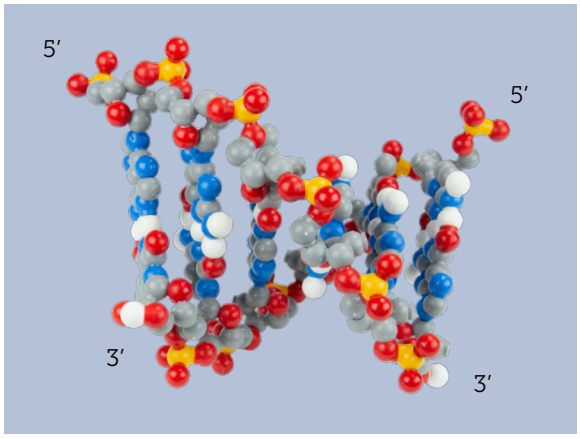
Teacher Guide

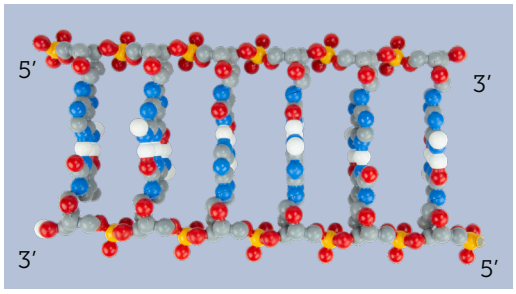
Part 2 - Modeling DNA Function: Replication

What is the relevance of DNA replication? Without replication, each cell formed from either mitosis or meiosis would lack the instructions to make the proteins necessary to maintain life. Now that's important!

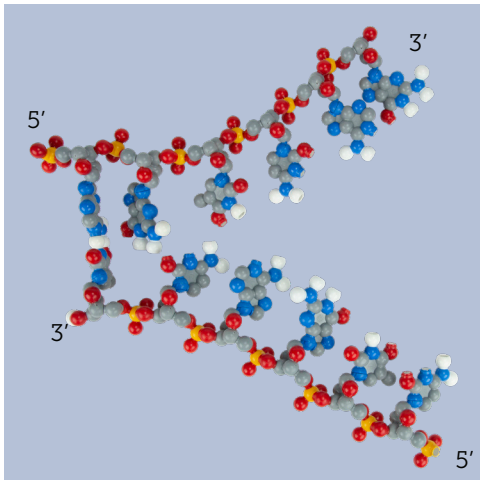


To teach 3-dimensional aspects of **DNA replication** using one 12 base pair set of *Dynamic DNA©,* assemble a DNA sequence using a combination of 6 base pairs to form a double helix. Use 3 A-T base pairs and 3 G-C base pairs in any order to create your sequence. You will use the other 12 nucleotides to form the new DNA strands. You can create a replication bubble if you have 3 or more *Dynamic DNA Kits©*. (See page 4.)

Untwist the DNA double helix.



Separate the two strands to form a replication fork.



New DNA strands are synthesized in the 5' → 3' direction. Due to the anti-parallel nature of DNA structure, one strand will be synthesized *continuously* while the opposite strand will be synthesized in short fragments (**Okazaki fragments**). The DNA strand that is synthesized continuously is known as the **leading strand**. The new strand formed from a series of segments is referred to as the **lagging strand**.

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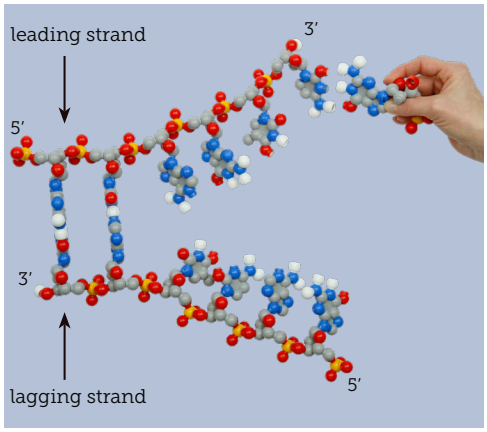
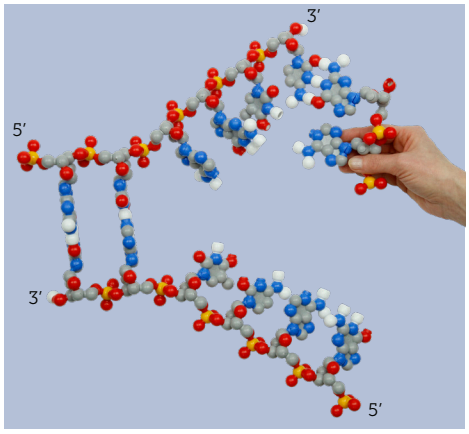
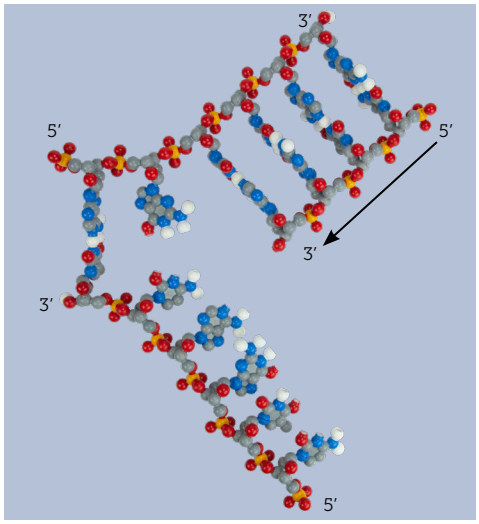
Continuous Replication

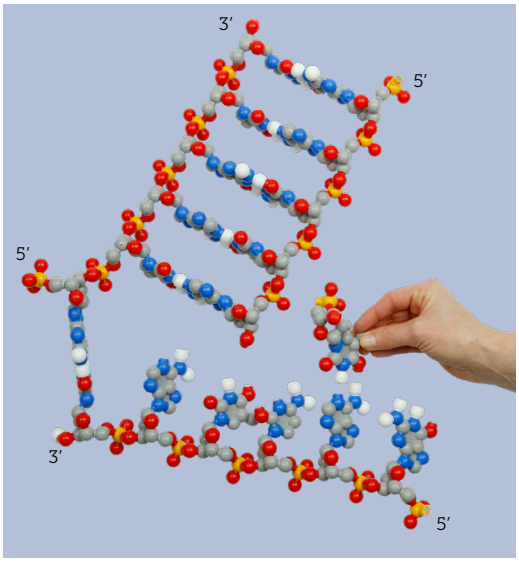


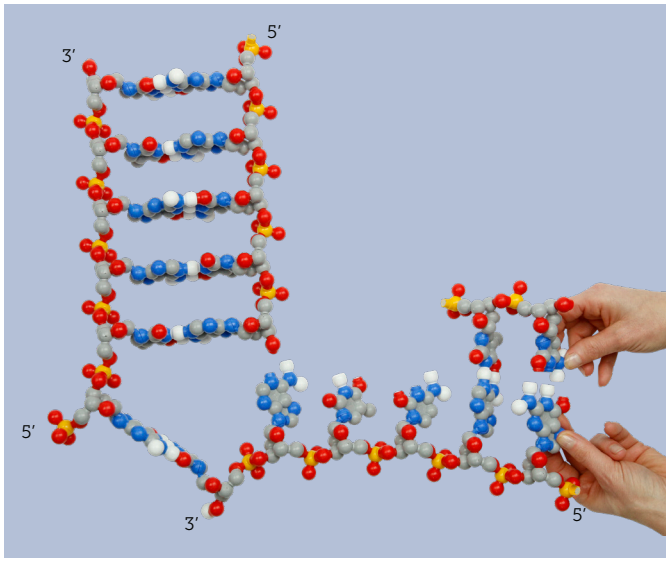




Discontinuous Replication

You can model **discontinuous replication** by adding the first nucleotide in the new strand to the second to the last position of the 5’ end of the parental strand (left image below). Add the second nucleotide in the new strand to the last position of the 5’ end of the parental strand (right image below).





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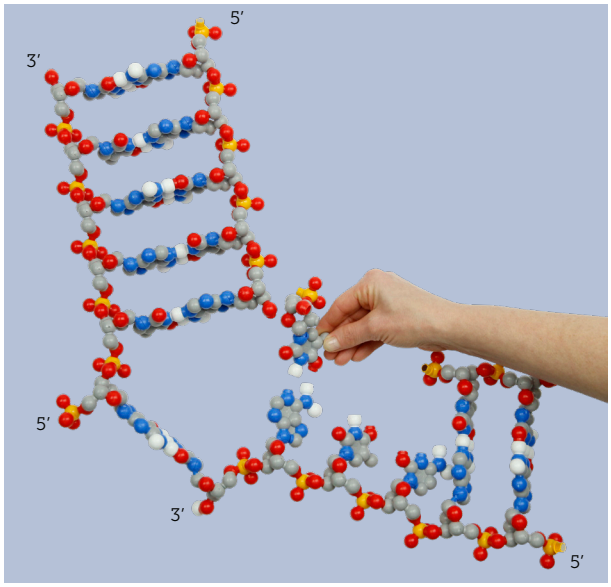
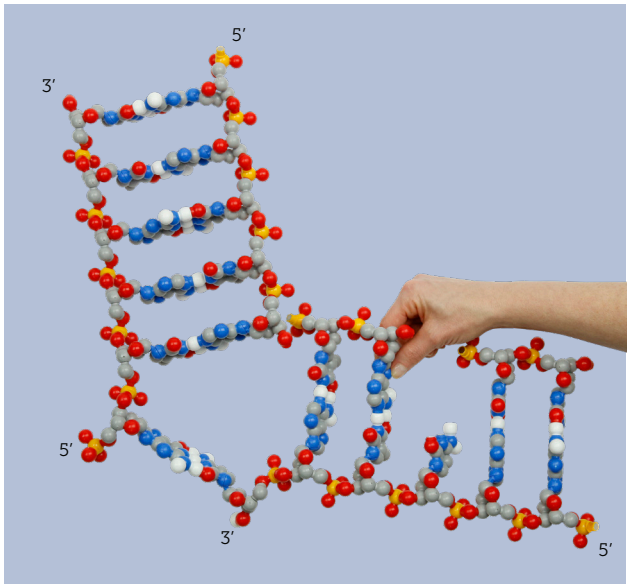
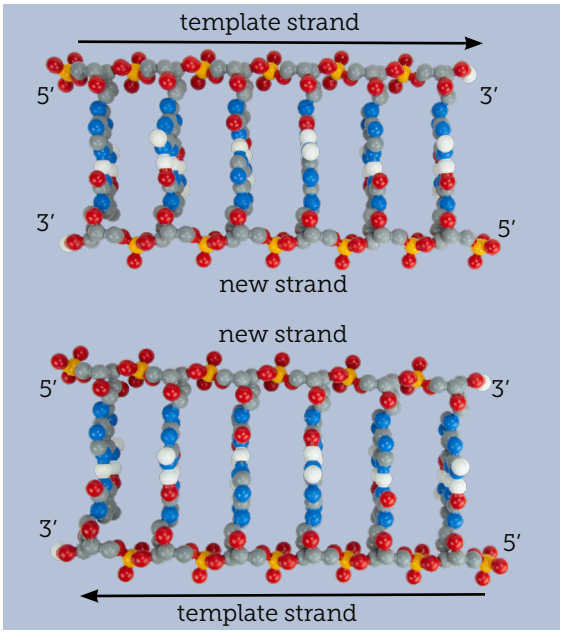
DNA polymerase will detach and reattach to form the second fragment. You can simulate this by adding a new nucleotide at the base of the fork and then adding subsequent nucleotides until you meet the first fragment.





Note: Both strands replicate simultaneously. They are shown separately for clarity.

Semiconservatively Replicated DNA



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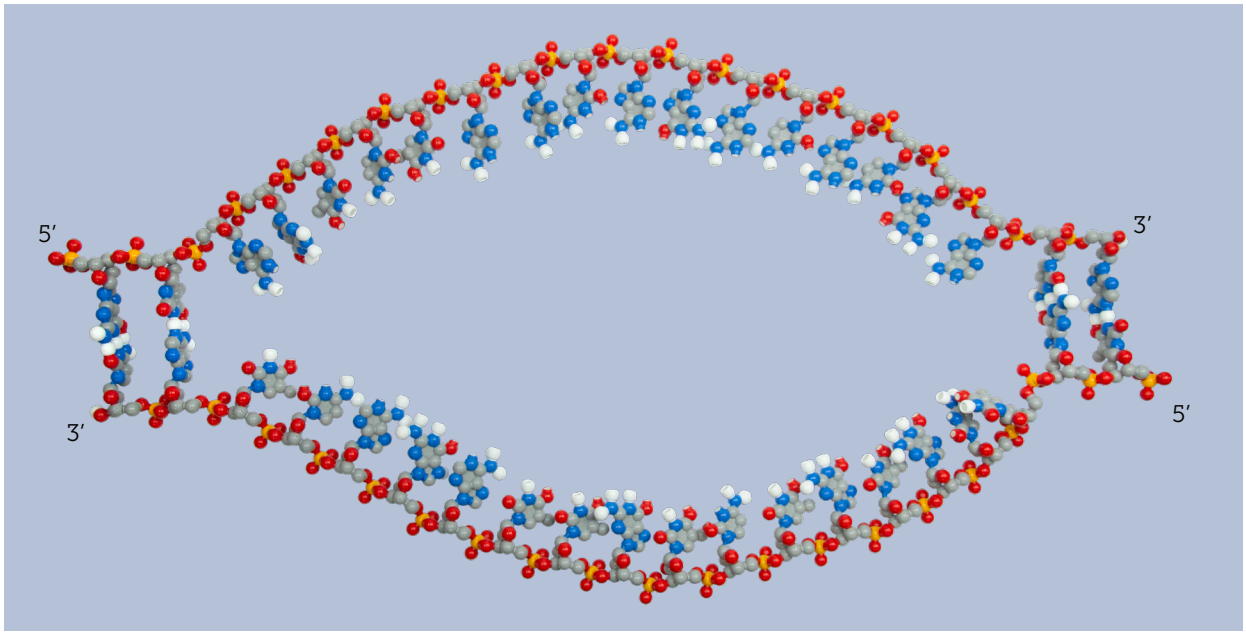
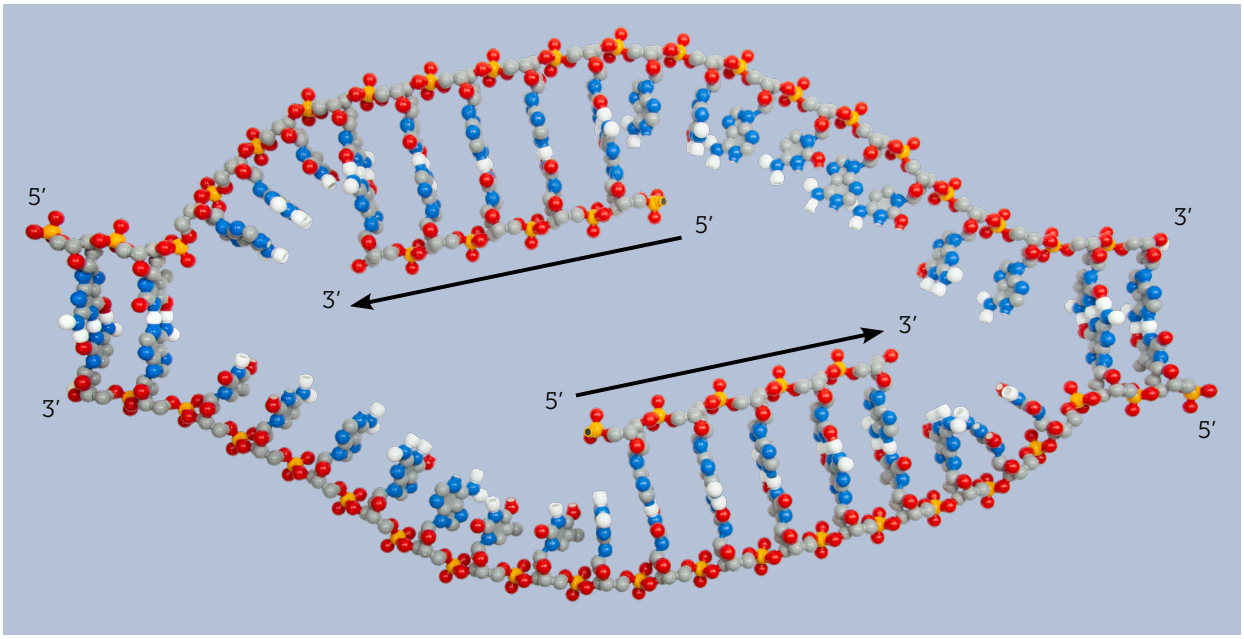
If 3 or more *Dynamic DNA Kits*© are available, create a replication bubble to model DNA replication.



replication bubble



continuous replication

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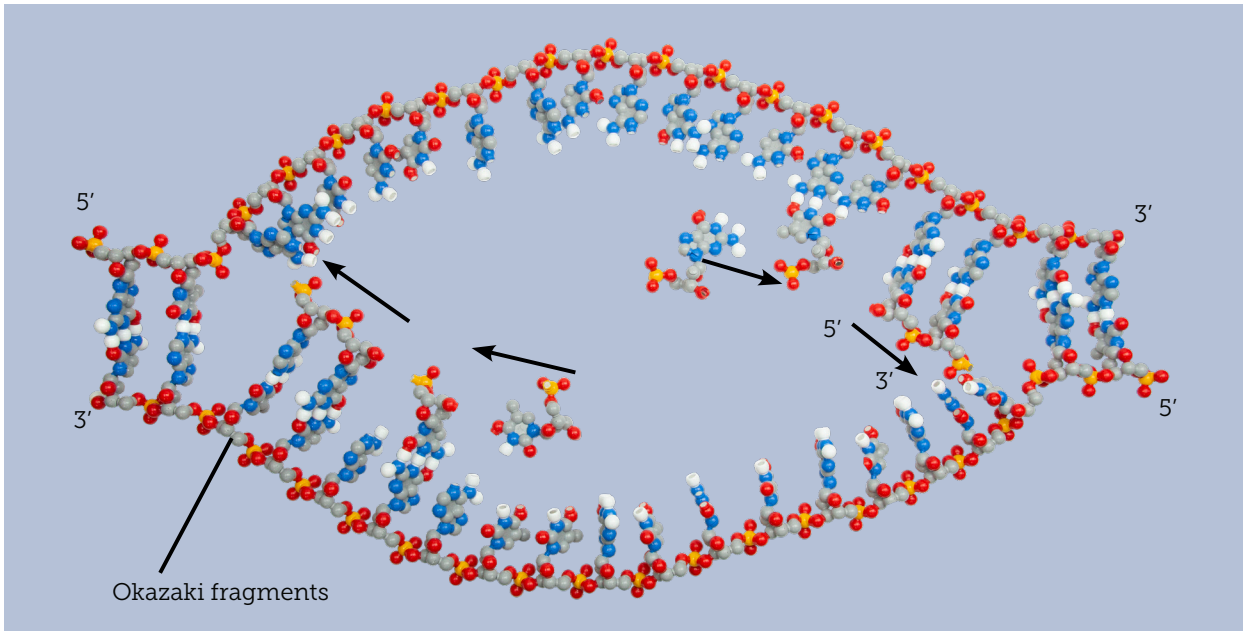
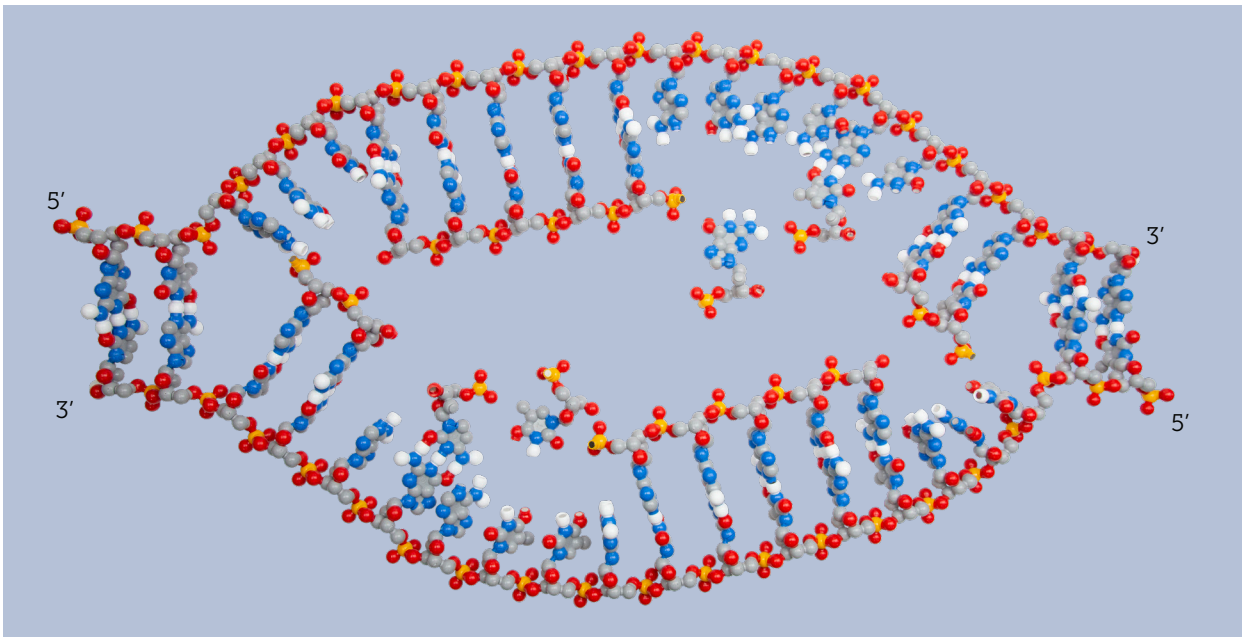


discontinuous replication



discontinuous and continuous
replication occur simultaneously

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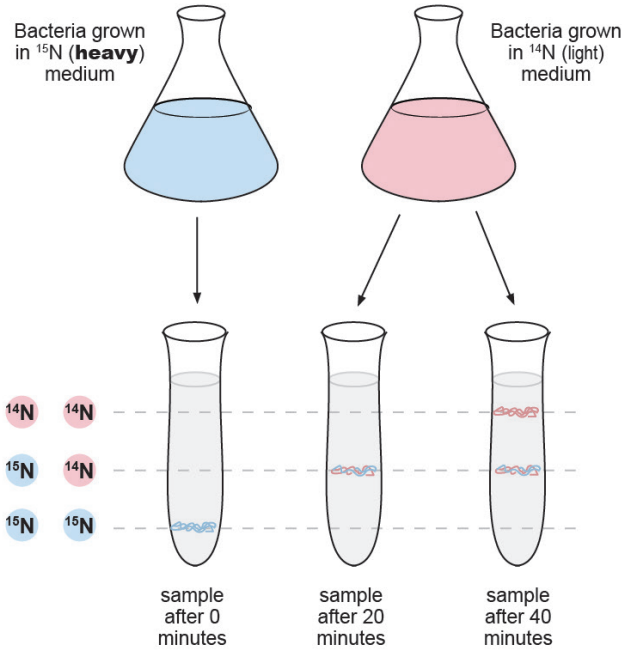
Historically, the mechanism DNA replication was explained by three alternative models: conservative replication, dispersive replication or semiconservative replication. The **conservative model** results in the two parental strands reassociating and restoring the original parental double helix after acting as templates for the new strands. The **dispersive model** results in each strand of both new DNA molecules containing a mixture of old and newly synthesized DNA. The **semiconservative model** results in two new DNA molecules, each with half of the parental DNA and half of newly synthesized DNA. In the late 1950's Matthew Meselson and Franklin Stahl devised an eloquent experiment to determine the mechanism of DNA replication.



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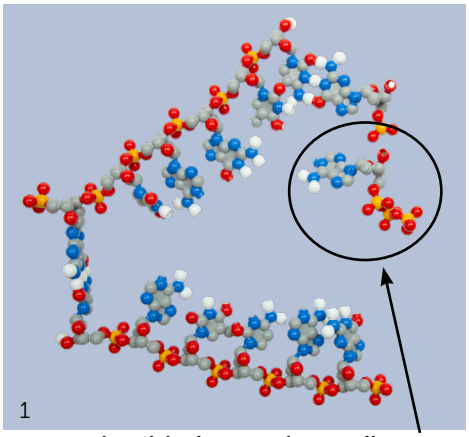
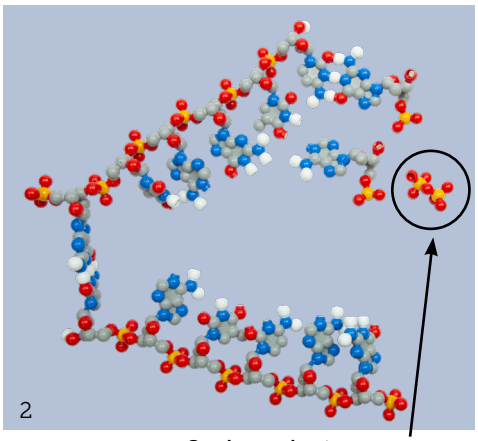
Finer Points

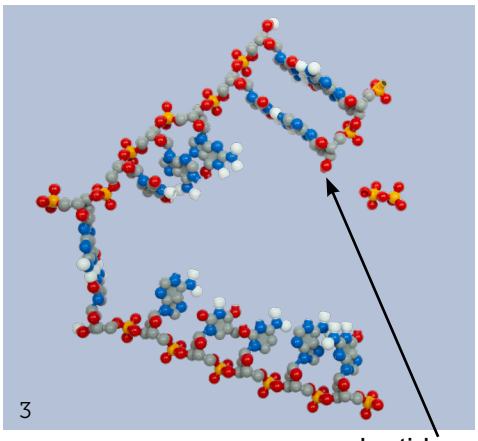
NOTE: Each nucleotide added to the growing DNA strand consists of a deoxyribose sugar attached to a base and to **three** phosphate groups. The nucleotides used for DNA synthesis are chemically reactive, in part because their triphosphate tails have an unstable cluster of negative charge. In a dehydration synthesis reaction, two phosphate groups are released from the new nucleotide and water is formed when DNA polymerase joins each new nucleotide to the growing DNA strand. It is possible to model this more accurate depiction of the addition of new nucleotides to 6-7 complementary bases without running out of phosphate groups. You will run out of phosphate groups if you try to model the addition of ALL the nucleotides in this manner. However, you will NOT be able to show the formation of water with the kit.



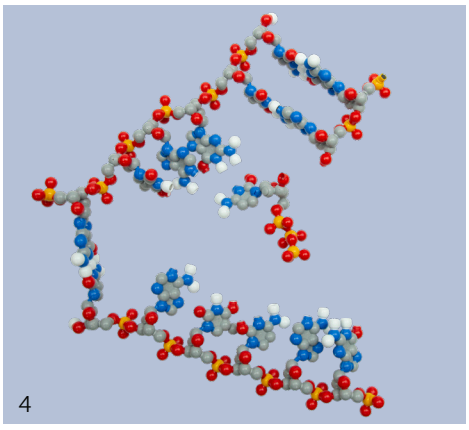
nucleotide base, deoxyribose sugar and 3 phosphate groups



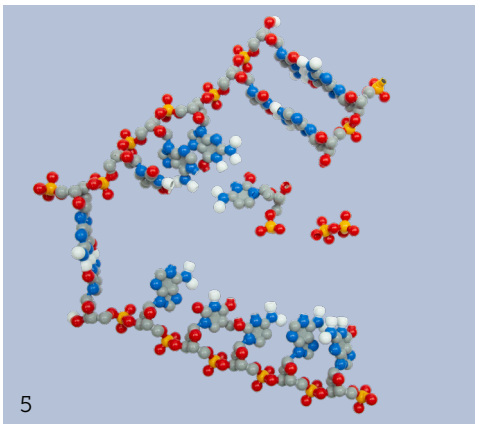
2 phosphate groups are released

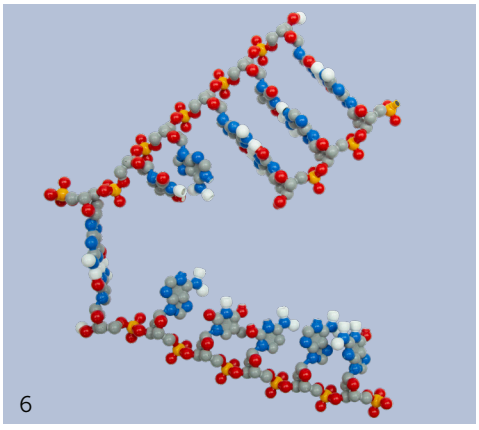


new nucleotide joins DNA strand



repeat





NOTE: Synthesis of new DNA strands cannot be *initiated* by the enzymes that add DNA nucleotides to the end of an already existing chain that is base-paired with the template strand. The initial nucleotide chain that is produced during DNA synthesis is actually a short segment of RNA, about 5-10 nucleotides in length, by the enzyme primase. The new DNA strand will start from the 3" end of the RNA primer. Later the RNA primer is replaced with DNA nucleotides. DNA ligase joins the DNA segments together. Consider the need for topoisomerase to relieve the over-winding of the double helix that would result from the advancing replication fork.

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