Mader/*Biology*, 11/e – Chapter Outline

Chapter 12

12.2 Replication of DNA

1. **DNA replication** is the process of copying a DNA molecule. Replication is **semiconservative**, with each strand of the original double helix (*parental* molecule) serving as a **template** (mold or model) for a new strand in a *daughter* molecule. This process consists of:
    a. **Unwinding:** old strands of the parent DNA molecule are unwound as weak hydrogen bonds between the paired bases are "unzipped" and broken by the enzyme *helicase.*
    b. **Complementary base pairing:** free nucleotides present in the nucleus bind with complementary bases on unzipped portions of the two strands of DNA; this process is catalyzed by **DNA polymerase.**
    c. **Joining:** complementary nucleotides bond to each other to form new strands; each daughter DNA molecule contains an old strand and a new strand; this process is also catalyzed by DNA polymerase.

A. Aspects of DNA Replication (*Biological Systems* reading)
    1. For complementary base pairing to occur, the DNA strands need to be antiparallel, as discovered by Watson and Crick.
    2. One strand of DNA is 5' at the top and the other strand is 3' at the top of the strand.
    3. During replication the DNA polymerase can only join to the free 3' end of the previous nucleotide.
    4. DNA polymerase cannot start the synthesis of a DNA chain, so an RNA polymerase lays out an *RNA primer* that is complementary to the replicated strand.
    5. Now the DNA polymerase can join the DNA nucleotides to the 3' end of the new strand.
    6. The helicase enzyme unwinds the DNA and one strand (called the *leading new strand*) can be copied in the direction of the replication fork.
    7. The other strand of DNA is copied in the direction away from the fork, and replication begins again.
        a. This new lagging strand is discontinuous and each segment is called an *Okazaki fragment*, after the scientist who discovered them.
    8. Replication is only complete when RNA primers are removed.
    9. During replication, DNA molecules gets smaller and smaller.
    10. The end of eukaryotic DNA molecules have nucleotide sequences called **telomeres.**
        a. Telomeres don't code for proteins. They are repeats of short nucleotide sequences (i.e., TTAGGG).
    11. Normal mammalian cells divide approximately 50 times and then stop. However in cancer cells the telomerase can be turned on and cancer cells then divide without limit.

B. Prokaryotic Versus Eukaryotic Replication
    1. Prokaryotic DNA Replication
        a. Bacteria have a single loop of DNA that must replicate before the cell divides.
        b. Replication in prokaryotes may be bidirectional from one point of origin or in only one direction.
        c. Replication only proceeds in one direction, from 5' to 3'.
        d. Replication begins at a special site on a bacterial chromosome, called the *origin of replication*.
        e. Bacterial cells can complete DNA replication in 40 minutes; eukaryotes take hours.
    2. Eukaryotic DNA Replication

a. Replication in eukaryotes starts at many points of origin and spreads with many replication bubbles—places where the DNA strands are separating and replication is occurring.

b. **Replication forks** are the V-shape ends of the replication bubbles; the sites of DNA replication.

c. Eukaryotes replicate their DNA at a slower rate—500 to 5,000 base pairs per minute.

d. Eukaryotes take hours to complete DNA replication.

3. Accuracy of Replication

a. A mismatched nucleotide may occur once per 100,000 base pairs, causing a pause in replication.

b. Proofreading is the removal of a mismatched nucleotide; DNA repair enzymes perform this proofreading function and reduce the error rate to one per billion base pairs.