# NUCLEOTIDES

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Nucleotides consist of a nitrogen-containing base, a five-carbon sugar and one or more phosphate groups. Cells contain many types of nucleotides, which are in constant flux between free and polymeric states. Nucleotides play central roles in many cellular processes, including metabolic regulation and the storage and utilisation of genetic information.

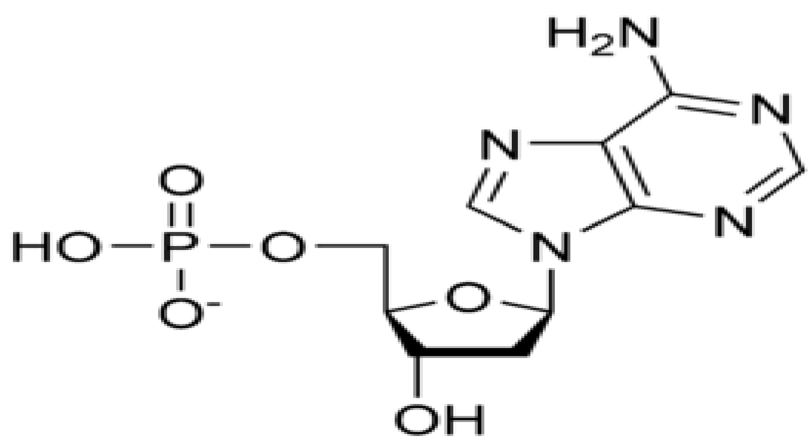



FIG - This nucleotide contains the five-carbon sugar deoxyribose (at center), a nitrogenous base called adenine (upper right), and one phosphate group (left). The deoxyribose sugar joined only to the nitrogenous base forms a Deoxyribonucleoside called deoxyadenosine, whereas the whole structure along with the phosphate group is a nucleotide, a constituent of DNA with the name deoxyadenosine monophosphate.

Nucleotides play central roles in many cellular processes, including metabolic regulation and the storage and expression of genetic information. Thus, cells contain many types of nucleotides and a complex and conflicting terminology for nucleotides and related compounds has been used.

All nucleotides have three fundamental components

1. **Base:** Also referred to as heterocycles, these nitrogen-containing ring compounds are derivatives of purine or pyrimidine. The atoms within the purine/pyrimidine rings have a common arrangement and they are given the same number in different nucleotides. A variety of chemical groups can be bonded at different positions to the ring constituents.

2. **Sugar:** A five-carbon sugar, usually ribose, is linked to the base. Each carbon atom is numbered and, to allow their distinctionfromatomsinthebase,thenumberisfollowedby a prime mark: thus, ribose has five carbon atoms, numbered 1′ to5′.Thesugarsarelockedintoafive-memberedfuranose ring by the bond from C1′ of the sugar to the base.

3. **Phosphate ester**: Phosphate groups are attached to the sugar yesterlinkages,withthemostcommonsiteofesterification in natural compounds being via the hydroxyl at the C5′ position. Typically, one, two or three phosphates are joined, producing mono-, di- and triphosphates, respectively.

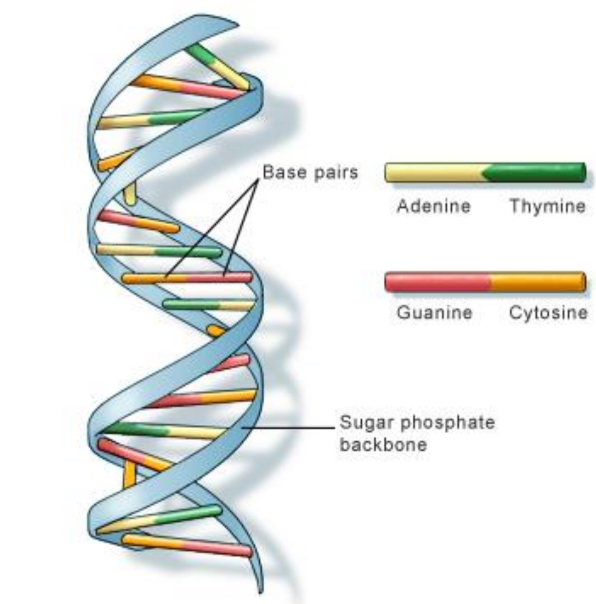
## The structure and role of nucleic acids

Nucleic acids are polymers of nucleotides, in which the phosphate from the 5´ position of one nucleotide is attached to the 3´ hydroxyl of the preceding nucleotide. This phosphodiester link is created using the energy from the triphosphate form of the nucleotide being added, driven by the release of inorganic pyrophosphate. Because of this intrinsic directionality, nucleic acid sequences are typically written from 5´ to 3´ unless otherwise specified.

**DNA**

DNA, or deoxyribonucleic acid, is the hereditary material in humans and almost all other organisms. Most DNA is located in the cell nucleus (where it is called nuclear DNA), but a small amount of DNA can also be found in the mitochondria (where it is called mitochondrial DNA or mtDNA).

The information in DNA is stored as a code made up of four chemical bases: adenine (A), guanine (G), cytosine (C), and thymine (T). DNA bases pair up with each other, A with T and C with G, to form units called base pairs. Each base is also attached to a sugar molecule and a phosphate molecule. Together, a base, sugar, and phosphate are called a nucleotide. Nucleotides are arranged in two long strands that form a spiral called a double helix. The structure of the double helix is somewhat like a ladder, with the base pairs forming the ladder’s rungs and the sugar and phosphate molecules forming the vertical sidepieces of the ladder.



**RNA**

RNA differs from DNA in both structural and functional respects. RNA has two major structural differences: each of the ribose rings contains a 2´-hydroxyl, and RNA uses uracil in place of thymine. RNA molecules are capable of base pairing, but generally will not form large regions of stable RNA-RNA double helix. RNA can act as a genetic material.

**FUNCTION**

Nucleotides have a wide variety of functions.

One major function is to provide the thermodynamic driving force for a number of chemical reactions. This is especially well-known for ATP, but GTP is also used for a variety of reactions, UTP is used in glycogen and complex carbohydrate biosynthesis, and CTP is used in complex lipid synthesis.

Nucleotides are used to form intracellular signaling molecules such as cAMP and cGMP. In addition, ATP, ADP, and AMP act as signals to modulate energy metabolism. Nucleotides form parts of some cofactors, including NAD, FAD, and coenzyme A. Finally, nucleotides are the monomer units that comprise the nucleic acids RNA and DNA.

Cells maintain pools of free nucleotides for a variety of purposes. Adenosine derivatives are the most common free nucleotides, because ATP is used in the largest number of reactions. In addition, ATP is converted into S-adenosylmethionine, and a number of other molecules involved in metabolic reactions. As mentioned above, pools of other free nucleotides are also important in some types of reactions, although these pools tend to be much smaller than those of ATP.

Synthesis of nucleic acids (and especially synthesis of DNA) requires synthesis of nucleotides, because the cellular pools of the required free nucleotides are insufficient to provide all of the monomer units required.