Welcome to DNA Replication 101

If one cell is going to divide to produce two new cells, the first cell must copy all of its parts before it can split in half. The cell grows, makes more organelles, and copies its genetic information (the DNA) so that the new cells each have a copy of everything they need.

Cells use a process called *DNA replication* to copy their genetic material. In this process, the original DNA strands serve as the template for the construction of the new strands. It's particularly important that each new cell receives an accurate copy of the genetic information because this copy, whether it's accurate or faulty, directs the structure and function of the new cells.

The basic steps of DNA replication are as follows:

- *First, the two parental DNA strands separate so that the rungs of the double helix ladder are split apart with one nucleotide on one side and one nucleotide on the other.*

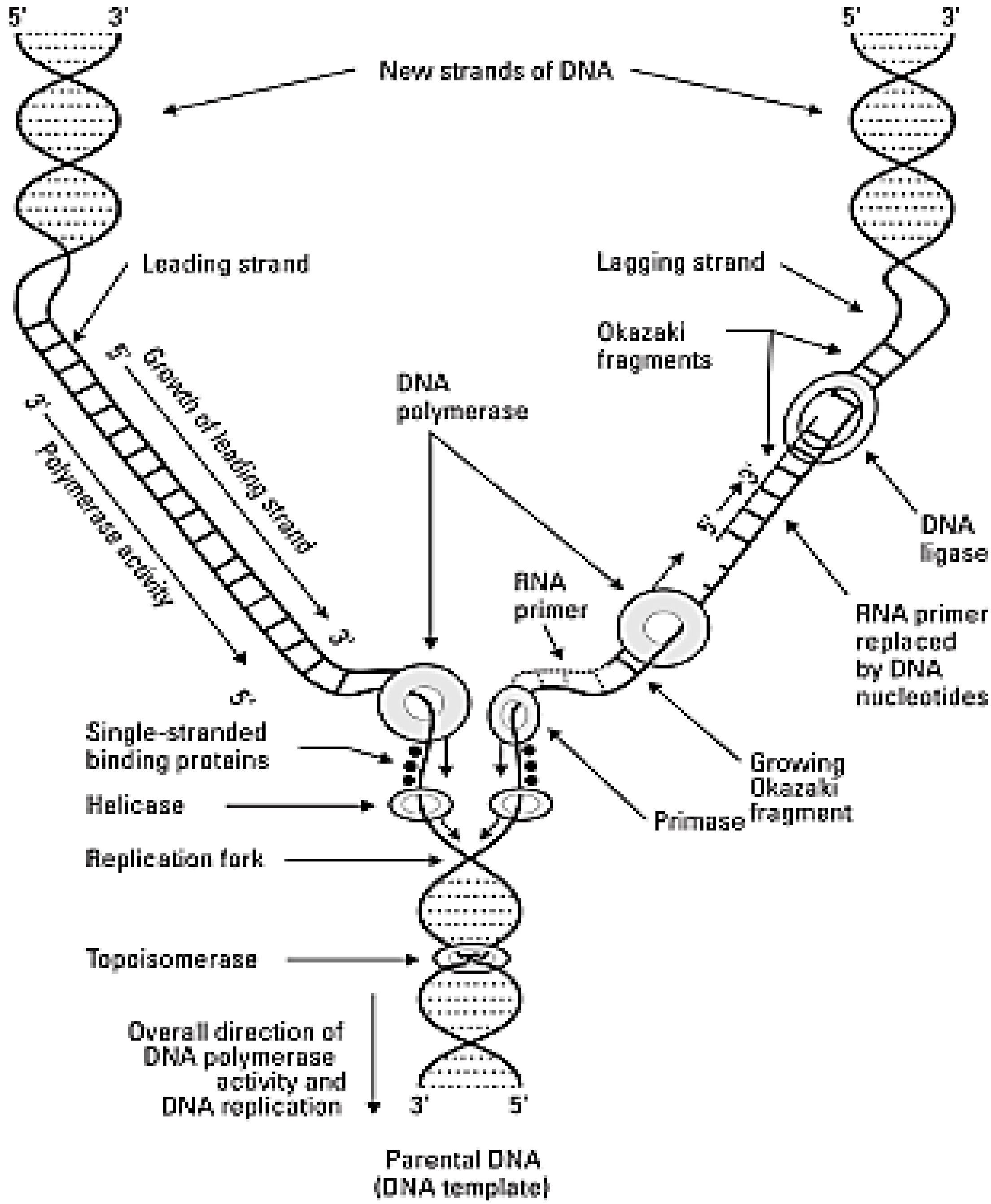
- *The entire DNA strand doesn't unzip all at once*, however*. Only part of the original DNA strand opens up at one time. The partly open/partly closed area where the replication is actively happening is called the replication fork (this is the Y-shaped area in Figure 6-1).*

- *The enzyme DNA polymerase reads the DNA code on the parental strands and builds new partner strands that are complementary to the original strands.*

- *To build complementary strands, DNA polymerase follows the base-pairing rules for the DNA nucleotides: A always pairs with T, and C always pairs with G (see Chapter 3 for further details about nucleotides). If, for example, the parental strand has an A at a particular location, DNA polymerase puts a T in the new strand of complementary DNA it's building.*

- *When DNA polymerase is done creating complementary pairs, each parental strand has a brand-new partner strand.*

Figure 6-1 DNA replication.



RememberDNA polymerase is considered *semiconservative* because each new DNA molecule is half old (the parental strand) and half new (the complementary strand).

Several enzymes help DNA polymerase with the process of DNA replication (you can see them and DNA polymerase hard at work in Figure 6-1):

- ***Helicase*** *separates the original parental strands to open the DNA.*

- ***Primase*** *puts down short pieces of RNA, called primers, that are complementary to the parental DNA. DNA polymerase needs these primers in order to get started copying the DNA.*

- ***DNA polymerase I*** *removes the RNA primers and replaces them with DNA, so it's slightly different from the DNA polymerase that makes most of the new DNA (that enzyme is officially called DNA polymerase III, but we refer to it simply as DNA polymerase).*

- ***DNA ligase*** *forms covalent bonds in the backbone of the new DNA molecules to seal up the small breaks created by the starting and stopping of new strands.*

The parental strands of the double helix are oriented to each other in opposite polarity: Chemically, the ends of each strand of DNA are different from each other, and the two strands of the double helix are flipped upside down relative to one another.

Note in Figure 6-1 the numbers 5′ and 3′ (read "5 prime" and "3 prime"). These numbers indicate the chemical differences of the two ends. You can see that the 5′ end of one strand lines up with the 3′ end of the other strand. The two strands of DNA have to be flipped relative to each other in order for the bases that make up the rungs of the ladder to fit together the right way for hydrogen bonds to form between them.

Because the two strands have opposite polarity, they're *antiparallel strands*.

The antiparallel strands of the parent DNA create some problems for DNA polymerase. One quirk of DNA polymerase is that it's a one-way enzyme — it can only make new strands of DNA by lining up the nucleotides a certain way.

But DNA polymerase needs to use the parent DNA strands as a pattern, and they're going in opposite directions.

As a result, DNA polymerase makes the two new strands of DNA a bit differently from each other, as you can see from the following:

- ***One new strand of DNA, called the leading strand, grows in a continuous piece.*** *Refer to Figure 6-1. See how the new DNA on the left side of the replication fork is growing smoothly? The 3′ end of this new strand points toward the replication fork, so after DNA polymerase starts building the new strand, it can just keep going.*

- ***One new strand of DNA, called the lagging strand, grows in fragments.***

- *Look at Figure 6-1 again. Notice how the right side of the replication fork looks a little messier? That's because the replication process doesn't occur smoothly over here.*

- *The 3′ end of this new strand points away from the fork. DNA polymerase starts making a piece of this new strand but has to move away from the fork to do so (because it can only work in one direction).*

- *DNA polymerase can't go too far from the rest of the enzymes that are working at the fork, however, so it has to keep backing up toward the fork and starting over.*

- *As a result, the lagging strand is made in lots of little pieces called Okazaki fragments.*

- *After DNA polymerase is done making the fragments, the enzyme DNA ligase comes along and forms covalent bonds between all the pieces to make one continuous new strand of complementary DNA.*