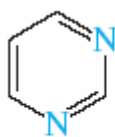


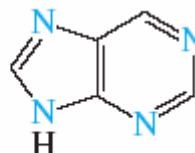
Nucleosides, Nucleotides, and Nucleic Acids

SUMMARY

Section 28.1 Many biologically important compounds are related to the heterocyclic aromatic compounds pyrimidine and purine.

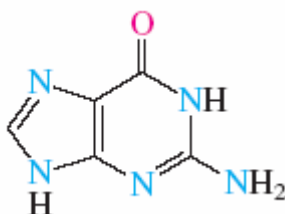


Pyrimidine



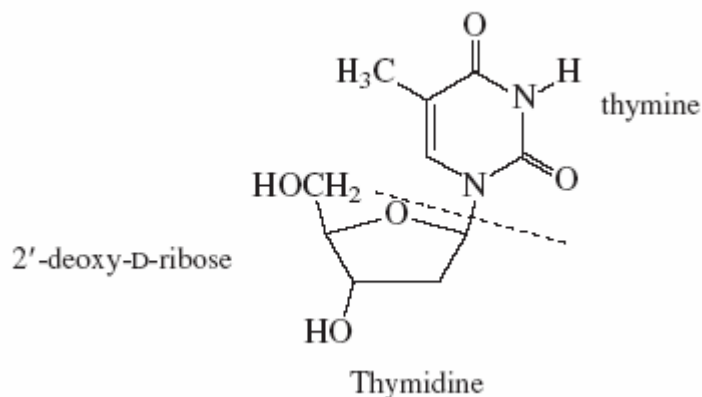
Purine

The structure of guanine illustrates an important feature of substituted pyrimidines and purines. Oxygen substitution on the ring favors the keto form rather than the enol. Amino substitution does not.

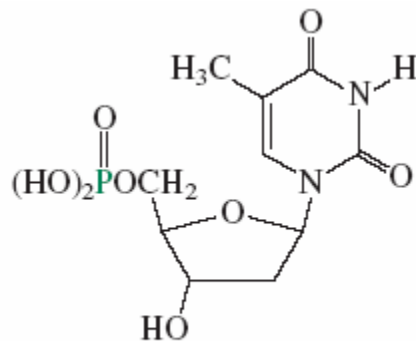


Guanine

Section 28.2 **Nucleosides** are carbohydrate derivatives of pyrimidine and purine bases. The most important nucleosides are derived from D-ribose and 2-deoxy-D-ribose.



Section 28.3 **Nucleotides** are phosphoric acid esters of nucleosides.

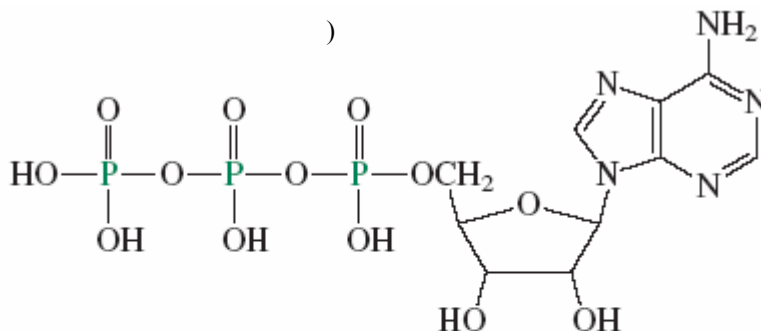


Thymidine 5'-monophosphate

In the example shown, the 5'-OH group is phosphorylated. Nucleotides are also possible in which some other OH group bears the phosphate ester function. Cyclic phosphates are common and important as biochemical messengers.

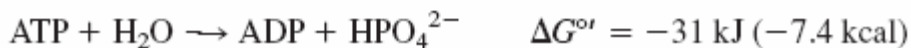
Section 28.4 **Bioenergetics** is concerned with the thermodynamics of biological processes. Particular attention is paid to ΔG° , the standard free-energy change of reactions at pH 7. When the sign of ΔG° is 1, the reaction is **endergonic**; when the sign of ΔG° is 2, the reaction is **exergonic**.

Section 28.5 **Adenosine triphosphate (ATP)** is a key compound in biological energy storage and delivery.



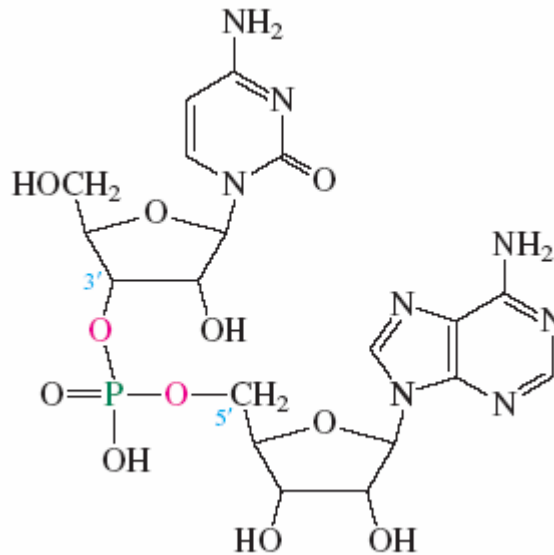
Adenosine triphosphate (ATP)

The hydrolysis of ATP to ADP and HPO_4^{2-} is exergonic.



Many formally endergonic biochemical processes become exergonic when they are coupled mechanistically to the hydrolysis of ATP.

Section 28.6 Many important compounds contain two or more nucleotides joined together by a **phosphodiester** linkage. The best known are those in which the phosphodiester joins the 5'-oxygen of one nucleotide to the 3'-oxygen of the other.



Oligonucleotides contain about 50 or fewer nucleotides held together by phosphodiester links; **polynucleotides** can contain thousands of nucleotides.

- Section 28.7 **Nucleic acids** are polynucleotides present in cells. The carbohydrate component is D-ribose in ribonucleic acid (RNA) and 2-deoxy-D-ribose in deoxyribonucleic acid (DNA).
- Section 28.8 The most common form of DNA is B-DNA, which exists as a right-handed double helix. The carbohydrate-phosphate backbone lies on the outside, the purine and pyrimidine bases on the inside. The double helix is stabilized by complementary hydrogen bonding (base pairing) between adenine (A) and thymine (T), and guanine (G) and cytosine (C).
- Section 28.9 Within the cell nucleus, double-helical DNA adopts a **supercoiled** tertiary structure in which short sections are wound around proteins called **histones**. This reduces the effective length of the DNA and maintains it in an ordered arrangement.
- Section 28.10 During DNA replication the two strands of the double helix begin to unwind, exposing the pyrimidine and purine bases in the interior. Nucleotides with complementary bases hydrogen bond to the original strands and are joined together by phosphodiester linkages with the aid of DNA polymerase. Each new strand grows in its 5' to 3' direction.
- Section 28.11 Three RNAs are involved in gene expression. In the **transcription** phase, a strand of **messenger RNA (mRNA)** is synthesized from a DNA template. The four bases A, G, C, and U, taken three at a time, generate 64 possible combinations called **codons**. These 64 codons comprise the **genetic code** and code for the 20 amino acids found in proteins plus start and stop signals. The mRNA sequence is **translated** into a prescribed protein sequence at the ribosomes. There, small polynucleotides called **transfer RNA (tRNA)**, each of which contains an **anticodon** complementary to an mRNA codon, carries the correct amino acid for incorporation into the growing protein. **Ribosomal RNA (rRNA)** is the main constituent of ribosomes and appears to catalyze protein biosynthesis.
- Section 28.12 The start codon for protein biosynthesis is AUG, which is the same as the codon for methionine. Thus, all proteins initially have methionine as their N-terminal amino acid, but lose it subsequent to their formation. The reaction responsible for extending the protein chain is nucleophilic acyl substitution.
- Section 28.13 HIV, which causes AIDS, is a retrovirus. Its genetic material is RNA instead of DNA. HIV contains an enzyme called reverse transcriptase that allows its RNA to serve as a template for DNA synthesis in the host cell.
- Section 28.14 The nucleotide sequence of DNA can be determined by a technique in which a short section of single-stranded DNA is allowed to produce its complement in the presence of dideoxy analogs of ATP, TTP, GTP, and CTP. DNA formation terminates when a dideoxy analog is incorporated into the growing polynucleotide chain. A

mixture of polynucleotides differing from one another by an incremental nucleoside is produced and analyzed by electrophoresis. From the observed sequence of the complementary chain, the sequence of the original DNA is deduced.

Section 28.15 The sequence of nucleotides that make up the human genome has been completed. There is every reason to believe that the increased knowledge of human biology it offers will dramatically affect the practice of medicine.

Section 28.16 In **DNA profiling** the noncoding regions are cut into smaller fragments using enzymes that recognize specific sequences, and these smaller bits of DNA are then separated by electrophoresis. The observed pattern of DNA fragments is believed to be highly specific for the source of the DNA. Using the **polymerase chain reaction (PCR)**, millions of copies of minute amounts of DNA can be produced in a relatively short time.