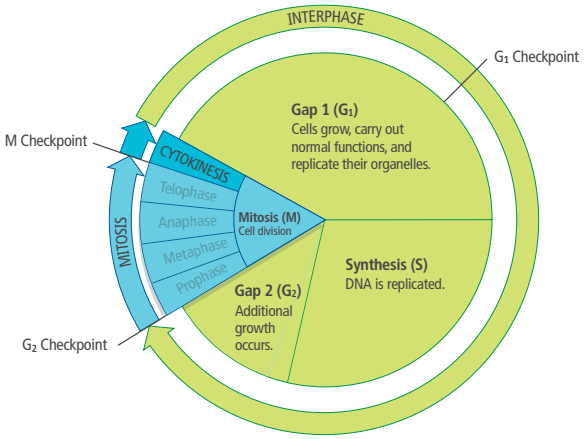
DNA Replication

FIGURE 13: The Cell Cycle



The process by which DNA is copied during the cell cycle is called replication. This process takes place in the nucleus during the S phase of the cell cycle. After the two strands of DNA are separated, each strand becomes a template for a new strand of DNA. The order of the bases is preserved, so DNA is replicated accurately each time. Replication ensures that every cell has a complete set of identical genetic information.

DNA Process for Replication

DNA stores genetic information; however, it does not copy itself. Enzymes and other proteins do the work of replication. Some enzymes start the process by breaking the weak hydrogen bonds that hold the base pairs together. This "unzips" the DNA molecule into two separate strands. Other proteins hold the strands apart while each strand serves as a template. Nucleotides that are floating free in the nucleus can then pair up with the nucleotides of the templates on each strand of the separated DNA. A group of enzymes called DNA polymerases are involved in this process. DNA polymerase binds the new nucleotides together. When the process is finished, the result is two complete molecules of DNA, each exactly like the original double strand.

Explain The word *synthesis* comes from a Greek word meaning "to put together, or combine." Why is the S phase called the *synthesis phase*?

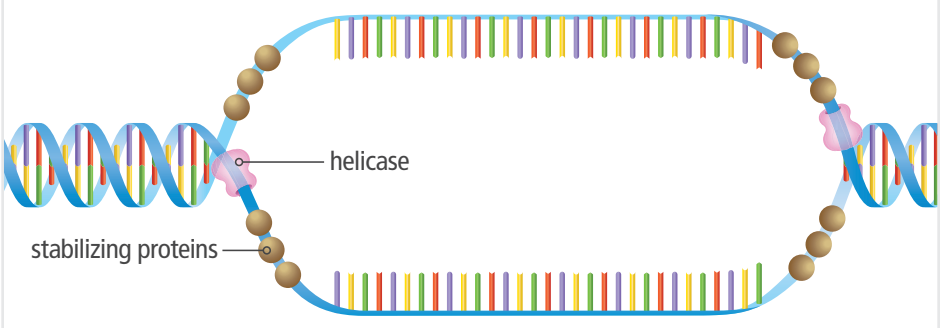
DNA Unzips

An enzyme called helicase binds to the DNA molecule and unzips the strands. This occurs at many places along the chromosome, called the *origins of replication*. The hydrogen bonds connecting base pairs are broken, the original molecule separates, and the bases on each strand are exposed. Other proteins, called stabilizing proteins, bind to and stabilize the separated strands. The process of unzipping DNA proceeds in two directions simultaneously, rather like unzipping a suitcase.

Structure and Function

The name of an enzyme can explain its function. The suffix *-ase* indicates that a protein is an enzyme. The root word before the suffix indicates which molecule is the substrate for this enzyme. One enzyme involved in DNA replication is called helicase.

FIGURE 14: DNA unzipping. Explore Online

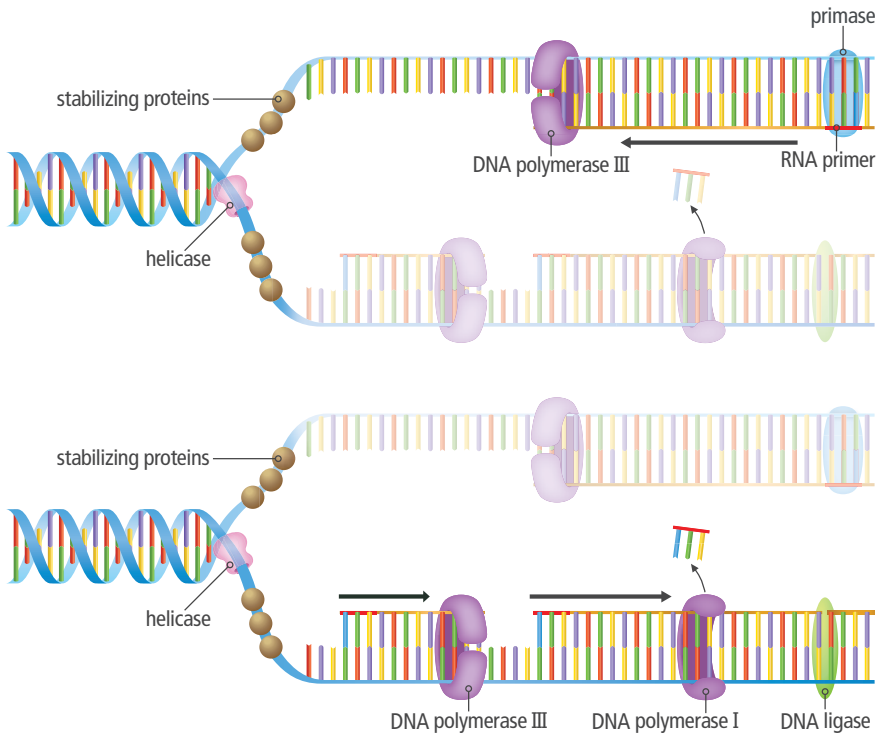


Nucleotide Pairing

Once the DNA is unzipped, the process of adding nucleotides to the single-stranded templates begins. An enzyme called *primase* makes an RNA primer, a short nucleotide segment that begins the synthesis process. The RNA primer segment is necessary because DNA polymerase can only add nucleotides to an existing strand.

Similar to the unzipping process, replication takes place at both forks simultaneously. One by one, free nucleotides pair with the bases exposed as the template strands unzip. Starting at the primer, DNA polymerases bond the nucleotides together and form new strands using DNA nucleotides that are complementary to each template. Because the two strands of the DNA molecule are positioned in opposite directions, there are differences in how each strand is copied. On the *leading strand,* highlighted in the top image in Figure 15, DNA replication begins at the primer and proceeds in one direction as *DNA polymerase III* adds new nucleotides. On the *lagging strand*, highlighted in the bottom image in Figure 15, replication occurs in a discontinuous, piece-by-piece way in the opposite direction. On the lagging strand, primers attach at multiple locations so multiple molecules of DNA polymerase III can add nucleotides to each primer at the same time.

FIGURE 15: DNA polymerases bond nucleotides together to form the new strands.



Language Arts Connection Use an analogy to explain the sequence of events in the replication of DNA. Cite evidence from the diagram to support your explanation.

Once the open regions on both strands are filled in, an enzyme called *DNA polymerase I* removes the RNA primers from both strands and replaces them with DNA nucleotides. On the lagging strand, the fragments are then bound together by an enzyme called *ligase*.

When replication is complete, there are two identical molecules of DNA. Each molecule contains one strand of DNA from the original molecule and one new strand. This type of replication is called *semiconservative* because each new molecule of DNA conserves, or keeps unchanged, one strand of DNA from the original molecule.

Model Make a model of a DNA molecule to explain semiconservative replication.