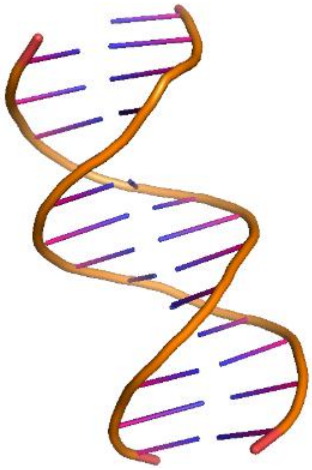
TA7 - DNA Structure and Base Pairing



PDBe entry 4rdu, a human DNA section

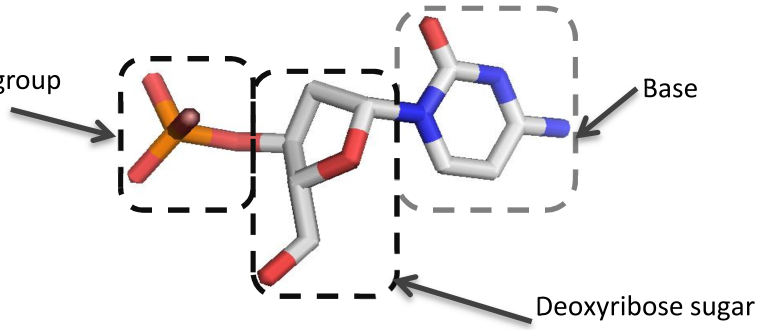
DNA, deoxyribonucleic acid, is one of the most important structures in nature. It exists as a type of macromolecule called a **nucleic acid**, which is a large **polymer** that carries the genetic code in organisms. The classically recognised structure of DNA is a **double helix**. In a double helix, two strands of DNA wrap around each other and are connected through **hydrogen bonds**.

Because it is a large **biopolymer**, it is important to consider the **monomer** units which make up DNA. In the same way that it is important to consider the peptides which make up a polypeptide. Nucleic acids are made from **nucleotide** units. There are **four** key nucleotides which make DNA. Each nucleotide is made from three different components.

NUCLEOTIDES

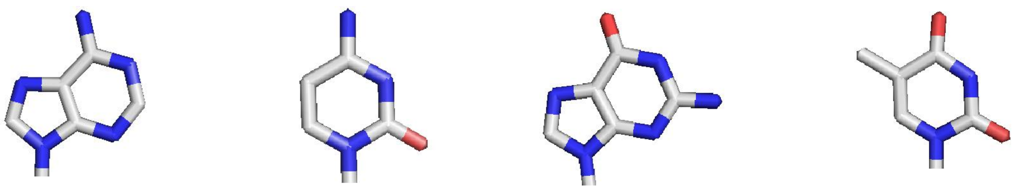
There are three distinct parts in a nucleotide: A **base**, a **deoxyribose sugar**, and a **phosphate group**.

4rdu_mononucleotide.pse



Together the phosphate group and deoxyribose sugar make up the **sugar-phosphate backbone**. This part is the same in each of the four nucleotides. When nucleotides combine to form polymers such as DNA, they do so through **covalent bonds** between adjacent sugar and phosphate groups. We call this the sugar-phosphate backbone, because this is the outer part of the helix which gives the overall DNA molecule its classic structure, just like our own backbones.

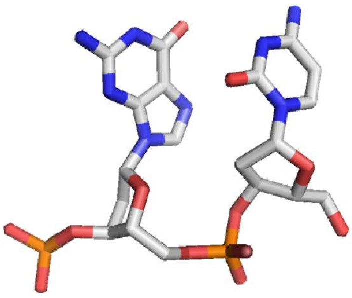
The difference between each of the four nucleotides, lies in their DNA base. Each has a different one. They are all similar, having **nitrogen rich rings**. They all have C=O groups as well, apart from adenine. Cytosine and thymine only have a 6-membered ring, whereas adenine and thymine have a 5-membered ring fused too.



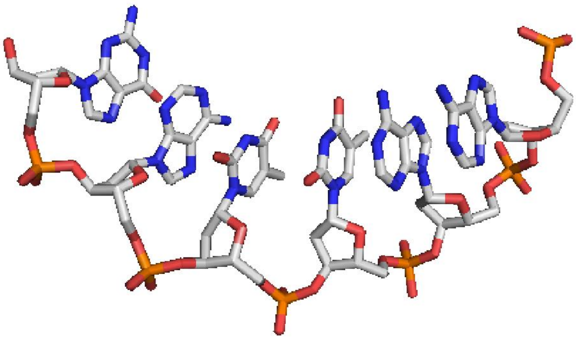
4rdu_DNA_Bases. Adenine, Cytosine, Guanine, and Thymine, the four DNA bases. Note that the hydrogen atoms are not included.

POLYNUCLEOTIDES

When two nucleotides combine, they form a **dinucleotide**. When many nucleotides are combined, they form a **polynucleotide**, such as the individual **strands** in DNA. The nucleotide units polymerise and join through strong covalent bonds formed by **condensation reactions**. The sugar-phosphate backbone is visible in the polynucleotide below. Each DNA strand can be considered as a polymer chain with various DNA bases attached.



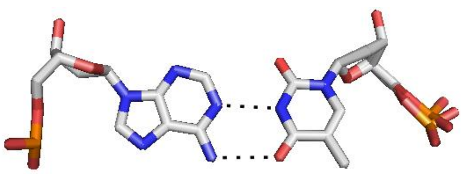
Dinucleotide 4rdu_dinucleotide



Polynucleotide 4rdu_polynucleotide

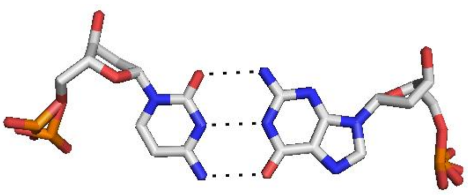
DNA BASE PAIRING

For a double helix to form, the bases on the inside of the helix need to bond and pair up. This stabilises the double helix, and connects the two strands together. However, only certain bases can pair up. **Adenine bonds to thymine**, and **cytosine bonds to guanine**. Why is this? Firstly, we can model the double helix as a ladder which has a sugar-phosphate backbone, and the DNA base pairs as the 'rungs'. If you look at the structure of the bases, you will see that adenine and guanine are larger than cytosine and thymine. This is important because if adenine and guanine bonded, and cytosine and thymine bonded, then the rungs would be of different lengths! In other words, you wouldn't be able to build the ladder! This is why the larger adenine binds to the smaller thymine, and likewise for the CG base pair – they are a **complementary base pair**.



Adenine-Thymine 1enn_base_pairs

The adenine-thymine base pair forms only **two hydrogen bonds** between the bases. NB. Hydrogen atoms are not shown.



Cytosine-Guanine 1enn_base_pairs

The cytosine-guanine base pair which forms has **three hydrogen bonds** between them. This is why C binds to G, and not A, because A would only be able to form two bonds.

The bases on each of the two DNA strands will pair up, this complementarity arranges the **overall structure in a double helix.**

Produced by Adam Stubbs at Newcastle University as part of a summer outreach project.