

Chapter 9

Topic: DNA history, replication

Main concepts:

- When DNA was first discovered in the 19th century, scientists only knew it was a chemical in the cell. They did not know what it was for, nor could they correctly identify the physical structure.
- By the end of the 19th century, scientists knew that something in the nucleus of the cell controlled heredity. They used the term “gene” to refer to the sets of instructions for traits, though they did not know what genes were made of.
- One of the scientific controversies in the early 20th century was around the identity of the hereditary molecule. Some scientists thought it must be DNA, since DNA was found only in the nucleus and was contained in the chromosomes. Other scientists thought that since DNA was made from only four nucleotides that it was not complex enough to code for thousands of traits. These scientists, including Linus Pauling, thought that proteins must be the molecules controlling heredity.
- Researcher Frederick Griffith carried out an experiment with a bacteria that caused pneumonia in mice. He found that the only biomolecule that could turn a non-virulent (non-disease-causing) bacteria into a virulent (disease-causing) strain was DNA. His findings were later confirmed by a team led by Oswald Avery.
- Erwin Chargaff studied DNA and the proportions of the four nucleotide bases that made it up. He discovered that DNA had more Adenine (A) and Thymine (T) than Cytosine (C) and Guanine (G), but that there were always equal amounts of Adenine and Thymine, and equal amounts of Cytosine and Guanine. This suggested that A and T somehow came in pairs, as did C and G.
- Rosalind Franklin used X-ray crystallography to determine the structure of DNA, and hypothesized that it formed a long, helix-shaped strand.
- Watson and Crick, using data from Franklin and Chargaff, built the first accurate model of DNA, and are given credit for discovering the structure.
- DNA is a ladder-shaped molecule. The sides of the “ladder” are made up of deoxyribose sugar and phosphate groups. The rungs are formed by the four bases: Adenine, Thymine, Cytosine, and Guanine. These always match across the rungs in a certain pattern: Adenine matches up with Thymine, Cytosine matches up with Guanine. This is because A and T form two hydrogen bonds with one another, while C and G form three hydrogen bonds.
- Each strand of DNA in a cell becomes a chromosome during cell division.
- When a cell must divide, it must produce two cells with exactly the same genetic material. To do this, cells replicate (double) each strand of DNA.
- DNA duplication is an orderly process carried out by enzymes.
 - **DNA helicase** “unzips” the two sides of the DNA strand by breaking the hydrogen bonds between bases.
 - **DNA polymerase** matches free nucleotides to the exposed bases, creating new strands by using the halves of the old strands as templates (semi-conservative replication).
 - **DNA ligase** joins fragments of the sugar-phosphate backbones together to complete the new strands.
- Enzymes patrol and “proofread” DNA constantly to prevent errors. However, some errors do occur. These are known as mutations. A mutation in a body cell may cause the cell to die, or can cause a malfunction, such as cancer (when the genes controlling cell division are mutated). A mutation in a sex cell (eggs or sperm) can be passed on to an offspring, so that all of the offspring’s body cells have the mutation.

Common misconceptions:

- Students sometimes confuse DNA replication with cell division. Replication does occur before cell division, but replication only concerns the DNA.
 - Students often have very vague ideas about where genes are located and what they do. Genes are segments of information on DNA strands which code for particular proteins.
 - Thanks to comic books and cartoons, many people believe that “mutations” can transform the whole body due to exposure to “chemicals” or “radiation.” Mutations happen to the DNA inside of cells, and while multiple cells may be involved, the actual mutations may be different from cell to cell, since the action of a mutagen is unpredictable.
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Chapter study guide:

- Read and summarize Griffith's experiment with pneumonia in mice. Note particularly what data led Griffith to the conclusion that DNA was the hereditary material.
- List the four nucleotide bases of DNA. Note which ones are single-ring bases and which ones are double-ring bases.
- Read and summarize the data that led Franklin to believe that DNA formed a double helix.
- Summarize the role that hydrogen bonds play in keeping the two sides of the DNA ladder together.
- State how DNA codes information.
- When is DNA replicated?
- State the roles of these enzymes in DNA replication: DNA helicase, DNA polymerase, DNA ligase.
- List the steps of DNA replication. Use Figure 9-4 as a guide. Also carefully read A Closer Look to understand the details.
- Summarize how errors can creep into the DNA. (Note that ultraviolet light, a strong mutagen, is only *one* component of sunlight. UV light used in tanning beds also causes mutations that lead to wrinkling, premature skin aging, and skin cancer.)

Useful websites:

- "Build a DNA Molecule" <http://learn.genetics.utah.edu/units/basics/builddna/> is an interactive feature that allows you to drag and drop nucleotides to build a short DNA strand. Requires Flash.
 - "DNA Replication" http://www.fed.cuhk.edu.hk/~johnson/teaching/genetics/animations/dna_replication.htm is an animation that shows how enzymes assist in replication. Requires Shockwave.
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