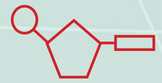
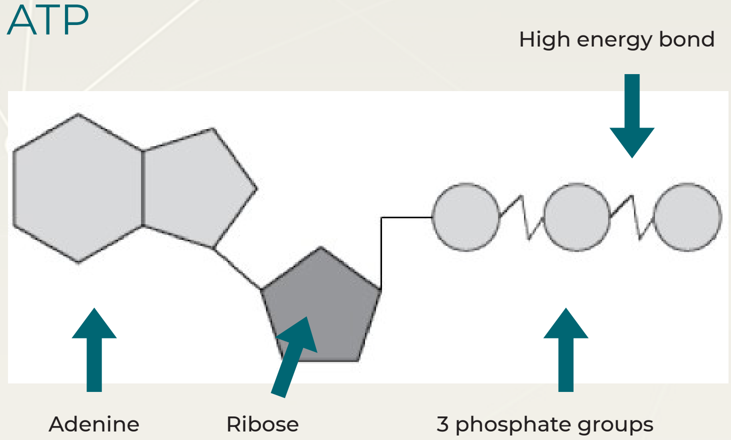
Nucleic acids and their functions

The general structure of a nucleic acid consists of a pentose sugar  a phosphate group  and an organic base.  So, a generalised structure looks like: 

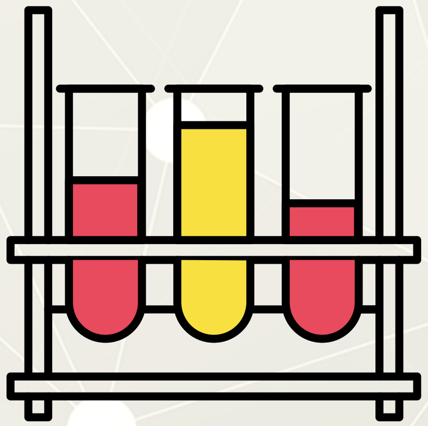
ATP



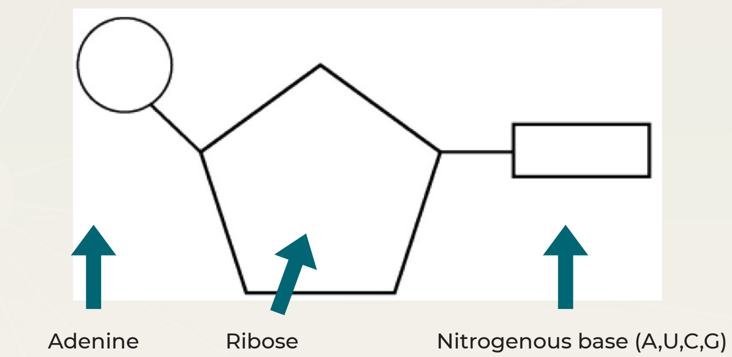
ATP is formed in an endergonic reaction (in respiration). 30.6kJ of energy is stored in this bond and released when it is hydrolysed into ADP and an inorganic phosphate (Pi).

ATP is called the 'Universal energy currency' as it is used to provide energy for all biochemical reactions in all living organisms.

- ATP releases energy in one hydrolysis reaction controlled by one enzyme.
- ATP releases energy in small usable amounts.
- ATP travels easily to where it may be used for secretion, muscle contraction, nerve transmission, active transport.



RNA



These RNA nucleotides are linked together in a single stranded polynucleotide.

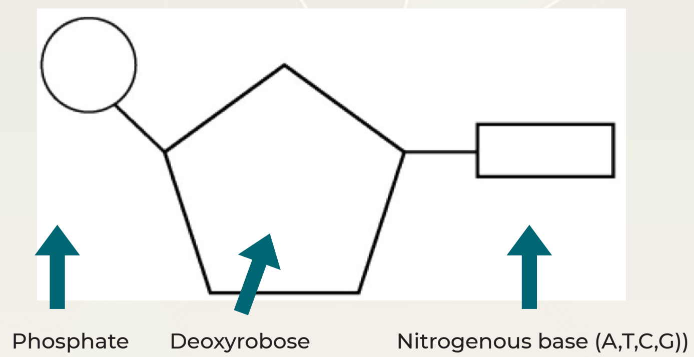
There are 3 different types of RNA with different functions.

Messenger RNA (mRNA) – made as a complementary copy of the DNA genetic code in the nucleus during transcription. The molecule length is related to the length of the gene transcribed. It attaches to a ribosome in the cytoplasm.

Ribosomal RNA (rRNA)- forms ribosomes.

Transfer RNA (tRNA)- carries an amino acid at the 3' end and an anticodon arm to attach to the mRNA.

DNA



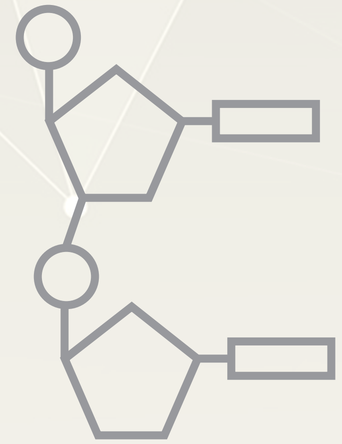
DNA is made from one strand of nucleotides linked by hydrogen bonds between the bases to another strand that runs antiparallel to the first.

There are 2 types of bases:

Purines: Adenine and Guanine.

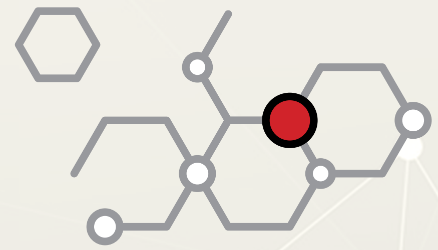
Pyrimidines: Cytosine and Thymine.

They pair up with hydrogen bonds - A pairs with T, C pairs with G. This complementary base pairing links the two strands and a double helix is formed.



Differences between RNA and DNA

RNA	DNA
Ribose sugar	Deoxyribose sugar
Single stranded	Double stranded
A,U,C,G bases	A,T,C,G bases
Long polynucleotide	Shorter polynucleotides

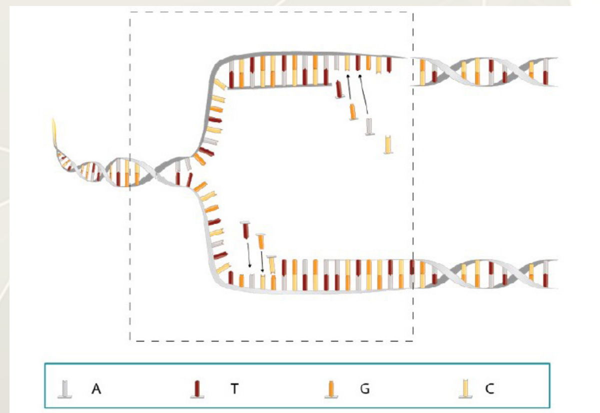


DNA Replication

When cells divide to form new cells they must receive a copy of the DNA. Therefore, chromosomes must be able to make exact copies of themselves.

The replication fork is shown here, and DNA replication occurs in the following steps:

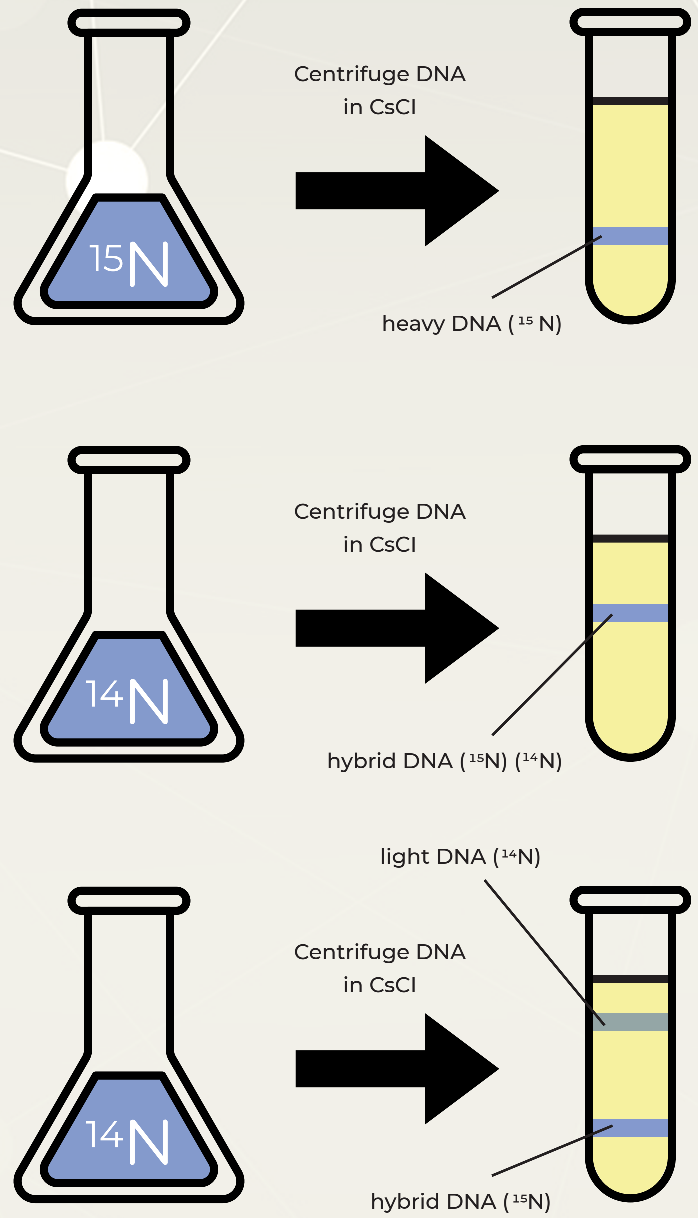
- DNA helicase breaks the hydrogen bonds between the bases in the double helix.
- This unwinds the DNA and exposes unpaired bases.
- Free nucleotides in the nucleoplasm are bound to their complementary bases on the unzipped strand by DNA polymerase.
- Eventually, 2 new DNA molecules are formed from 1 new and 1 old strand of the DNA. This is called semi-conservative replication.

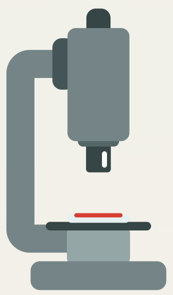


Nucleic acids and their functions

Meselson and Stahl carried out an experiment which gave evidence to the theory of semi-conservative replication of DNA.

1. Grow bacteria with a heavy isotope of nitrogen. Centrifuge a sample, a heavy band is seen.
2. Remove bacteria with heavy DNA and place into a medium with light nitrogen and allow bacteria to divide. They will synthesise DNA with the nitrogen isotope available meaning their DNA will contain 1 new and 1 old strand, making it intermediate in density when centrifuged.
3. Allow 1 more generation to grow and the hybrid strands will now be copied in a semi conservative way creating 50% hybrid and 50% light DNA.





DNA strands:
Heavy nitrogen (^{15}N) = I
Light nitrogen (^{14}N =) I

The genetic code is a linear, triplet, non-overlapping, degenerate, unambiguous, universal code for the production of polypeptides.

Learners should know the structure of tRNA

This continues until a stop codon is reached.

(n) the 'one gene - one polypeptide' hypothesis

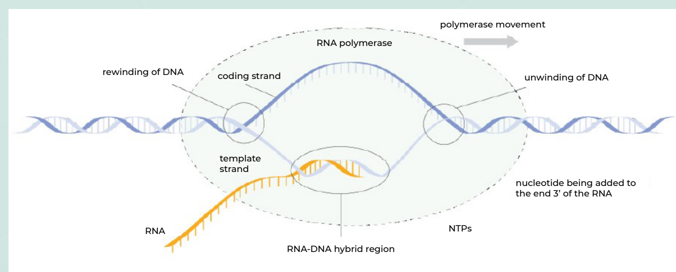
(o) the further modification and combination of some polypeptides.

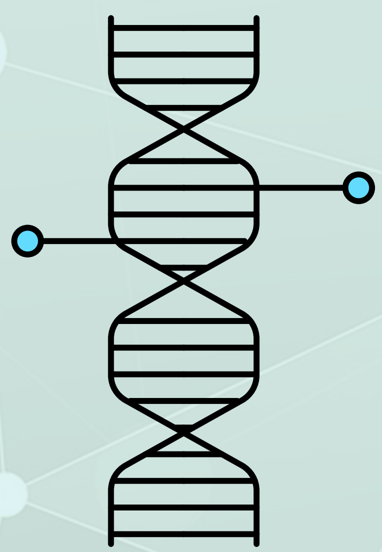
Polypeptides can be further modified by the addition of carbohydrates, lipids or phosphate. Polypeptides can be combined as exemplified byhaemoglobin.

Protein Synthesis

Transcription

1. **DNA helicase** unzips a section (gene) of the DNA by breaking the hydrogen bonds between complementary base pairs.
2. **RNA polymerase** links to the template (coding) strand of DNA and attaches mRNA nucleotides to their complementary base pairs, e.g. Adenine in DNA now pairs with the mRNA base Uracil, Cytosine continues to pair with Thymine.
3. This copying stops at a stop sequence.
4. The newly made **premRNA** then leaves the DNA.
5. Post transcriptional modification of the premRNA occurs to remove the **non-coding introns** leaving only the **coding sections, exons** in the mature mRNA that now leaves the nucleus to be translated into a protein in the cytoplasm.

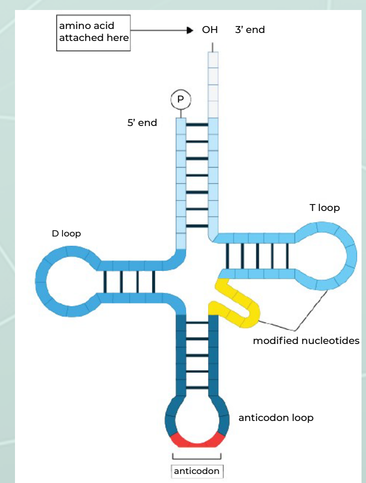




Translation

1. mRNA is a linear chain of three base codons. There are complementary anticodons on tRNA molecules.
2. When the mRNA leaves the nucleus, it attaches to the small subunit of a ribosome.
3. The large subunits of a ribosome have 2 attachment sites for tRNA. The ribosome holds the mRNA and the tRNA (which have attached amino acids) in position for the amino acids to form peptide bonds and create a polypeptide chain.
4. The codon on the mRNA (3 base code) therefore chooses the tRNA as the tRNA which attaches must have a complementary 3 base code. E.g. mRNA CGA, tRNA GCU.
5. The tRNA that matches the codon on the mRNA has a specific amino acid attached to the 3' end of the tRNA molecule. The ribosome moves along the mRNA holding each tRNA in place until the amino acid attaches. The tRNA then leaves, the ribosome moves along and the next tRNA attaches to the next codon.
   In this way the mRNA (translated from a gene) carries the code for the formation of a polypeptide chain with amino acids set out in a particular order.

One gene = one polypeptide.



Modification of new polypeptides

Polypeptides can be modified by the addition of carbohydrates, lipids or phosphate or can be combined together, e.g. haemoglobin.