Nucleoproteins

Nucleoproteins are compounds containing nucleic acid and protein, especially, protamines and histones. These are usually the salt-like compounds of proteins since the two components have opposite charges and are bound to each other by electrostatic forces. They are present in nuclear substances as well as in the cytoplasm. These may be considered as the sites for the synthesis of proteins and enzymes.

There are two kinds of nucleoproteins: 1) *Deoxyribo nucleo proteins* (DNP) – *deoxyribonucleic acid* (DNA) is prosthetic group; 2) *Ribo nucleo proteins* (RNP) – *ribonucleic acid* (RNA) is prosthetic group.

Nucleo proteins are of central importance in the *storage*, *transmission*, and e*xpression* of genetic information.

Nucleotides and their derivatives are biologically ubiquitous substances that participate in nearly all biochemical processes:

1. They form the monomeric units of nucleic acids and thereby play central roles in both the storage and the expression of genetic information.
2. **Nucleoside triphosphates**, most conspicuously ATP, are the ―energy-rich‖ end products of the majority of energy-releasing pathways and the substances whose utilization drives most energy-requiring processes.
3. Most metabolic pathways are regulated, at least in part, by the levels of nucleotides such as ATP and ADP. Moreover, certain nucleotides function as intracellular signals that regulate the activities of numerous metabolic processes.
4. Nucleotide derivatives, such as **nicotinamide adenine dinucleotide**, **flavin adenine dinucleotide**, and **coenzyme A**, are required participants in many enzymatic reactions.
5. As components of the enzymelike nucleic acids known as **ribozymes**, nucleotides have important catalytic activities themselves.

Nucleotides, Nucleosides, and Bases

Nucleotides are phosphate esters of a five-carbon sugar (which is known as a **pentose**) in which a nitrogenous base is covalently linked to C1′of the sugar residue.

In **ribonucleotides** (Fig. 1), the monomeric units of RNA, the pentose is **D-ribose**, whereas in **deoxyribonucleotides** (or just deoxynucleotides; Fig. 1), the monomeric unitsofDNA,thepentoseis2′-deoxy-D-ribose(notethatthe―primed‖numbersrefer to the atoms of the ribose residue; ―unprimed‖ numbers refer to atoms of the nitrogenous base). The phosphate group may be bonded to C5′of the pentose to form a 5′-nucleotide (Fig. 1) or to its C3′ to form a 3′-nucleotide. If the phosphate group is absent, the compound is known as a nucleoside. A 5′-nucleotide, for example, may therefore be referred to as a nucleoside-5′-phosphate. In all naturally occurring nucleotides and nucleosides, the bond linking the nitrogenous base to the pentose C1′ atom (which is called a glycosidic bond) extends from the same side of the ribosering as does the C4′-C5′ bond (the so-called β configuration) rather than from the opposite side (the α configuration). Note that nucleotide phosphate groups are doubly ionized at physiological pH‘s; that is, *nucleotides are moderately strong acids*.

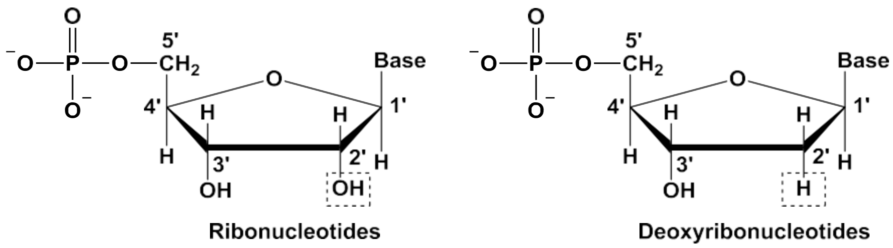
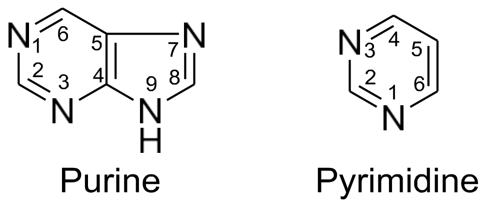


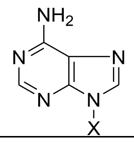
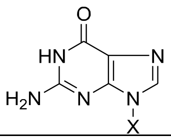
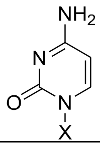
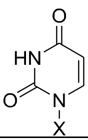
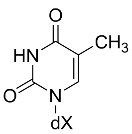
Figure1. Chemical Structures of Ribonucleotides and Deoxyribo nucleotides.

The nitrogenous bases are planar, aromatic, heterocyclic molecules which, for the most part, are derivatives of either **purine** or **pyrimidine**.



The structures, names, and abbreviations of the common bases, nucleosides, and nucleotides are given in Table 1. The major purine components of nucleic acids are adenine and guanine residues; the major pyrimidine residues are those of cytosine, uracil (which occurs mainly in RNA), and thymine (5-methyluracil, which occurs mainly in DNA). ThepurinesformglycosidicbondstoriboseviatheirN9atoms, whereas pyrimidines do so through their N1 atoms (note that purines and pyrimidines have dissimilar atom numbering schemes).

Table1. NamesandAbbreviationsofNucleicAcidBases, Nucleosides, and Nucleotides.

Base Formula	**Base (X=H)**	**Nucleoside (X= ribose*)**	**Nucleotide (X= ribose phosphate*)**
	Adenine Ade A	Adenosine Ado A	Adenylic acid Adenosinemonophosphate AMP
	Guanine Gua G	Guanosine Guo G	Guanylic acid Guanosinemonophosphate GMP
	Cytosine Cyt C	Cytidine Cyd C	Cytidylicacid Cytidinemonophosphate CMP
	Uracil Ura U	Uridine Urd U	Uridylic acid Uridinemonophosphate UMP
	Thymine Thy T	Deoxythymidine dThd dT	Deoxythymidylicacid Deoxythymidine monophosphate dTMP

* The presence of a 2′-deoxyribose unit in place of ribose, as occurs in DNA, is implied by the prefixes ―deoxy‖ or ―d.‖ For example, the deoxynucleoside of adenine is deoxyadenosine or dA. However, for thymine-containing residues, which rarely occur in RNA, the prefix is redundant and maybedropped.Thepresenceofariboseunitmaybeexplicitlyimpliedbytheprefixes―ribo‖or ―r.‖Thustheribonucleotideofthymineisribothymidineorr T.

The Chemical Structures of DNA and RNA. The chemical structures of the nucleic acids were elucidated by the early 1950s largely through the efforts of Phoebus Levene, followed by the work of Alexander Todd. Nucleic acids are, with few exceptions, linear polymers of nucleotides whose phosphate groups bridge the 3′ and 5′ positions of successive sugar residues (e.g., Fig. 2). The phosphates of these **polynucleotides**, the **phosphodiester** groups, are acidic, so that, at physiological pH‘s, nucleic acids are polyanions. Polynucleotides have directionality, that is, each

has a **3′end**(theendwhoseC3′atomisnotlinkedtoaneighboringnucleotide)and a

5′end(theendwhoseC5′atomisnotlinkedtoaneighboringnucleotide).

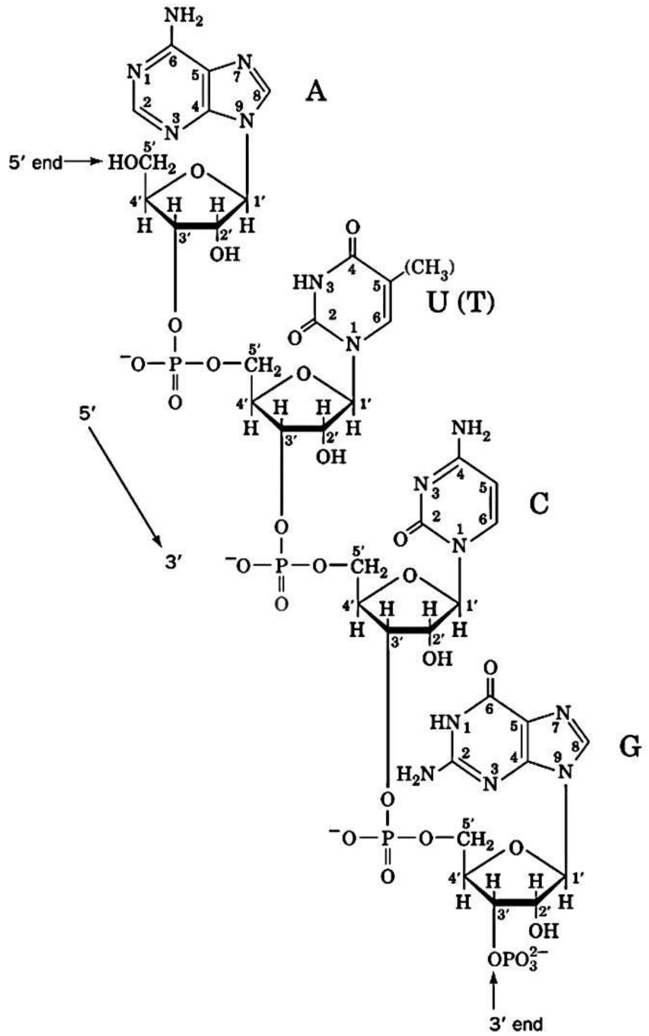


Figure 2. The Tetranucleotide Adenyl-3′,5′-uridyl-3′,5′-cytidyl-3′,5′-guanylyl-3′-phosphate.

DNA has equal numbers of adenine and thymine residues (A = T) and equal numbers of guanine and cytosine residues (G = C). These relationships, known as **Chargaff’s rules**, were discovered in the late 1940s by Erwin Chargaff, who first devised reliable quantitative methods for the separation and analysis of DNA hydrolysates. Chargaff also found that the base composition of DNA from a given organismis characteristic of that organism; that is,It is independent of the tissue from which the DNA is taken as well as the organism‘s age, its nutritional state, or any other environmental factor. The structural basis for Chargaff‟s rules is that in double-

stranded DNA, G is always hydrogen bonded (forms a **base pair**) with C, whereas A always forms a base pair with T (Fig. 3).

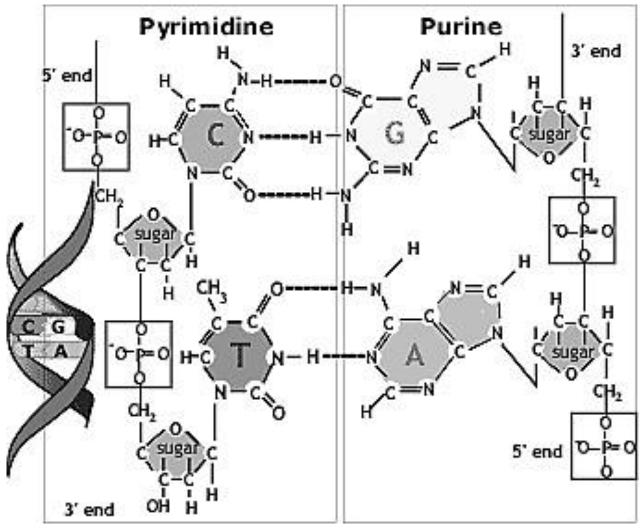
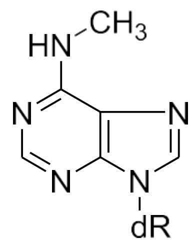


Figure3. Base Pairs in DNA Structure.

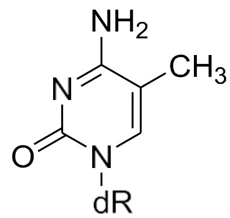
DNA‘s base composition varies widely among different organisms. It ranges from ~25% to 75% G+C in different species of bacteria. It is, however, more or less constant among related species; for example, in mammals G+C ranges from 39% to 46%.

RNA, which usually occurs as single-stranded molecules, has no apparent constraints on its base composition. However, double-stranded RNA, which comprises the genetic material of certain viruses, also obeys Chargaff‟s rules (here A base pairs with U in the same way it does with T in DNA). Conversely, single- stranded DNA, which occurs in certain viruses, does not obey Chargaff‟s rules. On entering its host organism, however, such DNA is replicated to form a double- stranded molecule, which then obeys Chargaff‟s rules.

SomeDNAscontainbasesthatarechemicalderivativesofthestandardset.For example, dA and dC in the DNAs of many organisms are partially replaced by **N^6- methyl-dA** and **5-methyl-dC**, respectively.



N^6-Methyl-dA



5-Methyl-dC

The altered bases are generated by the sequence-specific enzymatic modification of normal DNA. The modified DNAs obey Chargaff's rules if the derivatized bases are taken as equivalent to their parent bases. Likewise, many bases in RNAs and, in particular, those in **transfer RNAs** (**tRNAs**) are derivatized.