Thanks in part to the work done by Rosalind Franklin and others, such as Erwin Chargaff, Watson and Crick were able to determine the structure of DNA (Figure 10.4). Watson and Crick proposed that DNA is made up of two strands that are twisted around each other to form a right-handed **double helix**, and that in the interior base pairing takes place between a purine and pyrimidine (A-T or G-C), as was suggested by Chargaff's Rules.

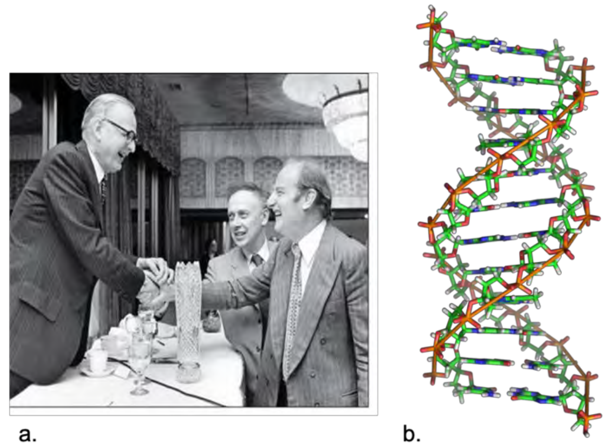

Figure 10.4 Pioneering scientists (a) James Watson and Francis Crick are pictured here with American geneticist Maclyn McCarty. (Biology 2E [OpenStax](https://openstax.org/)) (b) Double helix DNA model. (credit: [Zephyris/ CC BY-SA 3.0](https://creativecommons.org/licenses/by-sa/3.0/))

In 1962, James Watson, Francis Crick, and Maurice Wilkins were awarded the Nobel Prize in Medicine for their work in determining the structure of DNA. Rosalind Franklin died of ovarian cancer in 1958 at the age of 37. As a result, she was not awarded the Nobel Prize for her contribution in the discovery of the DNA structure because it is not given posthumously.

Nucleic Acids

In chapter three, students learned about nucleic acids, one of the four different biologically important molecules found in all living cells. Recall that there are two important polymers of nucleic acids, **deoxyribonucleic acid** (DNA) and **ribonucleic acid** (RNA). Although both DNA and RNA are made up of nucleotides, they function differently within the cell. DNA stores the genetic information needed to build proteins required for maintaining homeostasis. RNAs, on the other hand, are molecules that are involved in protein synthesis. Currently, cells use DNA as a template to assemble RNA. This process will be covered in sections 10.3 and 10.4.

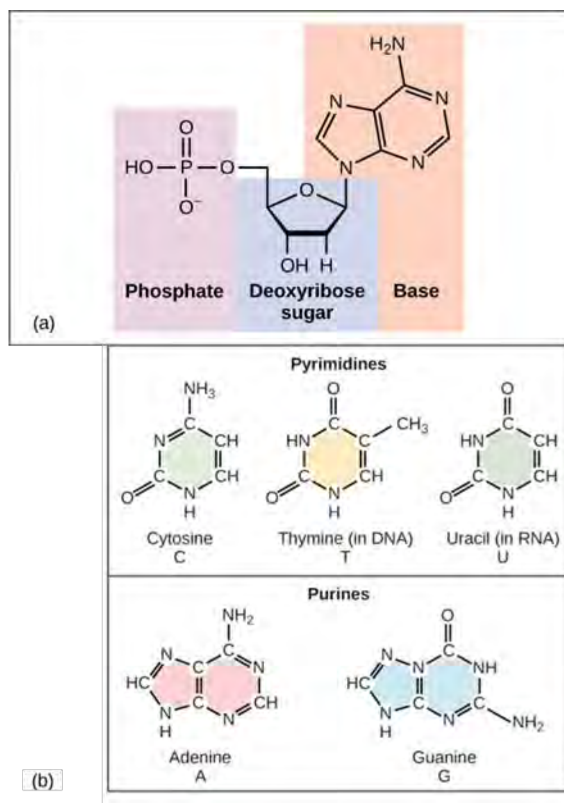

Figure 10.5 (a) Each nucleotide is made up of a sugar, a phosphate group, and a base. (b) Cytosine, thymine, and uracil are pyrimidines. Guanine and adenine are purines. (credit: Fowler et al. / [Concepts of Biology OpenStax](https://openstax.org/))

The Structure of DNA

All nucleic acids are made up of monomers called nucleotides. A **nucleotide** has three parts: a 5-carbon sugar, a phosphate group, and a **nitrogenous base** (Figure 10.5). DNA nucleotides contain the 5-carbon sugar **deoxyribose** and four types of nitrogenous bases: adenine (A), guanine (G), cytosine (C), and thymine (T).

Long polymers of DNA are formed when the phosphate group of one nucleotide bonds covalently with the sugar molecule of the next nucleotide (Figure 10.6). The sugar–phosphate groups line up and form a “backbone” for each strand of DNA. The nitrogenous bases stick out from each backbone and the bases on opposite DNA strands can base pair through hydrogen bonding (Figure 10.6).

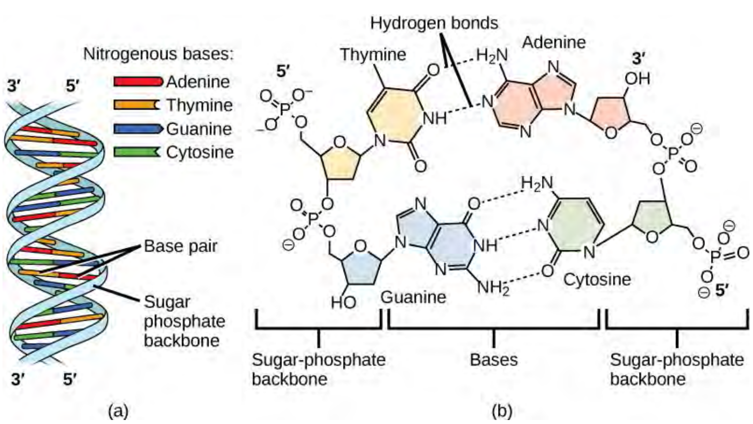

Figure 10.6 DNA (a) forms a double stranded helix, and (b) adenine pairs with thymine and cytosine pairs with guanine. (credit a: modification of work by Jerome Walker, Dennis Myts/ [Concepts of Biology OpenStax](#))

The carbon atoms of the five-carbon sugar are numbered clockwise from the oxygen as 1', 2', 3', 4', and 5' (1' is read as “one prime”) (Figure 10.7a). The phosphate group is attached to the 5' carbon of one nucleotide and the 3' carbon of the next nucleotide (Figure 10.7b). Each DNA strand has a 5’ carbon at one end and a 3’ carbon at the other end. In its natural state, each DNA molecule is composed of two single DNA strands held together by hydrogen bonds between the nitrogenous bases.

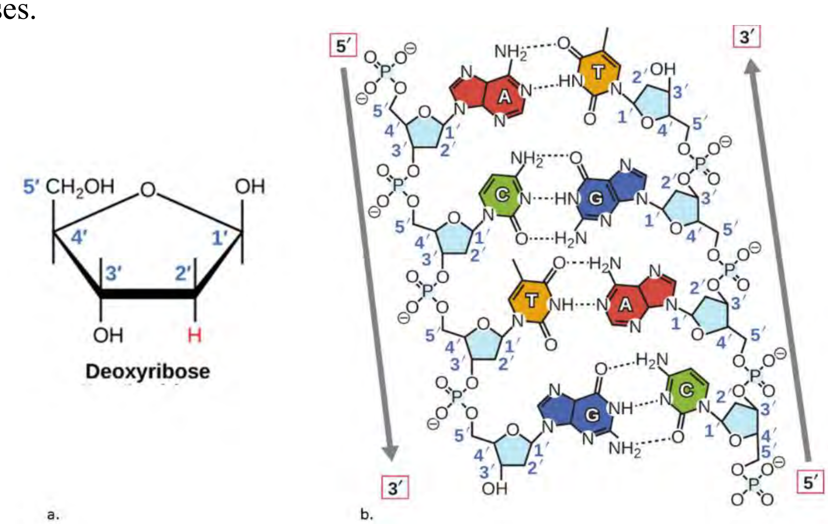

Figure 10.7 a. The carbon atoms of the five-carbon sugar are numbered clockwise from the oxygen as 1', 2', 3', 4', and 5' (1' is read as “one prime”). (credit: Fowler et al. / Concepts of Biology OpenStax) b. The direction of each strand is identified by numbering the carbons (1 through 5) in each sugar molecule. (credit: Parker et al. / Microbiology OpenStax)

It has long since been confirmed that base-pairing takes place between specific purines and pyrimidines. Adenine always base pairs with thymine and cytosine always base pairs with guanine. Adenine and thymine are connected by two hydrogen bonds, and cytosine and guanine are connected by three hydrogen bonds (Figure 10.6b). The two strands of DNA are anti-parallel in nature; that is, one strand will have the 3' carbon of the sugar in the "upward" position, whereas the other strand will have the 3' carbon in the "downward" position (Figure 10.7b).

The Structure of RNA

Like DNA, RNA is also a polymer composed of nucleotides. RNA nucleotides also contain a 5-carbon sugar, a phosphate group, and a nitrogenous base. RNA nucleotides are made of the five-carbon sugar **ribose**, unlike the deoxyribose found in DNA. Ribose has a hydroxyl group at the 2' carbon, unlike deoxyribose, which has only a hydrogen atom (Figure 10.8).

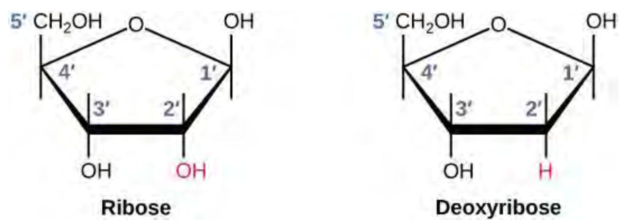

Figure 10.8 The difference between the ribose found in RNA and the deoxyribose found in DNA is that ribose has a hydroxyl group at the 2' carbon. (credit: Fowler et al. / Concept of Biology OpenStax)

RNA nucleotides also have a nitrogenous base; however, the four types of RNA nitrogenous bases are: adenine (A), uracil (U), cytosine (C), and guanine (G). Note, RNA does not use the nitrogenous base thymine, which is found in DNA. RNA is also different than DNA in that it is a single-stranded molecule rather than a double-stranded helix (Figure 10.9). Molecular biologists have named several different kinds of RNA based on their function. These include messenger RNA (mRNA), transfer RNA (tRNA), and ribosomal RNA (rRNA). All three types of RNA molecules are involved in protein synthesis and will be discussed in sections 10.3 and 10.4.

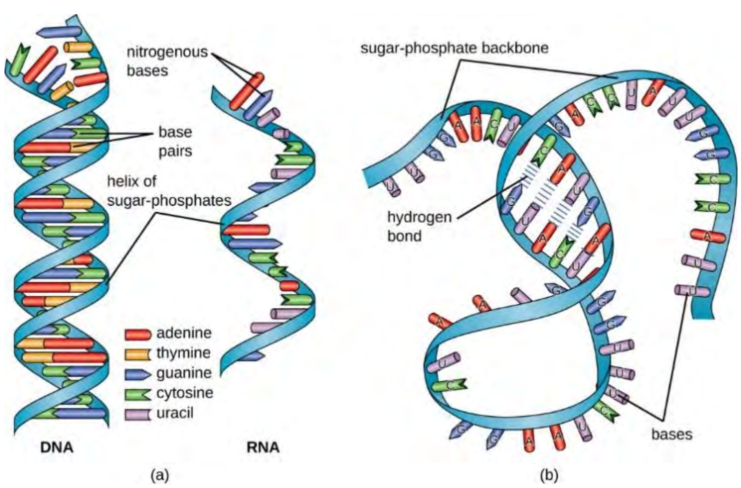

Figure 10.9 (a) DNA is typically double stranded, whereas (b) RNA is typically single stranded. Although it is single stranded, RNA can fold upon itself, with the folds stabilized by short areas of complementary base pairing within the molecule, forming a three-dimensional structure. (credit: Parker et al. / Microbiology OpenStax)