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NUCLEIC ACIDS

Nucleobases, also known as *nitrogenous bases* or often simply *bases*, are nitrogen-containing biological compounds that form nucleosides, which, in turn, are components of nucleotides, with all of these monomers constituting the basic building blocks of nucleic acids. The ability of nucleobases to form base pairs and to stack one upon another leads directly to long-chain helical structures such as ribonucleic acid (RNA) and deoxyribonucleic acid (DNA).

Five nucleobases—adenine (A), cytosine (C), guanine (G), thymine (T), and uracil (U)—are called *primary* or *canonical*. They function as the fundamental units of the genetic code, with the bases A, G, C, and T being found in DNA while A, G, C, and U are found in RNA. Thymine and uracil are distinguished by merely the presence or absence of a methyl group on the fifth carbon (C5) of these heterocyclic six-membered rings.

Adenine and guanine have a fused-ring skeletal structure derived of purine, hence they are called purine bases. The purine nitrogenous bases are characterized by their single amino group (NH_2), at the C6 carbon in adenine and C2 in guanine. Similarly, the simple-ring structure of cytosine, uracil, and thymine is derived of pyrimidine, so those three bases are called the pyrimidine bases. Each of the base pairs in a typical double-helix DNA comprises a purine and a pyrimidine: either an A paired with a T or a C paired with a G. These purine-pyrimidine pairs, which are called *base complements*, connect the two strands of the helix and are often compared to the rungs of a ladder. The pairing of purines and pyrimidines may result, in part, from dimensional constraints, as this combination enables a geometry of constant width for the DNA spiral helix. The A-T and C-G pairings function to form double or triple hydrogen bonds between the amine and carbonyl groups on the complementary bases.

Structure and function

Nucleotide

A nucleotide is an organic molecule that is the building block of DNA and RNA. They also have functions related to cell signaling, metabolism, and enzyme reactions. A nucleotide is made up of three parts:

- a phosphate group,
- a 5-carbon sugar, and
- a nitrogenous base.

The four nitrogenous bases in DNA are adenine, cytosine, guanine, and thymine. RNA contains uracil, instead of thymine. A nucleotide within a chain makes up the genetic material of all known living things. They also serve a number of function outside of genetic information storage, as messengers and energy moving molecules.

Nucleotide Structure

Nucleotide structure is simple, but the structure they can form together is complex. The DNA molecule consists of two strands which wrap around each other, forming *hydrogen bonds* in the middle of the structure for support. Each nucleotide within has a specific structure which enables this formation.

Nitrogenous base

The nitrogenous base is the central information carrying part of the nucleotide structure. These molecules, which have different exposed functional groups, have differing abilities to interact with each other. The ideal arrangement involves the maximum amount of hydrogen bonds between nucleotides. Because of the structure of the nucleotide, only a certain nucleotide can interact with other. This even formation causes a twist in the structure, and is smooth if there are no errors.

Sugar

The second portion of the nucleotide is the sugar. Regardless of the nucleotide, the sugar is always the same. The difference is between DNA and RNA. In DNA, the 5-carbon sugar is deoxyribose, while in RNA, the 5-carbon sugar is ribose. This gives genetic molecules their names; the full name of DNA is deoxyribonucleic acid, and RNA is ribonucleic acid.

The sugar, with its exposed oxygen, can bond with the phosphate group of the next molecule. They then form a bond, which becomes the *sugar-phosphate backbone*. This structure adds rigidity to the structure, as the *covalent* bonds they form are much stronger than the hydrogen bonds between the two strands. When proteins come to process and *transpose* the DNA, they do so by separating the strands and reading only one side. When they pass on, the strands of genetic material comes back together, driven by the attraction between the opposing nucleotide bases. The sugar-phosphate backbone stays connected the whole time.

Phosphate Group

The last part of nucleotide structure, the phosphate group, is probably familiar from another important molecule *ATP*. Adenosine triphosphate, or ATP, is the energy molecule that most life on Earth relies upon to store and transfer energy between reactions. ATP contains three phosphate groups, which can store a lot of energy in their bonds. Unlike ATP, the bonds formed within a nucleotide are known as *phosphodiester bonds*, because they happen between the phosphate group and the sugar molecule.

During DNA replication, an enzyme known as *DNA polymerase* assembles the correct nucleotide bases, and begins organizing them against the chain it is reading. Another protein, *DNA ligase*, finished the job by creating the phosphodiester bond between the sugar molecule of one base and the phosphate group of the next. This creates the backbone of a new genetic molecule, able to be passed to the next generation. DNA and RNA contain all the genetic information necessary for cells to function.

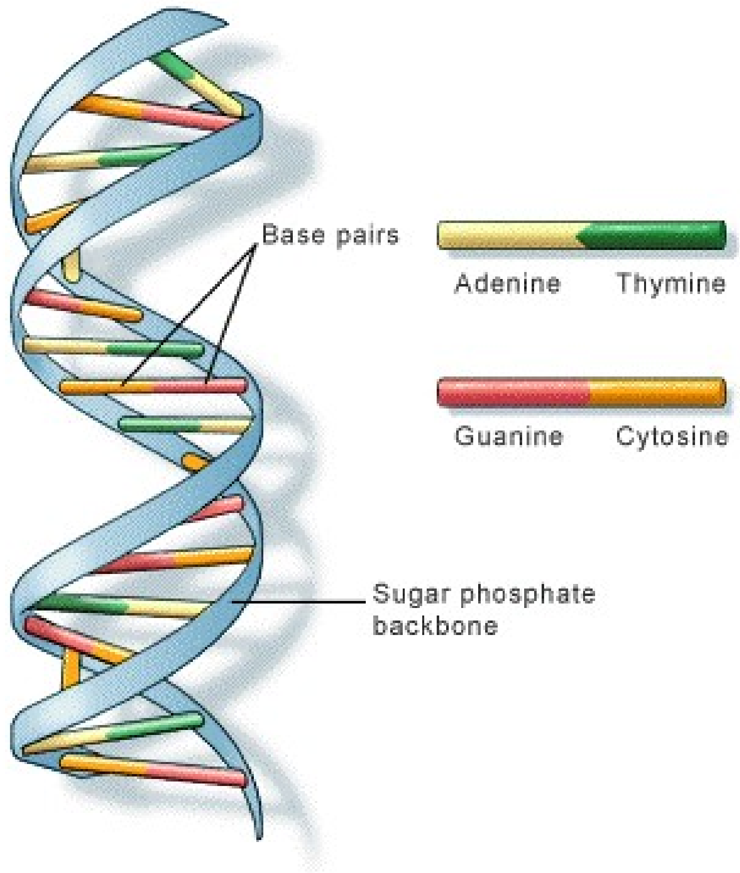


FIG: Backbone of the nuclic acid-DNA

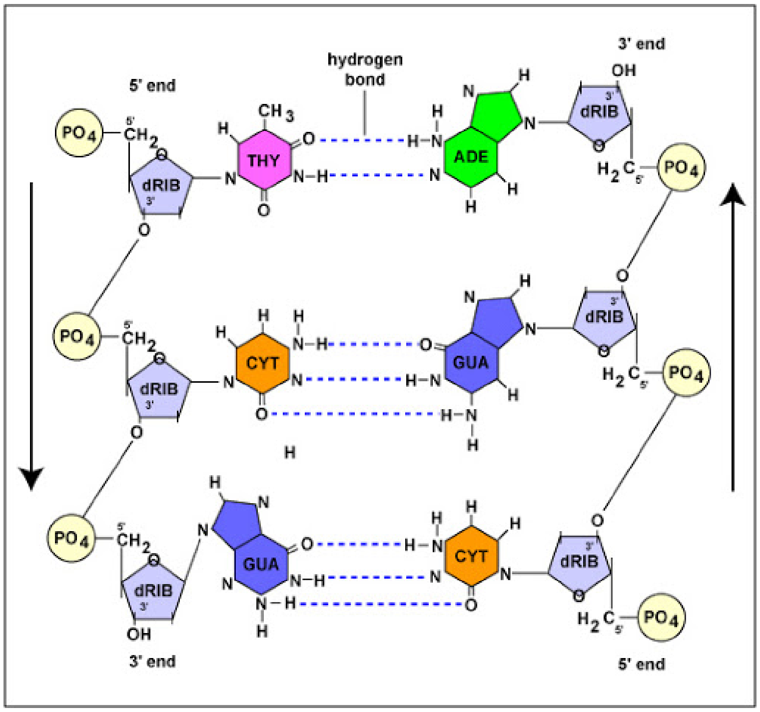


FIG: Molecular structure of the DNA double strand.

Structure Of Nucleotide

Adenine

Adenine is a purine, which is one of two families of nitrogenous bases. Purines have a double-ringed structure. In DNA, adenine bonds with thymine. In RNA, adenine bonds with uracil. Adenosine triphosphate, as discussed earlier, uses the nucleotide adenine as a base. From there, three phosphate groups can be attached. This allows a great deal of energy to be stored in the bonds. For the same reason that the sugar-phosphate backbone is so strong, the bonds in

ATP are as well. When combined with special enzymes which have formed to release the energy, it can be transferred to other reactions and molecules.

Guanine

Like adenine, guanine is a purine nucleotide; it has a double ring. It bonds with cytosine in both DNA and RNA. Guanine binds to cytosine through three hydrogen bonds. This makes the cytosine-guanine bond slightly stronger than the thymine-adenine bond, which only forms two hydrogen bonds.

Cytosine

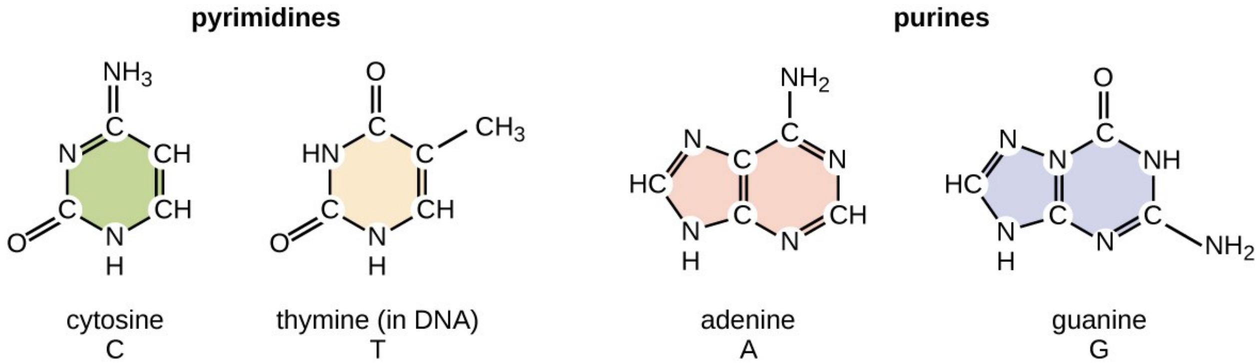
Pyrimidines are the other class of nucleotide. Cytosine is a pyrimidine nucleotide; it has only one ring in its structure. Cytosine bonds with guanine in both DNA and RNA. Bonding with the nucleotide guanine, the two make a strong pair.

Thymine

Like the nucleotide cytosine, thymine is a pyrimidine nucleotide and has one ring. It bonds with adenine in DNA. Thymine is not found in RNA. In DNA, it forms only two hydrogen bonds with adenine, making them the weaker pair.

Uracil

Uracil is also a pyrimidine. During transcription from DNA to RNA, uracil is placed everywhere a thymine would normally go. The reason for this is not entirely understood, though uracil has some distinct advantages and disadvantages. Most creatures do not use uracil within the DNA because it is short lived, and can degrade into cytosine. However, in RNA uracil is the preferred nucleotide because RNA is also a short lived molecule.



Nucleotide Function

Besides being the basic unit of genetic material for all living things, a nucleotide can have other functions as well:

- A nucleotide can be a base in another molecule, such as adenosine triphosphate (ATP), which is the main energy molecule of the cell.
- They are also found in coenzymes like NAD and NADP, which come from ADP; these molecules are used in many chemical reactions that play roles in metabolism.

- Another molecule that contains a nucleotide is cyclic AMP (cAMP), a messenger molecule that is important in many processes including the regulation of metabolism and transporting chemical signals to cells.
- Nucleotides not only make up the building blocks of life, but also form many different molecules that function to make life possible.

References:

- Biologydictionary.net/nucleotide
- En.wikipedia.org>wiki>Nucleobase