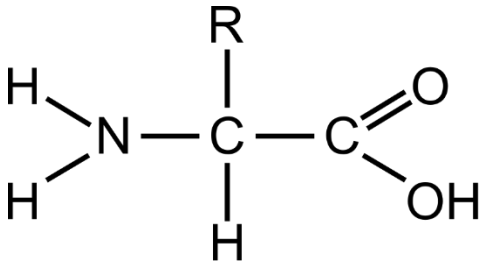


Both **DNA** and **RNA** carry information, for instance DNA holds genetic information whereas RNA then transfers this genetic information from DNA to **ribosomes** made of RNA and proteins. Both deoxyribonucleic and ribonucleic acid are **polymers of nucleotides**. **Nucleotides** consist of **pentose** 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 a **hydrogen bonds** between complementary bases whereas **RNA is a relatively short polynucleotide chain.**

Proteins



Amino acids are the monomers from which proteins are made. Amino acids contain an amino group – NH2, carboxylic acid group and a variable R group which is a carbon-containing chain. There are 20 different amino acids with different R groups. Amino acids are joined by peptide bonds formed in condensation reactions. A dipeptide contains two amino acids and polypeptides contain three or more amino acids.

Structure of proteins is determined by the order and number of amino acids, bonding present and the shape of the protein:

- **Primary structure** of a protein is the order and number of amino acids in a protein.
- The **secondary structure** is the shape that the chain of amino acids chains – **either alpha helix** or **beta pleated sheet**. The shape is determined by the type of bonding present such as **hydrogen bonding, ionic bonds and disulphide bridges**.

- **Tertiary structure** of proteins is the 3D shape of the protein, it can be globular of fibrous. **Globular proteins** such as enzymes are compact whereas **fibrous proteins** such as keratin are long and thus can be used to form fibres.

- For instance, **collagen** is a **fibrous** protein of great strength due to the presence of both **hydrogen and covalent bonds** in the structure. Collagen molecules wrap around each other and form fibrils which form strong collagen fibres. Collagen forms the structure of **bones, cartilage and connective tissue** and is a main component of **tendons** which connect muscles to bones.

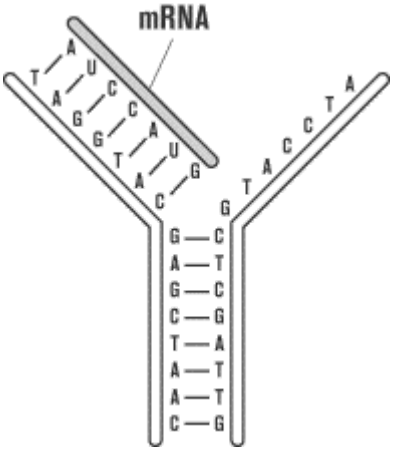
- **Haemoglobin** is a **water soluble globular protein** which consists of two **beta polypeptide chains and a haem group**. It **carries oxygen** in the blood as oxygen can bind to the haem (Fe2+) group and oxygen is then released when required.

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** to make the mRNA molecule, the template is called the **antisense strand**
- **Free nucleotides** line up by **complementary base pairing** and adjacent nucleotides are joined by phosphodiester bonds thus forming a 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**

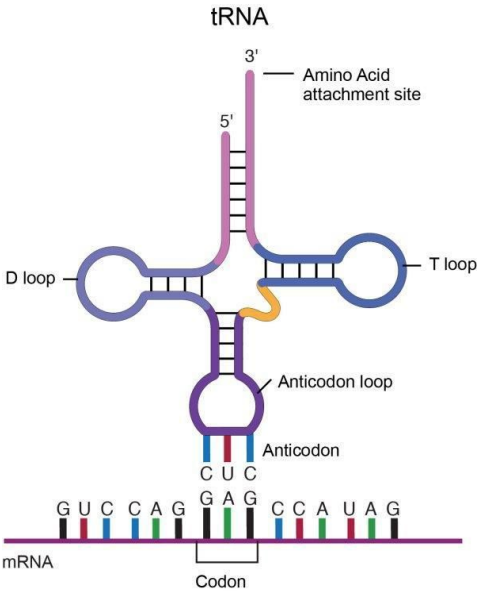
Translation:

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 joined 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.

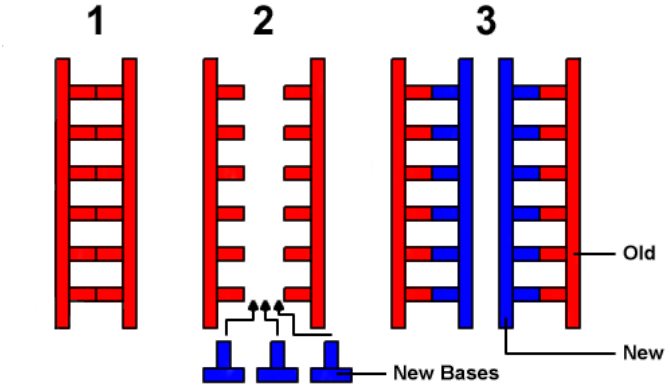


DNA replication

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

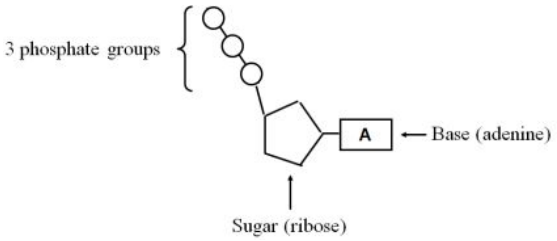


- One of the strands is used as the **template** and **complementary base pairing occurs** between the template strand and **free nucleotides.**

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

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.