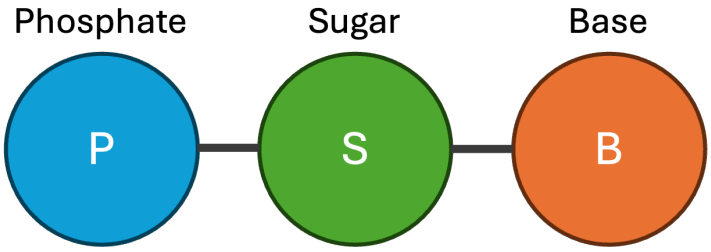
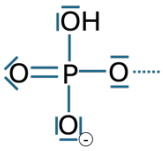
"One" molecule to rule them all

(D/R)NA, a polymer written from 4-letter alphabets

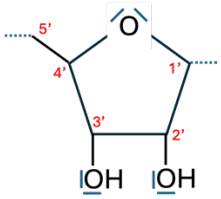
1. Structure of a nucleotide

A nucleotide is an organic molecule based on a sugar, linked to a phosphate group on one side and a nitrogenous base on the other side.

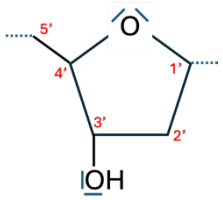




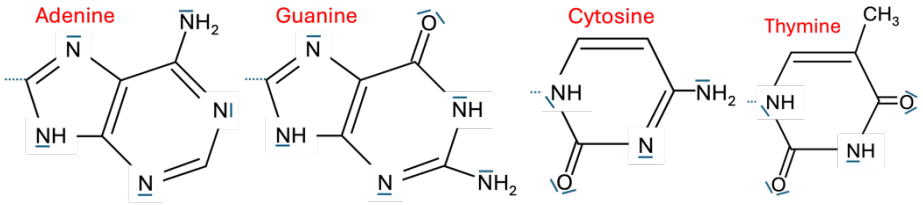
- The phosphate group is negatively charged
- The sugar is a 5C-cycle, which can exist in 2 forms:
  - Ribose for the building block of RNA:



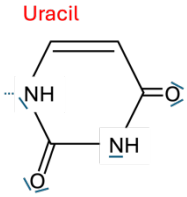
  - Desoxyribose for the building block of DNA:



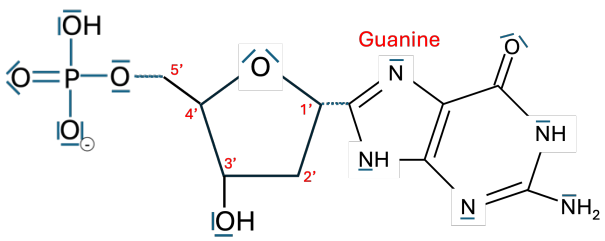
- The bases are the support of the genetic information. 4 of them are enough to define the whole diversity of life on Earth:



Note: In the RNA molecule, Thymine (T) is replaced by Uracil (U)

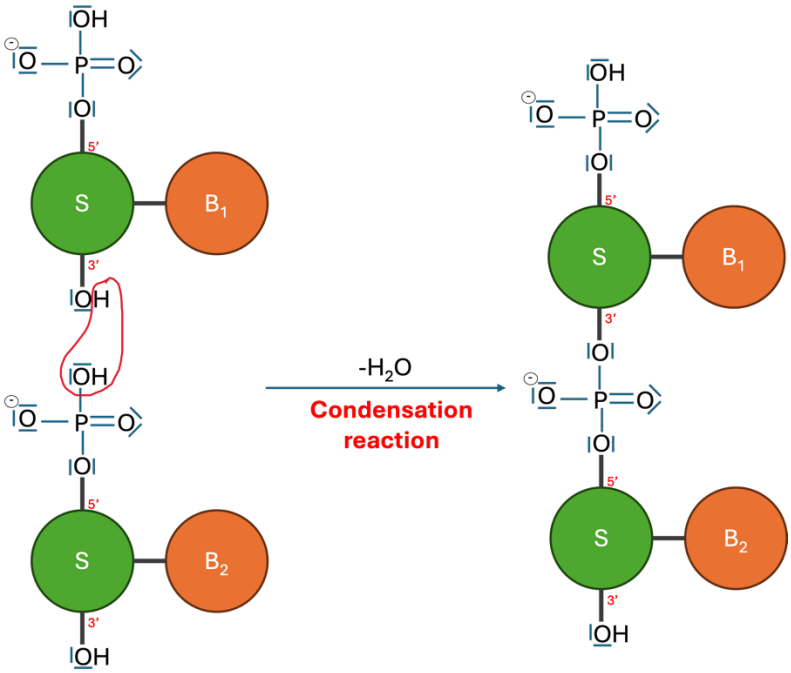


Example of nucleic acid present in DNA:



2. From nucleotides to a nucleic acid

Nucleotides can be linked to each other via a condensation reaction: A water molecule is released between the phosphate ion of carbon 5' and the -OH group of carbon 3', leading to the formation of a nucleic acid.

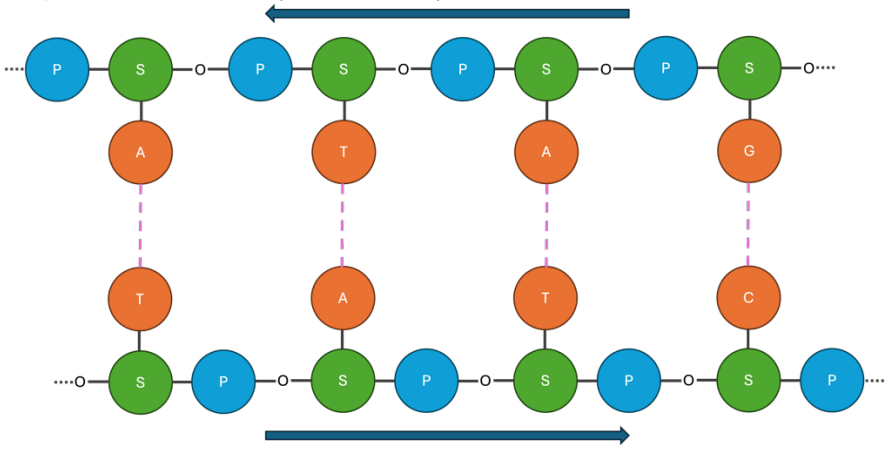


This condensation reaction can repeat undefinitely, leading to macromolecules of several cm long... DNA strands.

Note: In the body, this reaction is orientated, "from carbon 5' to carbon 3'": $5' \longrightarrow 3'$

3. A molecule made of 2 strands

DNA is made of 2 complementary strands of nucleic acids, each orientated in an opposite direction. These 2 strands are maintained together by Hydrogen-bonds between complementary bases (A-T and C-G)



The length of the DNA structure has consequence on its shape. Intramolecular interactions give it its characteristic shape of an helix.

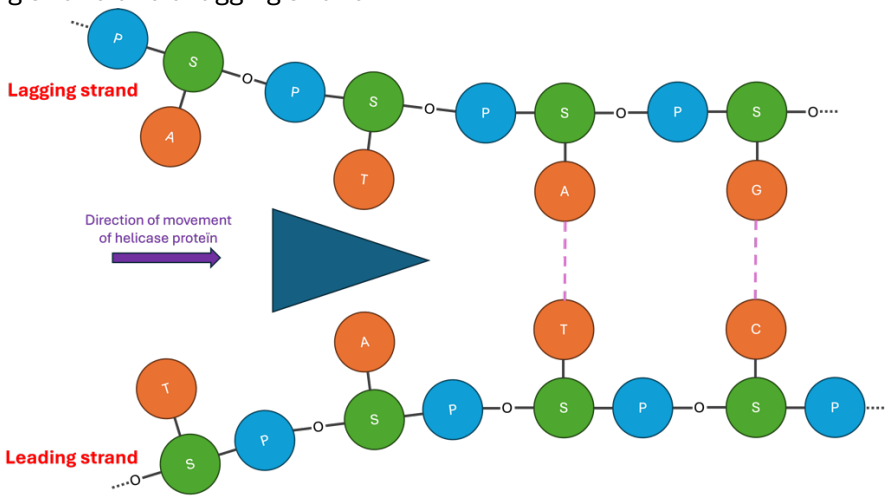
Replicating DNA

The first step in turning 1 cell into 2 identical cells is to replicate the DNA molecules, seat of the genetic information (Identity of the cell). The order of the nucleotides in its strands is FUNDAMENTAL, as the smallest change can have important consequences for the identity of the cell.

Therefore, replication of a DNA molecule must be done with high accuracy and reliability.
To do so, the process has to be based on the action of proteins. **! Structure ⟶ Function !**

1. **Topoisomerase** (the "hair straightener"): it turns the helix into a "ladder".
2. **Helicase**: Opening of the DNA molecule

The protein breaks the hydrogen bonds between the 2 strands, separating them into a leading strand and a lagging strand.



Note: The leading strand is the one for which the nucleotides will be able to be added following the 5′ ⟶ 3′ process.

3. **RNA-primase**: Initiation of the replication.

DNA nucleotides can only be added to an already existing strand, whereas it isn't the case for RNA nucleotides. Therefore , RNA-primase produces a short sequence of RNA (5 to 10 nucleotides, called RNA-primer) to provide a starting point for the synthesis of new DNA-strands.

4. **DNA-polymerase 1**: RNA ⟶ DNA

The ribose of the RNA-primer nucleotides are reduced into deoxyribose, and the eventual uracil bases are replaced by thymine bases.

5. **DNA-polymerase 2**: Extension of the chain

- Leading strand: it allows the 5'⟶3' condensation process. Therefore, the extension is continuous, one nucleotide after the other.
- Lagging strand: it doesn't allow the 5'⟶3' condensation process. Small fragments of DNA, randomly formed in the nucleus, form discontinuous chains of DNA. These fragments are Okasaki fragments.

Note: A RNA-primer is needed prior to EACH Okasaki fragment.
*An extra protein, **DNA-ligase**, is then needed to join the Okasaki fragments.*

Note: The replication of DNA occurs in the cell during a phase called interphase. Approximately 1000 bases can be replicated every second, leading to a duration of 6 to 20 hours for the whole process.

After replication, each DNA molecule has given place to 2 chromatids linked by a centromere: a CHROMOSOME.