Chapter 10: DNA replication and Protein Synthesis

Figure 10.1 This photo shows Dolly the sheep. Dolly the sheep was the first clone of a mammal. (credit: Clark et al. / Biology 2E OpenStax)

DNA, deoxyribonucleic acid, is found in every living cell. It can be isolated from single-celled organisms like bacteria, or multicellular organisms like plants and animals. Each organism's DNA is unique, making it an excellent tool for species identification.

The field of molecular biology, which was developed in the last half-century, has enabled us to both isolate and sequence DNA. These techniques allow us to look more closely at the history of life and to understand the relationships between different living organisms. Thousands of species have had their entire genomes sequenced. These sequences allow us to understand inheritance, evolutionary relationships, and much more.

10.1 The Structure of DNA

Learning objectives

By the end of this section, you will be able to:

- *Briefly explain the history and work of Watson, Crick, Franklin, and Wilkins*
- *Describe the structure of DNA including locations of covalent and hydrogen bonds, base pairing, and the major components of a nucleotide*
- *Compare DNA and RNA*
- *Be able to define and explain all bolded terms*

In the 1950s, many different scientists were working to answer the following question: what does the structure of DNA look like? Research supported that DNA was the heritable material being passed from parent to offspring. It was also understood that if cells were going to divide, the DNA needed to be replicated. However, to understand DNA synthesis or how DNA leads to specific phenotypes, the molecular structure of DNA needed to be determined.

Francis Crick and James Watson, both students at the University of Cambridge, England, worked together to determine the structure of DNA; however, they did not do it alone. They depended on the work and research of other scientists, including Rosalind Franklin and Maurice Wilkins. Maurice Wilkins and Rosalind Franklin were working in the same laboratory when Franklin developed an improved technique of X-ray crystallography to understand the structure of DNA (Figure 10.2). X-ray crystallography was a process that involved shooting X-rays through a crystal of a substance and then observing the patterns that were formed. The patterns give important information about the structure of the molecule of interest. Wilkins shared Franklin's X-ray crystallography data with Watson and Crick without her permission. With the help of her data, they were able to piece together the structure of DNA.

Figure 10.2 Rosalind Franklin provided X-ray crystallography data leading to the discovery of the structure of DNA. "Photo 51" led to a new understanding of DNA structure. (credit: Rosalind Franklin image MRC Laboratory of Molecular Biology/ Wikimedia Commons SA 4.0 (credit: X-ray crystallography image modification of work by NIH / Biology 2E OpenStax)

Watson and Crick also used information published by the researcher Erwin Chargaff. Chargaff was an Austrian biochemist who examined the content of DNA in different species and found that the amounts of pyrimidines (cytosine and thymine) were not found in equal quantities. Likewise, purines (adenine and guanine) were also not found in equal quantities (Figure 10.3). He found that the relative concentrations of the four nucleotide bases varied from species to species. He also discovered that the amount of adenine equaled the amount of thymine, and the amount of cytosine equaled the amount of guanine; that is, A = T and G = C. These observations became known as Chargaff's rules. Chargaff's findings proved immensely useful when Watson and Crick were getting ready to propose their DNA double helix model.

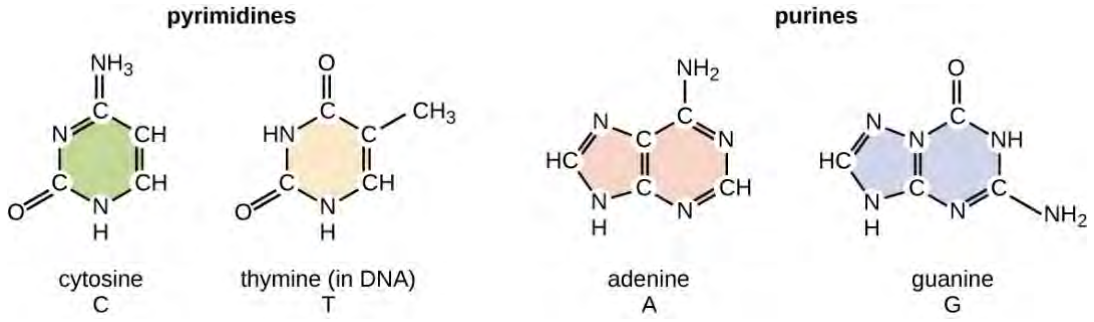

Figure 10.3 Nitrogenous bases within DNA are categorized into the two-ringed purines, adenine and guanine, and the single-ringed pyrimidines, cytosine and thymine. Thymine is unique to DNA. (credit: Parker et al. / Microbiology OpenStax)