Basic Molecular Biology: Basic Science

DNA Replication

You may have asked yourself about how DNA gets passed on from cell to cell. Before a cell divides, the DNA strands unwind and separate. Each strand makes a new complementary strand by adding the appropriate nucleotides. As a result, there are now two double-stranded DNA molecules in the nucleus that contain the same information. This process is known as replication. Keep this in mind, as this is the basis of PCR in molecular diagnostics. In this animation, we will see the remarkable way DNA is replicated.

The process begins when helicase enzymes unwind the double helix to expose two single DNA strands creating two replication forks. The mechanism of replication is identical at each fork but we will focus on just one replication fork for teaching purposes. Single-strand binding proteins, or SSBs, coat the single DNA strands to prevent them from reannealing or snapping back together. The parent strand of DNA running in the 3 prime to 5 prime direction toward the fork is called the leading strand.

The opposite strand is called the lagging strand. To give DNA polymerase 3 a place to start, an enzyme called DNA primase first copies a short stretch of the DNA strand creating a complementary RNA segment called a primer. Using this primer, DNA polymerase can now copy the DNA strand.

The DNA polymerase starts at the 3 prime end of the RNA primer, and, using the original DNA strand as a guide, begins to synthesize a new complementary DNA strand. Note that DNA polymerase 3 can only synthesize DNA from the 5 prime to the 3 prime direction. The sliding clamp helps hold DNA polymerase 3 onto the DNA as it moves down the strand.

Due to the opposing, or antiparallel nature of the DNA strands, the polymerase enzymes move in opposite directions. Because of its orientation, the leading strand is able to be replicated continuously by DNA polymerase 3. Because of the lagging strand's orientation, DNA polymerase 3 is forced to repeatedly release the DNA strand and slide further upstream to begin extension from another RNA primer. The lagging strand is made discontinuously in short pieces called Okazaki fragments which are later joined together. As replication proceeds, RNAse H recognizes and removes RNA primers bound to the DNA template.

DNA polymerase 3 can then fill in the gap left by RNase H. The DNA replication process is completed when the enzyme DNA ligase joins the short DNA pieces together into one continuous strand.