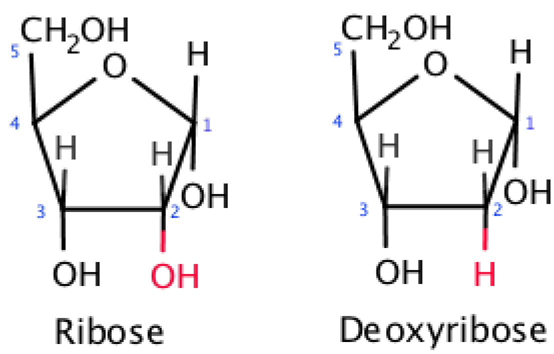
4.2

Nucleic Acids

Nucleic acids can be categorized into deoxyribonucleic acid (**DNA**) and ribonucleic acid (**RNA**) both of which act to carry the genetic information essential to life. DNA is the genetic material common to all living organisms with slight variation between organism type. For example, in eukaryotic cells, DNA complexes with proteins called histones to make chromatin which then forms chromosomes that are stored in the nucleus. Chromosomes are the site of genes, which contain all the information necessary to make proteins. In contrast, prokaryotic DNA is less organized and found throughout the cytoplasm of the cell. If DNA is packaged in a nucleus, it never leaves, instead it communicates instructions to the rest of the cell via the other type of nucleic acid, RNA. RNA comes in multiple different subtypes like rRNA, tRNA, mRNA and microRNA.

Both types of nucleic acids are made of monomers called nucleotides. All nucleotides contain three components: a nitrogenous base, a pentose sugar, and a phosphate group. These components interact in a very specific way in that each nitrogenous base attaches to the sugar molecule, and each sugar molecule then attaches to one or more phosphate groups.

Nitrogenous bases: Nitrogenous bases contain carbon and nitrogen and are considered “bases” because they contain an amino group that can bind hydrogen. Nitrogenous bases come in five varieties: adenine, guanine, cytosine, thymine, and uracil. Additionally, nitrogenous bases are categorized as either purines or pyrimidines. Purines structures contain two nitrogen-carbon rings and pyrimidines have one nitrogen-carbon ring. Guanine and adenine are purines while cytosine, thymine and uracil are pyrimidines. Each base is abbreviated as follows: adenine (A), thymine (T), guanine (G), cytosine (C), and uracil (U). DNA contains A, T, G and C and RNA contains A, U, G and C.



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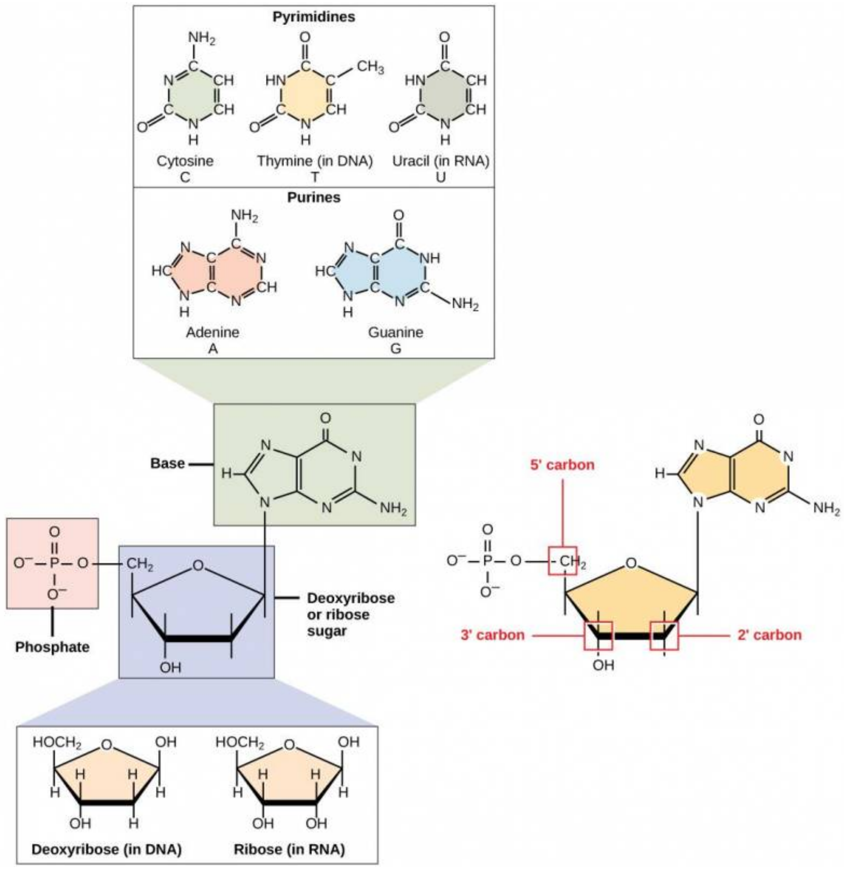
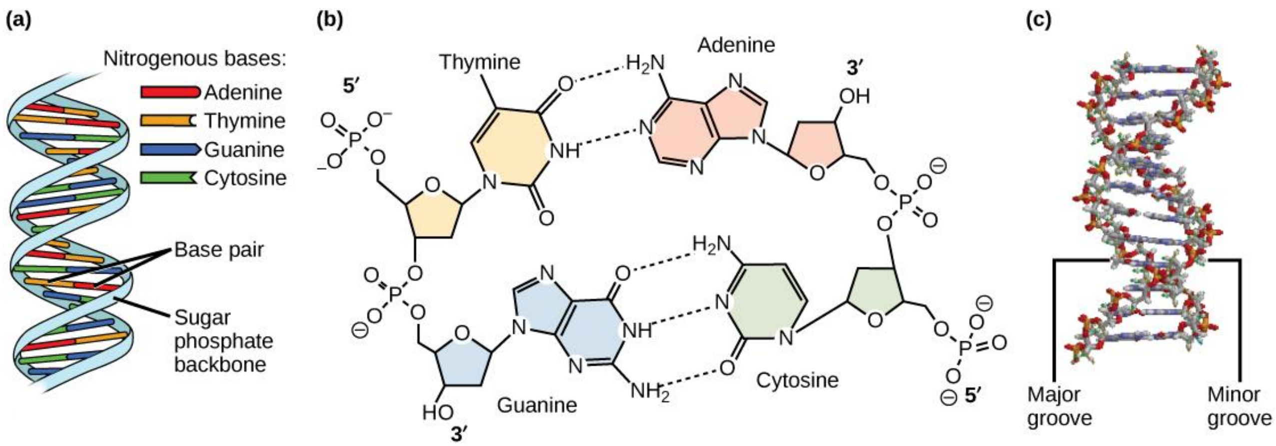


Pentose Sugar: The pentose sugar found in DNA is called deoxyribose and the pentose sugar found in RNA is ribose. The difference between the two sugars is whether they contain a hydroxyl or a hydrogen on the second carbon. Ribose contains a hydroxyl group and deoxyribose contains a hydrogen. Since pentose sugars are monosaccharides the most stable structure is "ring" shaped, and namely follows the conventional form of starting the number 1 carbon as the first carbon clockwise from oxygen. Thus, the carbon atoms are number 1,2,3,4, and 5 prime (i.e., one prime (1'), two prime (2'), etc).

Phosphate group: Phosphate groups are attached to the hydroxyl groups on carbon number five (5') and carbon number three (3') of different monomers to form polymers through phosphodiester linkages.

Once assembled, nucleic acids form long chains where the pentose and the phosphate phosphodiester linkages make up the backbone and the nitrogenous base extends out from the backbone chain. DNA exists as two chains interwoven around each other (double-helix structure) where the nitrogenous bases become stacked in the interior like steps on a spiral staircase. Hydrogen bonds stabilize the structure between the nitrogenous base and the two strands run in opposite directions so that the 5' carbon on one strand faces the 3' carbon of the matching strand. The backbones of DNA run antiparallel, meaning in opposite directions. In addition, only certain nucleotides can form hydrogen bonds with each other called pairing. For example, only A can pair with T (two hydrogen bonds form), and G with C (three hydrogen bonds form). Since hydrogen bonds are weaker bonds, the two strands can be pulled apart (unzipped) and put back together rather quickly. To summarize, strands run from 5' to 3' or from 3' to 5' and must be paired complementary to each other. Using only the nitrogenous base, if one strand ran 5' to 3'with nitrogenous bases lined up as ATTAGGCTG then the complementary strand would run 3' to 5' and the nitrogenous based would be lined up as TAATCCGAC. The order at which nitrogenous bases are lined up in a strand of DNA, much like how letters are lined up in this sentence, is the bases of the genetic code. For example, chromosome one is composed of 250 million base pairs (bp) and can be read by cellular machinery similar to how we are reading this textbook. Since we understand the order of letters and how they are used to form words and then sentences we can then build ideas based on what we read.



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Central Dogma