# *The Structure of DNA*

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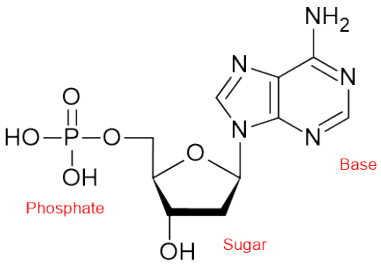
Even though DNA holds the instructions to create entire organisms, the components of DNA are not complicated. "Structure determines function" still holds for this molecule, and so to begin to understand how DNA functions as hereditary material, we must have a clear familiarity with its structure.

DNA is an acronym for deoxyribonucleic acid, which lets you know it is an acidic molecule made of nucleotides, and it contains the sugar deoxyribose. Other details emerge when we examine the building blocks of this essential biological molecule.

Below are 12 key points to remember about the structure of DNA. They may seem like an unrelated grab-bag of information at present, but knowing these details will make molecular biology (the study of the function of DNA and other biological molecules) much clearer. In addition to these notes, we recommend you spend time carefully examining a 3D model of DNA.

## *Key concepts about DNA Structure*

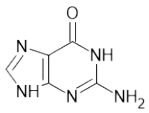
*1. A DNA **nucleotide** consists of three parts: a five-carbon sugar (deoxyribose), a phosphate group, and a nitrogenous base.*



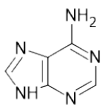

"Deoxyribose," meaning lacking one of the oxygens usually found in ribose. "Nitrogenous" base, meaning a base that contains nitrogen. The phosphate groups are what make DNA acidic.

*2. There are four kinds of nitrogenous bases found in DNA: G, A, T, and C.*

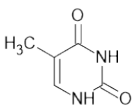
These stand for **Guanine, Adenine, Thymine, and Cytosine**. As shorthand, we usually refer to the four kinds of DNA nucleotides as G,A,T, and C as well. Guanine and Adenine are **purines**, and have two fused rings. Thymine and Cytosine are **pyrimidines**, and have single ring structures.



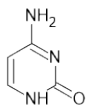
Guanine



Adenine



Thymine



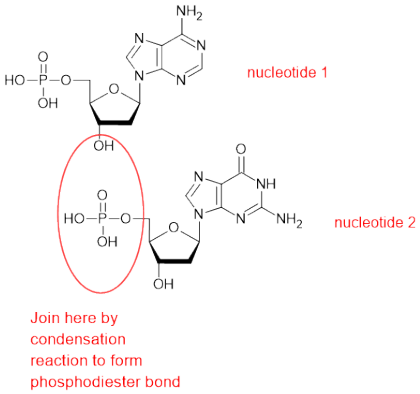
Cytosine

*3. DNA is a polymer, and the monomer is the nucleotide.*

When DNA nucleotide monomers are strung together (in a certain order), they form the polymeric nucleic acid, DNA. **Think of nucleotides like letters in a word.** They must be in the right order, or the word won't make sense. Similarly, words have to be in the right order for a sentence to make sense. This is how information is stored in DNA, much like the words in a very long book, broken into chromosome chapters and gene paragraphs (written in an alphabet with only four letters, G,A,T, and C).

*4. The nucleotides are linked together into a polymer (a long string of monomers) by phosphodiester bonds.*

The phosphate group of one nucleotide is covalently linked to the hydroxyl group on the sugar of the next nucleotide. You'll see very short sequences of DNA in textbooks as examples, but keep in mind most DNA molecules are *very* long (human chromosomes range from about 50 million to 250 million nucleotide pairs long).

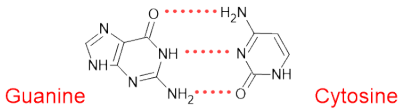



*5. DNA is usually double-stranded, resembling a ladder.*

So far we've described single-stranded DNA, but DNA usually has two strands bonded together. DNA thus takes on the appearance of a twisted ladder, with the sugar and phosphate groups forming the sides of the ladder, and the nitrogenous bases forming the rungs.

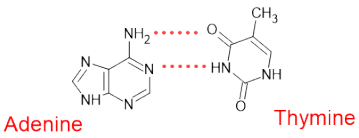
*6. The rungs of the ladder are held together by hydrogen bonds.*

The weak Hydrogen Bonds holding the bases together can break and re-form, allowing the strands to separate and zip back together. This happens during DNA replication, and when DNA is transcribed into RNA during gene expression.




*7. Chargaff's Rule: G always pairs with C, and A always pairs with T.*

G pairs with C via three Hydrogen Bonds. A and T are held together by two Hydrogen Bonds. We call these **base pairs**. Notice that when G pairs with C or A pairs with T, that keeps the diameter of the DNA molecule constant at about 2 nanometers.

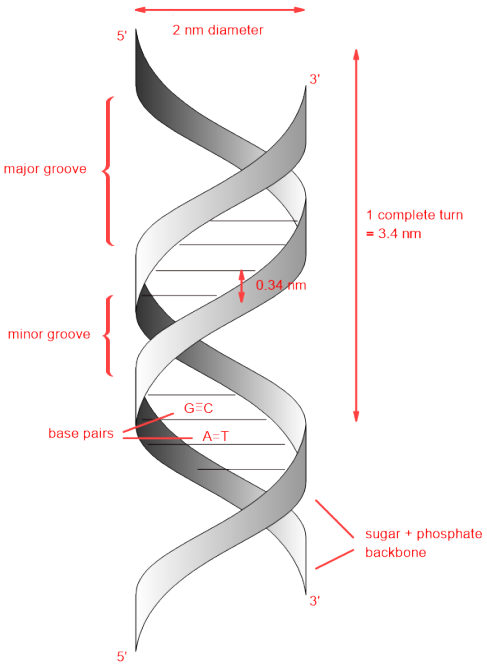


*8. The two strands of double-stranded DNA have complementary sequence.*

If one strand reads "GATTACAGAGA," the other strand that pairs will read "CTAATGTCTCT," because G always pairs with C, and A always pairs with T. So if you know the sequence of one strand, you automatically know the sequence of the other, complementary strand.

*9. The helix is right-handed.*

Take your right hand and bend your fingers inwards. That's the direction of the turn of the DNA helix.




*10. There are 10 base pairs, or rungs, per turn of the helix.*

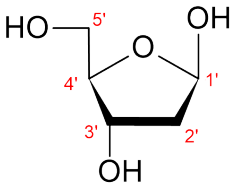
The DNA helix makes one full turn every 3.4 nanometers, and there is a 0.34 nanometer distance between nitrogenous bases.

*11. There are two different grooves (major and minor) running the length of the twisted DNA molecule.*

The major groove has the backbones far apart, while the backbones are closer together along the minor groove. This determines where certain DNA binding molecules latch on (some only bind in the major groove, others only bind in the minor groove).

*12. The two strands of DNA are antiparallel.*

The "coding" strand of DNA runs 5′ to 3′ (these labels refer to carbons in the deoxyribose). The other, non-coding strand, runs in the opposite direction.
coding: 5′ GAT TAC AGA GA 3′
noncoding: 3′ CTA ATG TCT CT 5′




*Additional Resources*

What is the Structure of DNA? (Video)