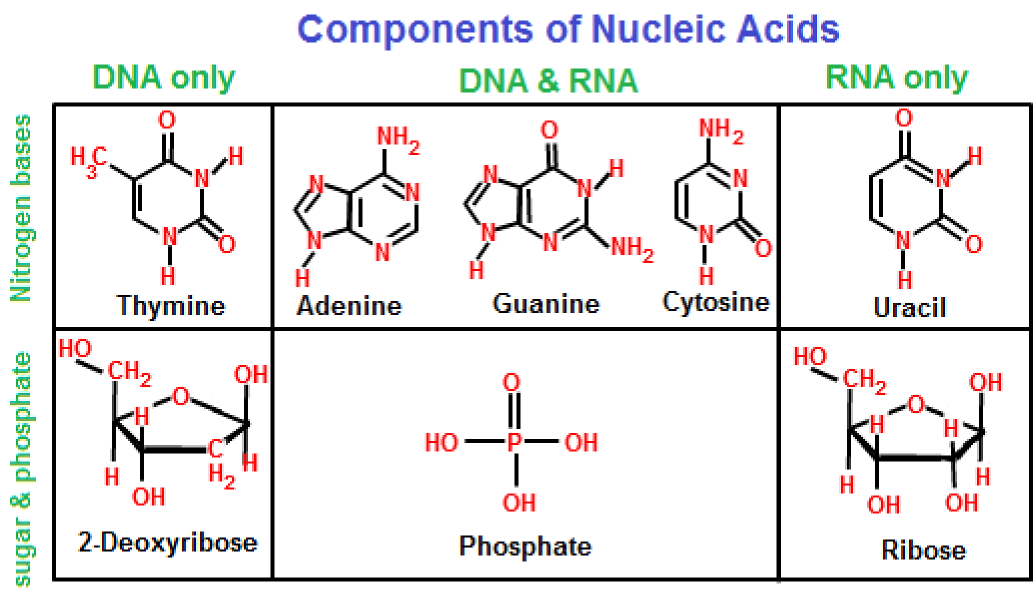
DNA is constructed from Nucleotide Units

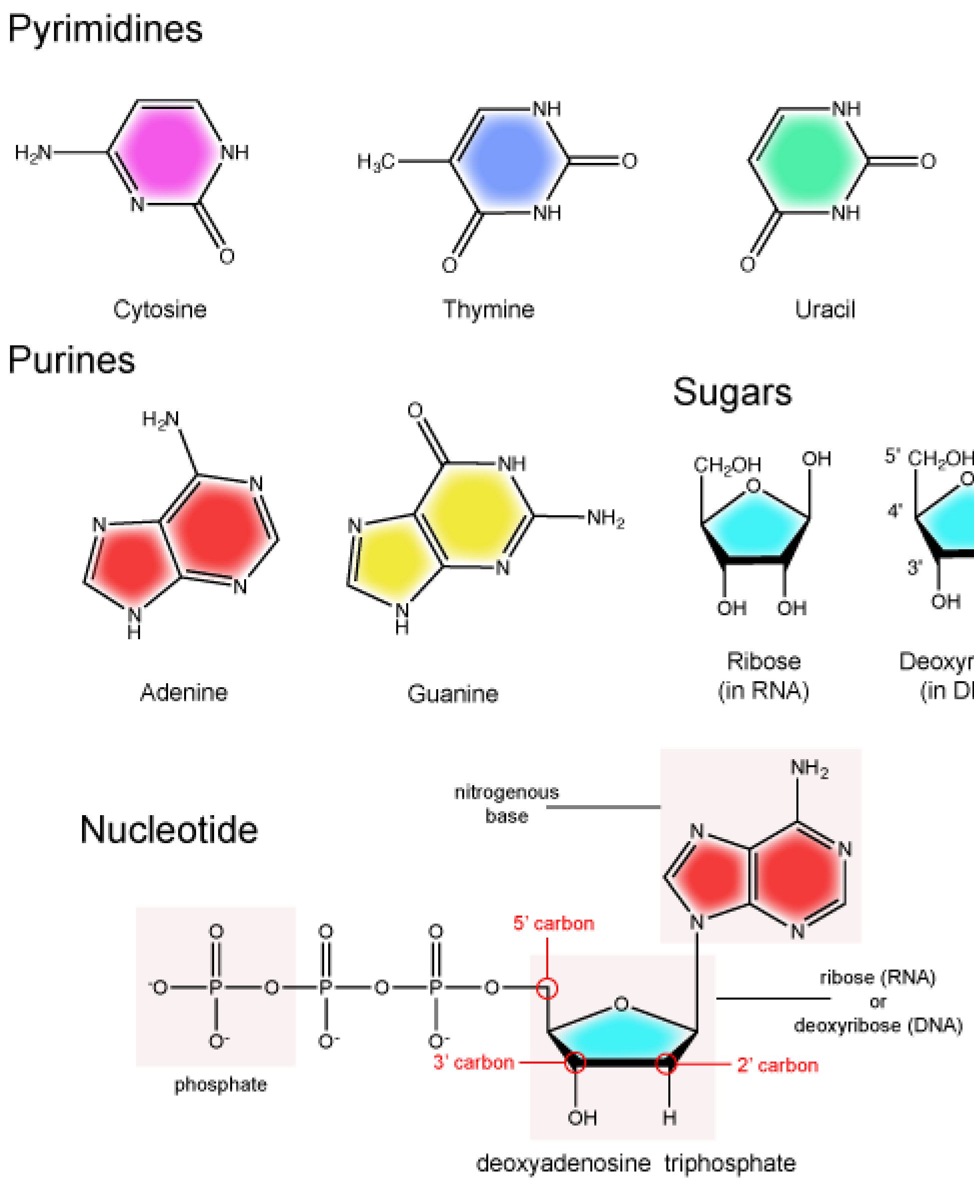
There are two types of nucleic acid - ribonucleic acid (RNA) and deoxyribonucleic acid (DNA) - isolated from all living things. Scientists' analyses revealed three fundamental components in both types of nucleic acids:

(1) A five-carbon sugar, which could be either ribose (in RNA) or deoxyribose (in DNA).

(2) Phosphate, a chemical group derived from phosphoric acid molecules.

(3) Four different compounds containing nitrogen.

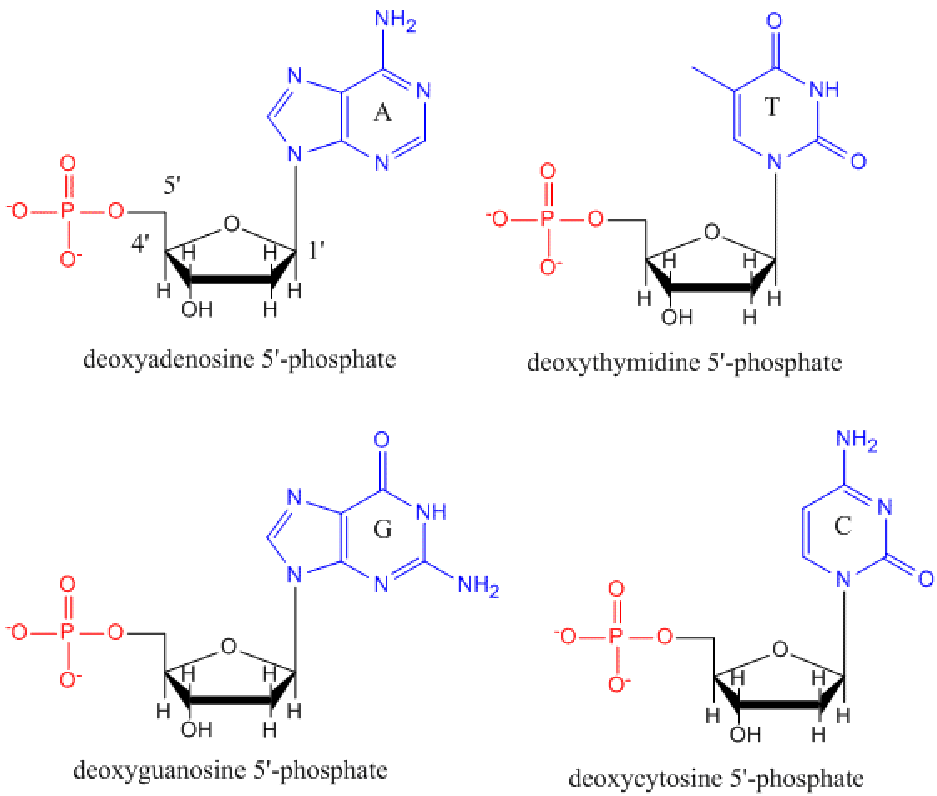




Because of their nitrogen content and basic qualities, the four nitrogenous compounds are simply referred to as bases. In DNA, the four most common bases are adenine (A), thymine (T), guanine (G), and cytosine (C).

RNA, the other important nucleic acid in cells, contains the A, G, and C bases, but a base called uracil (U) replaces thymine (T). The adenine (A) and guanine (G) bases are double-ring molecules called purines, whereas the cytosine (C), thymine (T), and uracil (U) bases are single-ring molecules called pyrimidines.

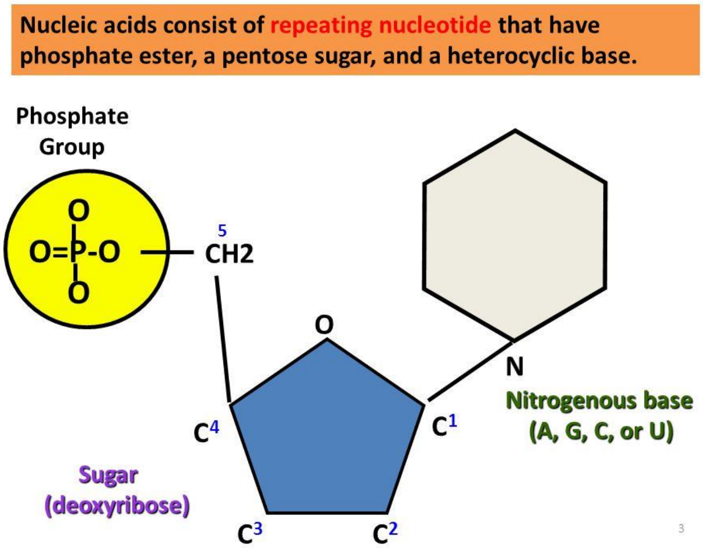
Scientists' concluded that DNA is composed of three essential components that form units, which are in turn strung together to form a long DNA chain. The units are called nucleotides. In DNA, each nucleotide consists of a deoxyribose sugar attached to a phosphate group and to a base. Each of the four nucleotides differs from the other three only in its base component.



DNA Nomenclature Helps to Understand DNA Function

Chemists have developed a nomenclature system to identify the molecular structures of many thousands of chemical compounds, including the components of DNA. The two ends of a DNA strand are not identical. In laboratory experiments. Thus, students who plan to pursue further studies in DNA technology must become familiar with fundamental DNA facts and terminology.

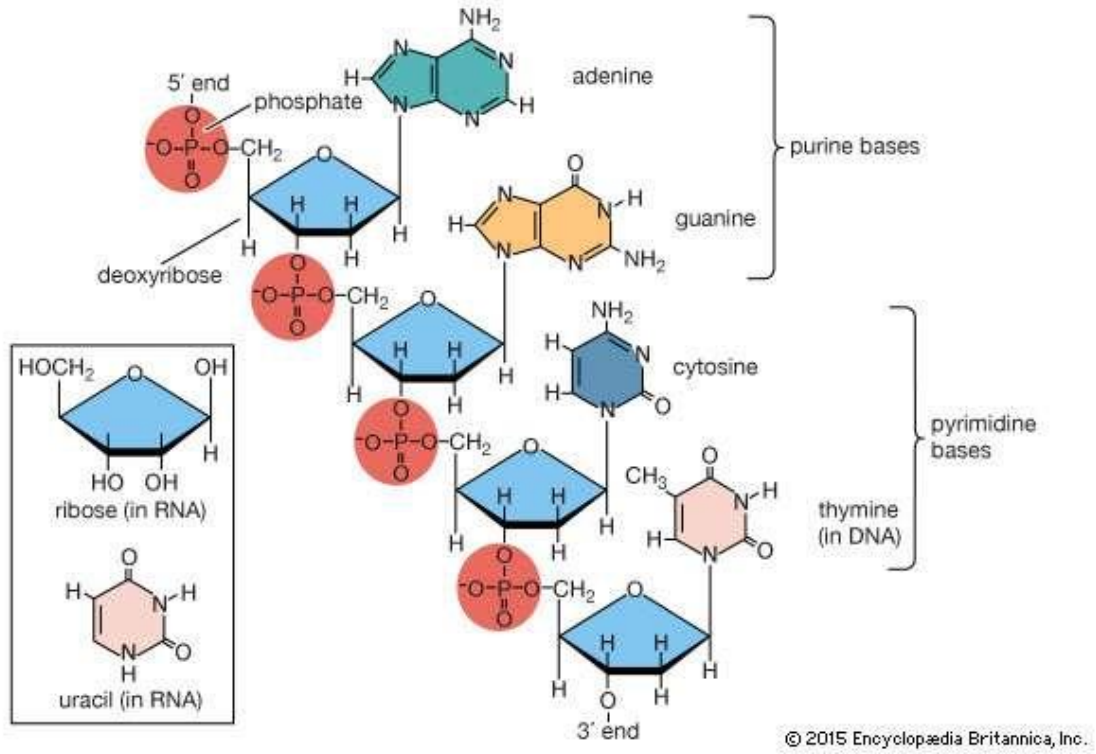
Using standard chemical nomenclature, numbers are assigned to the ring atoms of the base and sugar (Figure 3). When specifying where a chemical group is attached to a molecule, it is customary to refer to the number assigned to that specific carbon atom (Figure 3). The carbon atoms in deoxyribose are numbered 1' to 5' (pronounced "one-prime" and "five-prime") with the numbering system starting to the right of the oxygen atom and proceeding clockwise around the molecule.



The phosphate group attached to the 5' carbon atom of the deoxyribose establishes the 5' end of the DNA strand. The functionally important – OH (hydroxyl group) is attached at the 3' carbon atom of the deoxyribose molecule. This 3' -OH group is required for the addition of nucleotide units during DNA synthesis. The 3' and 5' carbons, as we'll see, are important markers for distinguishing the chemical direction (polarity) of a DNA strand (Figure 4). The bases are attached to the sugar through the 1' carbon. Note that the atom numbers in the bases do not use "prime" and thus are distinguished from the carbons in deoxyribose.

The Two Ends of a Single DNA Strand are Chemically Distinct

Because the 3’ end of the DNA strand contains a hydroxyl group (-OH) and the 5’ end of the DNA has a phosphate group (P), the DNA strand has polarity (Figure 4).



In the DNA helix, the two DNA strands are oriented in opposite directions and are said to be antiparallel. The chemical structures at the ends of DNA strands in both single-stranded and double-stranded DNA enable the DNA ends to engage in important processes in the cell. The chemical characteristics of the ends of the DNA strands are particularly important when the DNA is manipulated in the lab. For example, many enzymes can act only on the 3’ or 5’ end of the DNA strand. Special multiprotein enzymes in the nucleus of the cell synthesize DNA by linking nucleotides to each other; the 3’ carbon of one nucleotide is joined to the phosphate group of a second nucleotide. Note that because the “prime” notation follows the 3, we must be referring to carbon 3 on the sugar, not the base.

As Figure 4 shows, the phosphate group essentially forms a bridge connecting the two deoxyribose molecules. To continue building the DNA molecule, linkages to other nucleotides are forged in the same way, building up a strand of tens or thousands (or millions, or any number) of nucleotides linked to one another in the DNA molecule. By agreement among scientists, the sequence of the bases in a DNA molecule is read in the 5’ to 3’ direction, starting at the 5’ end of the DNA strand and reading toward the 3’ end.

Nucleic Acid and Function

One possible chemical component of chromosomes was a seemingly unique organic compound of the cell nucleus called nucleic acid. Nucleic acid was first described in 1869 by the Swiss researcher Johann Friedrich Miescher. With great difficulty, Miescher separated nuclei from human white blood cells, named the new substance “nuclein”. When he identified phosphorus in nuclein, he postulated that the substance was a storehouse for phosphorus in the cell. Then they gave it the more descriptive and technical name **deoxyribonucleic acid (DNA)**.

By the 1950s, it was becoming increasingly clear to the scientific community that the deoxyribonucleic acid (DNA) molecule is the basis of genetic heredity. It is hard to believe these days, but at the time, very little was known about DNA structure. Scientists realized that they needed to know the molecular structure of DNA because the structure of the DNA molecule might shed light on the hereditary process; also, understanding DNA structure might explain how the molecule duplicates during cell reproduction. The processes of genetic heredity and cellular reproduction are among the most fundamental and important events in biology, and the quest for this knowledge started a race to figure out what a DNA molecule actually looks like.