

DNA Replication (Core and AHL)

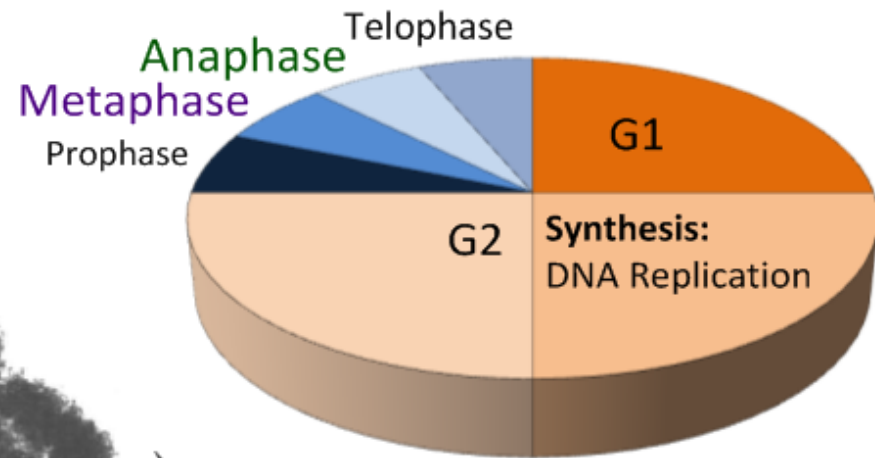
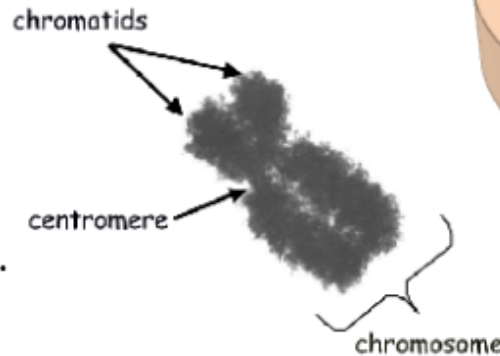
Stephen Taylor

Bandung International School

DNA Replication

DNA replication occurs during the S-phase of Interphase. Exact copies of all the DNA on all the chromosomes are made.

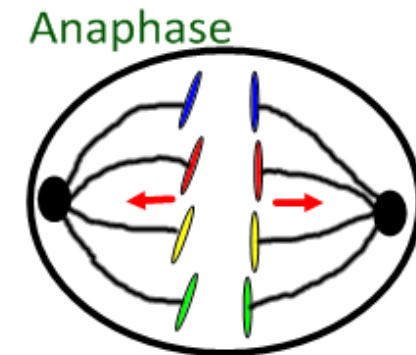
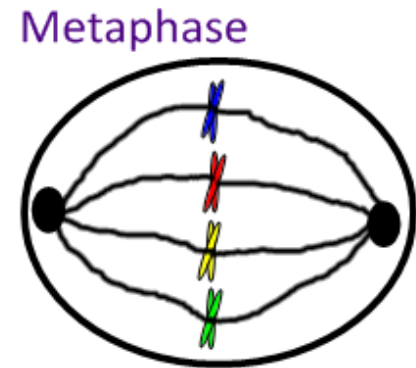
This gives **sister chromatids** - chromosomes and their copy - which will be separated in mitosis.



When the cell divides through mitosis, each daughter cell therefore contains a full set of DNA.

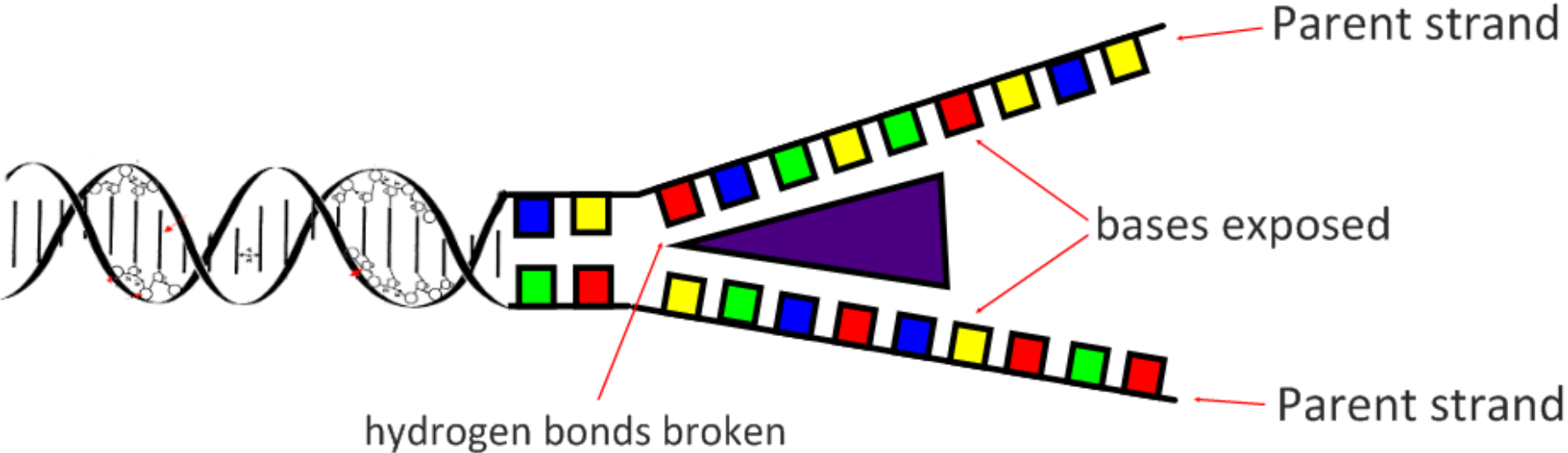
Mitosis ensures that each daughter cells gets the correct number of each chromosome through alignment at the equator (**metaphase**), and the separation of chromatids by spindle fibres during **anaphase**.

When the cell divides (cytokinesis), there is a full set of chromosomes at each pole, forming new nuclei.



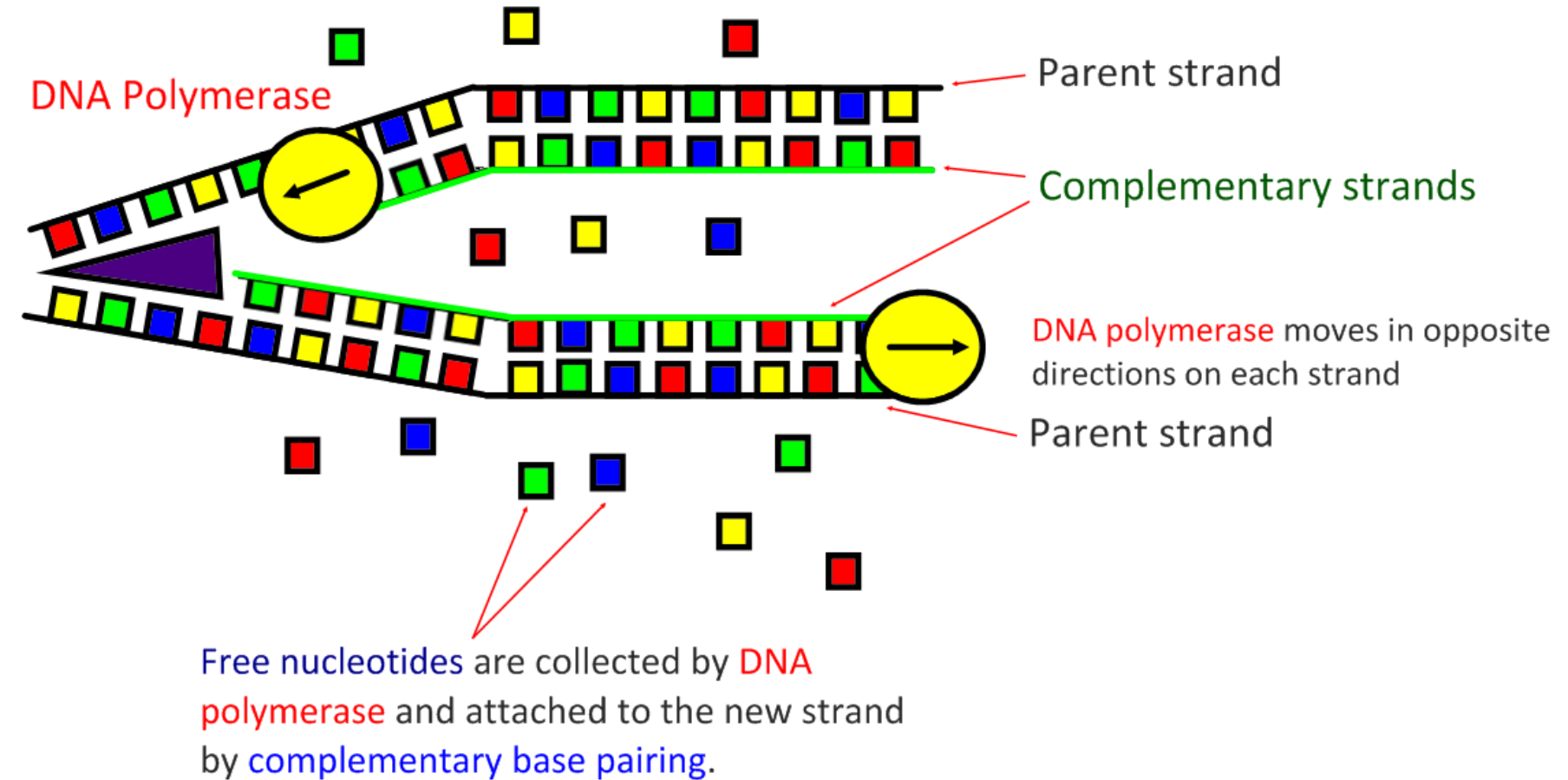
DNA Replication: Standard Level

1. DNA Helicase unwinds and unzips DNA



DNA Replication: Standard Level

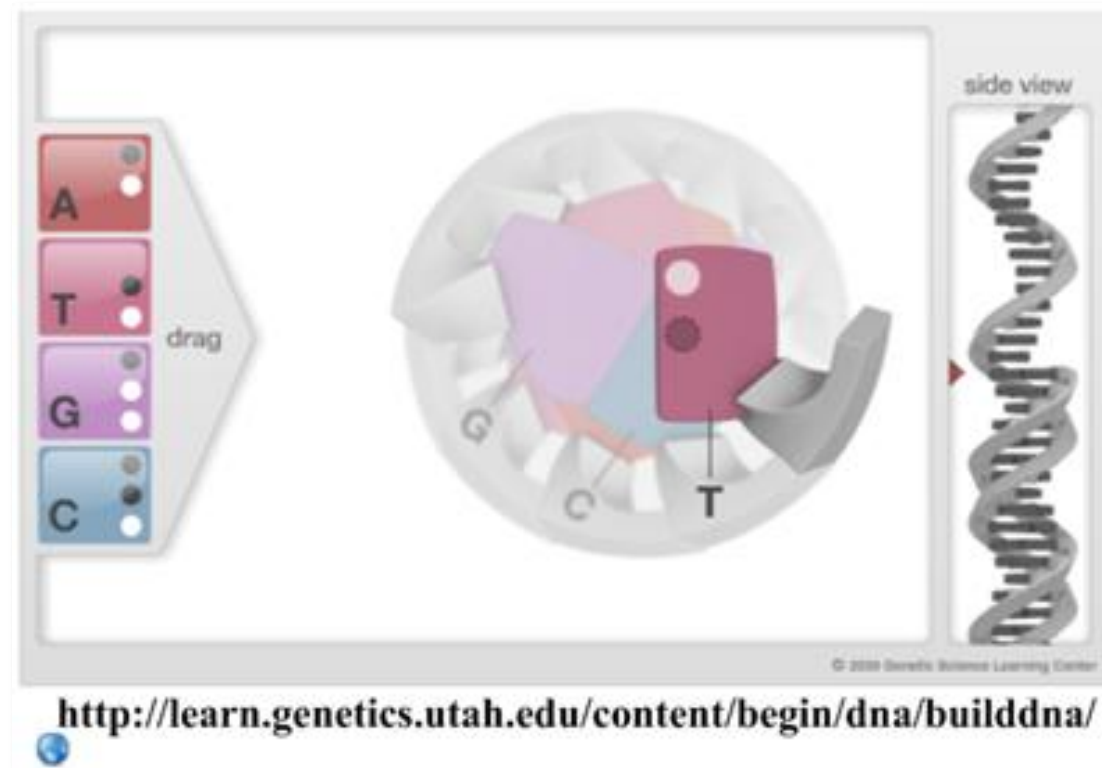
2. DNA Polymerase creates complementary strands



Complementary Base Pairing ensures identical copies of DNA

The parent strands act as a **template** for the new (complementary) strands.

Adenine pairs only with **Thymine**
Cytosine pairs only with **Guanine**



This ensures the **new DNA molecules** is identical to the **original** - no mistakes are made - so **the base-sequence of nucleotides is conserved**.

Have a go at this DNA Builder from Learn.Genetics.

This is important as the base-sequence of DNA provides the genetic information for the organism. A mistake in the order of bases may result in a mistake in gene expression, which could be detrimental (even fatal) to the cell or organism.

DNA Replication: Standard Level

3. DNA Replication is **semi-conservative**:



How do we know this?

So, as Watson and Crick had predicted, DNA is used as a template to replicate itself. DNA polymerase is the enzyme that makes it happen.



MOUSE OVER TUBE TO SEE CONTENTS



<http://www.learnerstv.com/animation/biology/con20ani.swf>



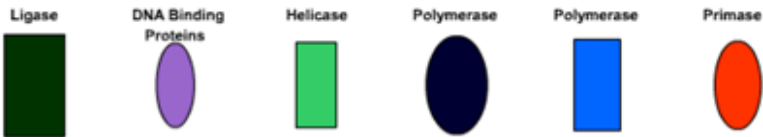
DNA Replication: Higher Level

Use the following animations to help you discover the roles of the following enzymes:

DNA Helicase DNA Polymerase III RNA Primase DNA Polymerase I DNA Ligase



DNA Replication



<http://www.stolaf.edu/people/giannini/flashanimat/molgenetics/dna-rna2.swf>

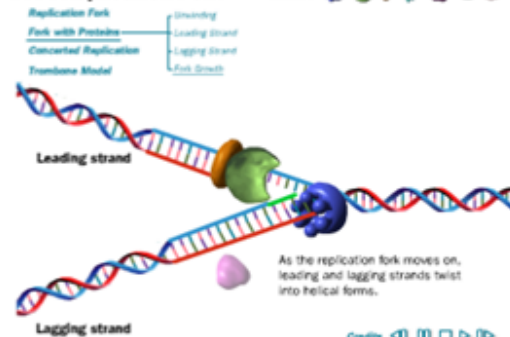
DNA Replication

The Whole Picture Unwinding the Helix Stabilizing the Strands Primer Addition
Nucleotide Addition Primer Removal Filling the Gaps

Introduction
Basics
Replication Forks
DNA Polymerase
Okazaki Fragments
The Whole Picture

<http://www.wiley.com/legacy/college/boyer/0470003790/animations/replication/replication.swf>

DNA Replication Fork



<http://www.mcb.harvard.edu/Losick/images/TromboneFINALd.swf>

DNA Replication

phosphate sugar A T G C

An exact copy of DNA must be created prior to cell division. Any errors represent genetic mutations.

Helicase splits the DNA molecule apart, starting at replication origins such as this one, rich in A-T pairs.

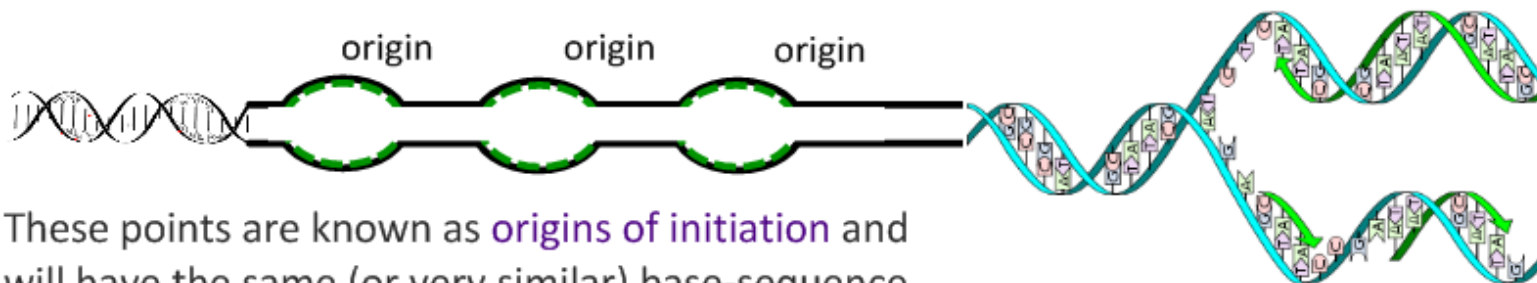
Many such "subunit" form.

A-T pairs are connected by only two hydrogen bonds, and so are easier to pull apart than C-G pairs.

<http://www.johnkyrk.com/DNAreplication.html>

DNA Replication is initiated at many points in eukaryotes:

This makes DNA replication faster and more efficient.



Replication fork

These points are known as **origins of initiation** and will have the same (or very similar) base-sequence.

Proteins called **Origin Recognition Complexes** will bind here and then **DNA Helicase** will be able to attach, to begin replication. Replication forks will move along the DNA strand in the same direction.

Replication in prokaryotes is bidirectional and initiated from a single origin.

This is because prokaryote DNA is looped, as opposed to the long strands of eukaryotes.

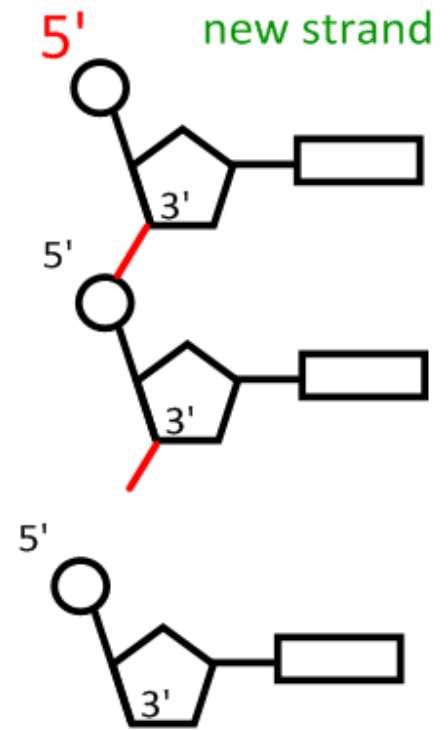
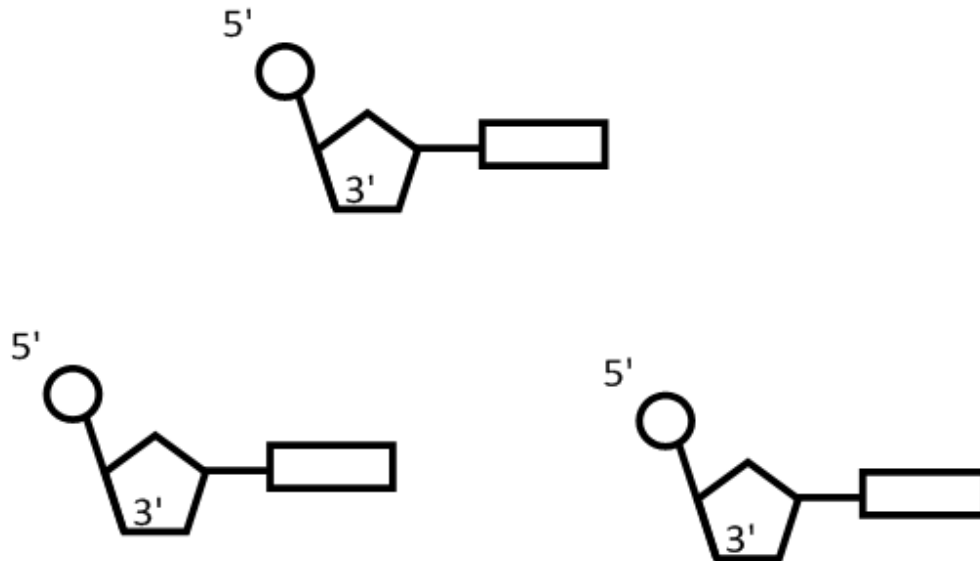
Other processes are essentially the same...

A screenshot of a video player titled "Bidirectional DNA Replication". The video shows a circular DNA molecule with a single origin of replication (a white dot) at the top. Two replication forks (red and blue dots) move in opposite directions around the circle. The original strands are solid lines, and the newly synthesized strands are dotted lines. The video player interface includes a play/pause button, a progress bar, and audio/text options. Below the video, there is a caption: "The two original strands, shown as solid lines, serve as the templates for synthesis of new strands, shown as dotted lines." The copyright notice "Copyright © The McGraw-Hill Companies, Inc." is visible at the bottom right of the video player. Below the video player, there is a URL: <http://tinyurl.com/y9e89rh>

DNA replication moves in a 5' to 3' direction

- This means the 5' end of the new strand

Free nucleotides in the nucleus
(deoxynucleoside triphosphates)

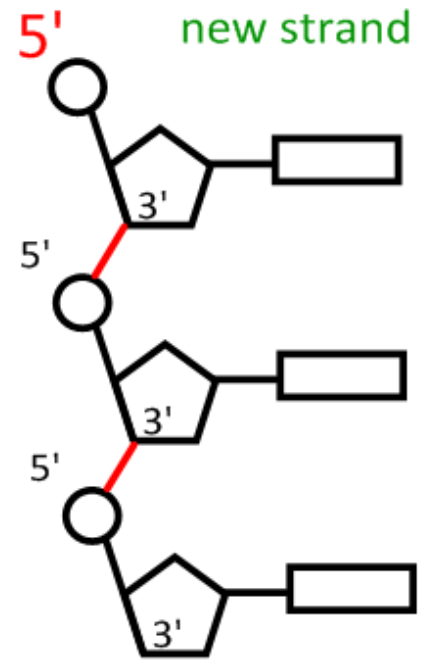
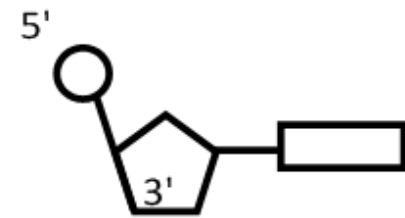
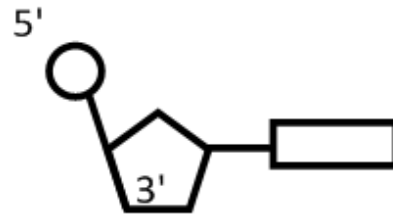
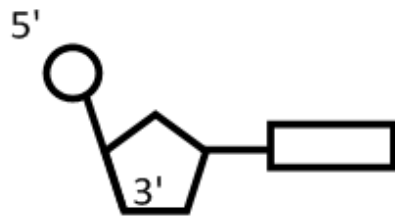


DNA replication moves in a 5' to 3' direction

- This means the 5' end of the new strand

Free nucleotides in the nucleus
(deoxynucleoside triphosphates)

The 5' end of the next nucleotide attaches to the 3' carbon of the last one to join the new strand.

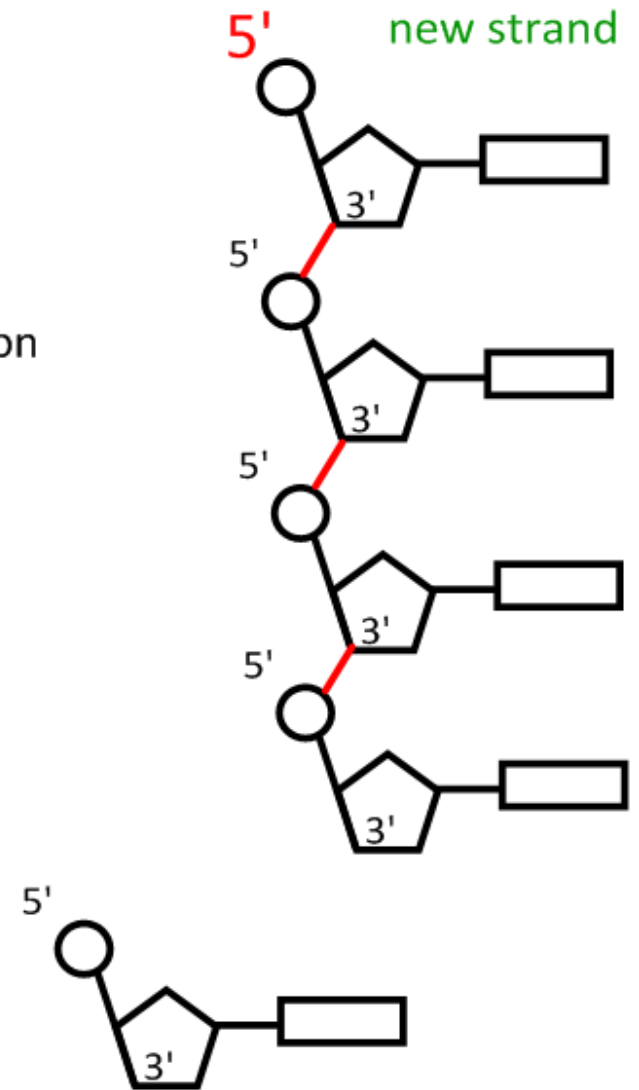
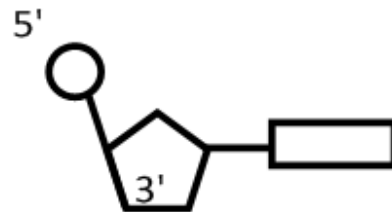


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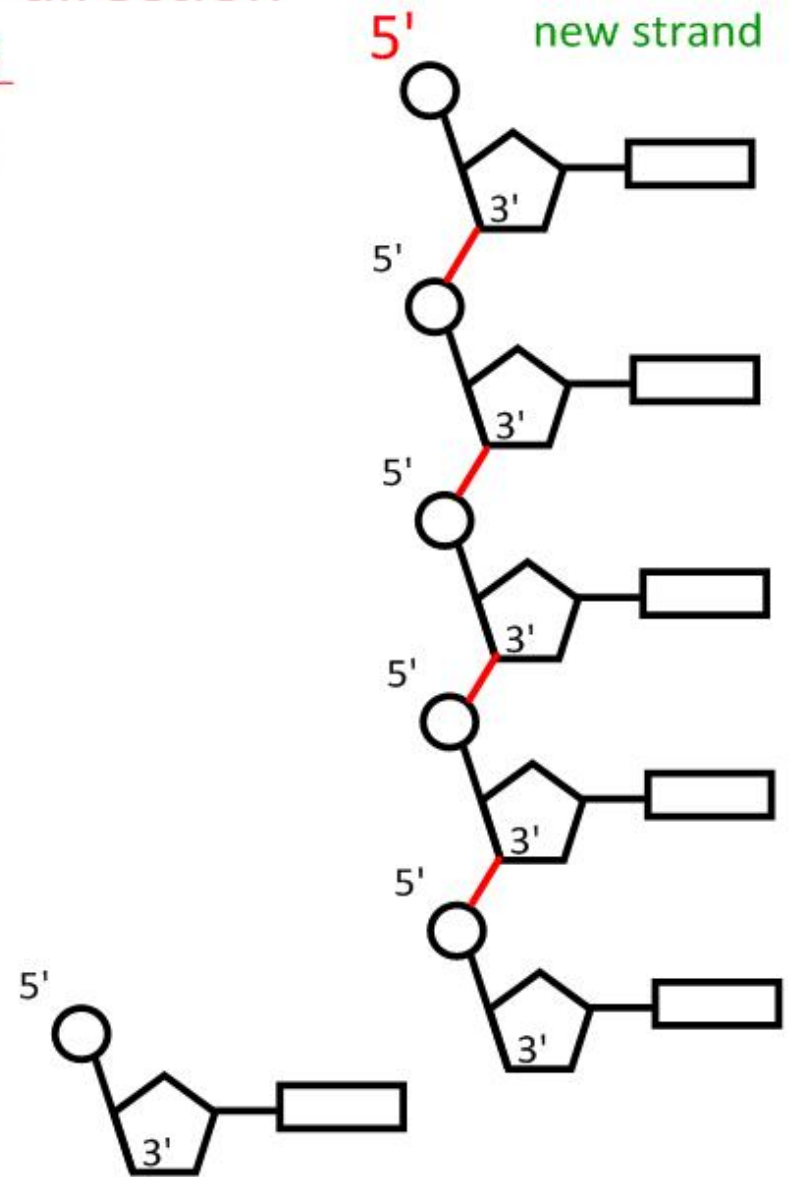
How are deoxynucleoside triphosphates added?

McGraw Hill How Nucleotides Are Added in DNA Replication

The diagram illustrates the process of DNA replication. A double-stranded DNA molecule is shown being unwound. The leading strand is synthesized continuously in the 5' to 3' direction, indicated by a red arrow. The lagging strand is synthesized discontinuously as Okazaki fragments, each starting with a green RNA primer and followed by DNA synthesis in the 5' to 3' direction. The 5' and 3' ends of the strands are clearly labeled. A video player interface is visible at the bottom of the image, including Play, Pause, Audio, and Text buttons.

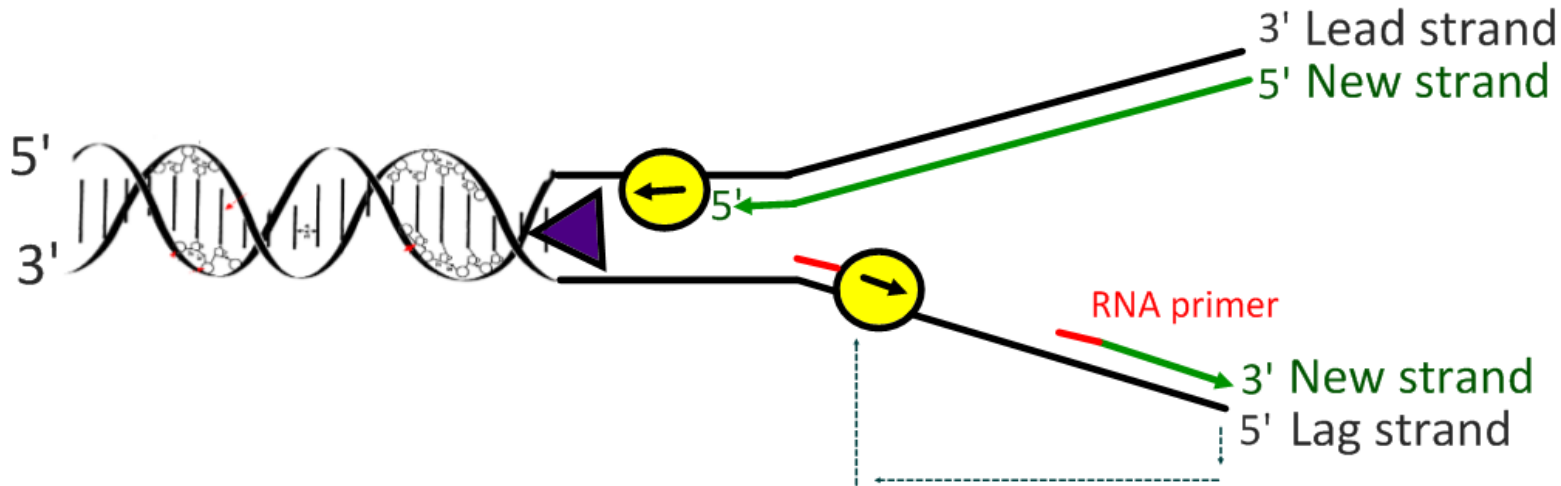
<http://tinyurl.com/3bah3q>

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DNA replication moves in a 5' to 3' direction

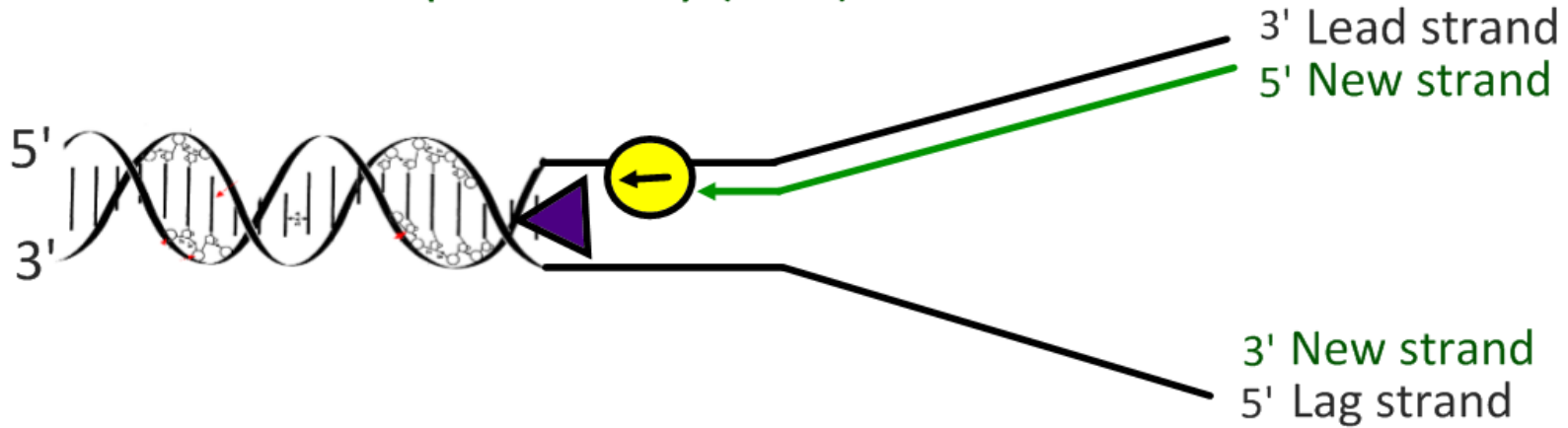
- This means the 5' end of the new strand
- Replication on the lead strand is continuous
- Replication on the lag strand 'leapfrogs'



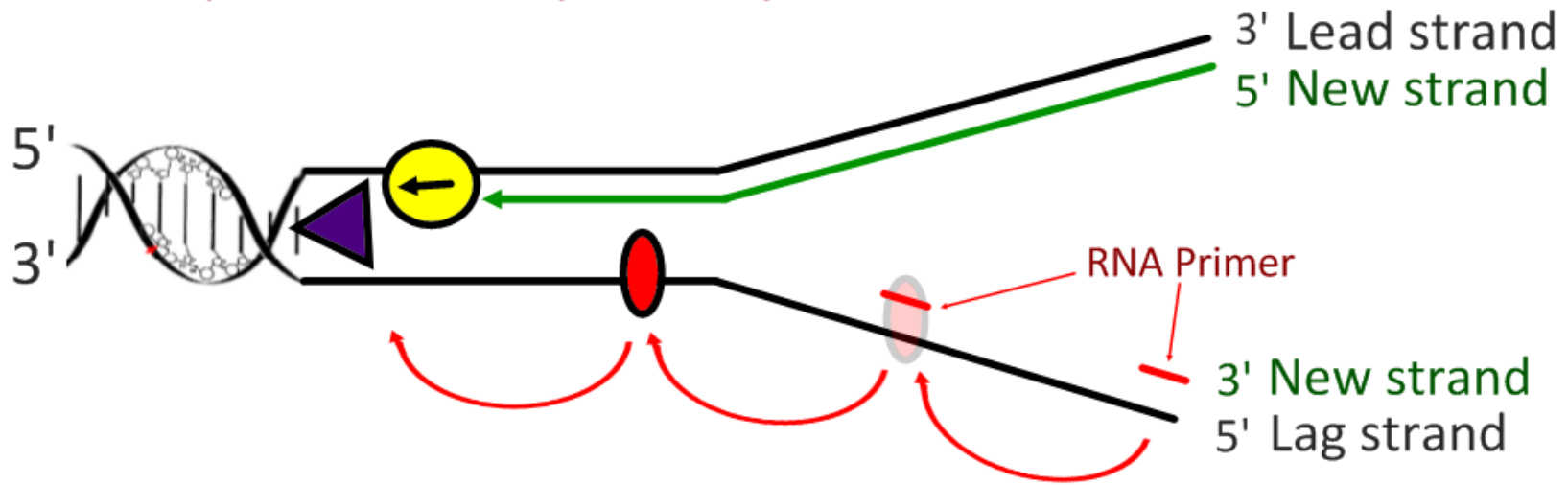
Lag strand DNA replication is more complex, as the DNA polymerase is moving in the opposite direction to the DNA Helicase. RNA primers are used to mark positions and replication goes in a 'leapfrog' (section-by-section) manner.

DNA replication in prokaryotes:

1. **DNA Helicase** unwinds and unzips the base pairs
2. **DNA Polymerase** makes a complementary strand on the leading strand - adding nucleotides to the 3' end of the complementary (new) strand.



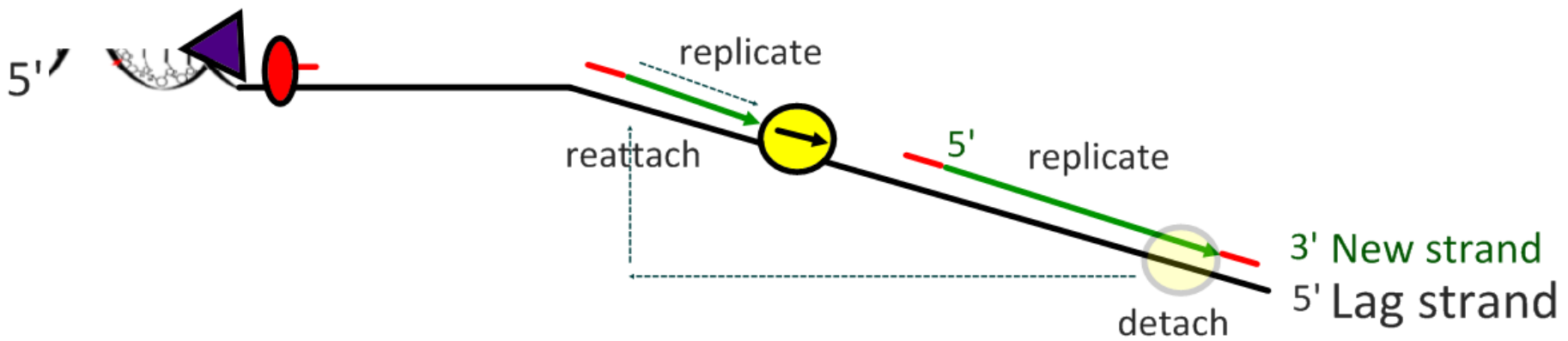
DNA replication in prokaryotes:



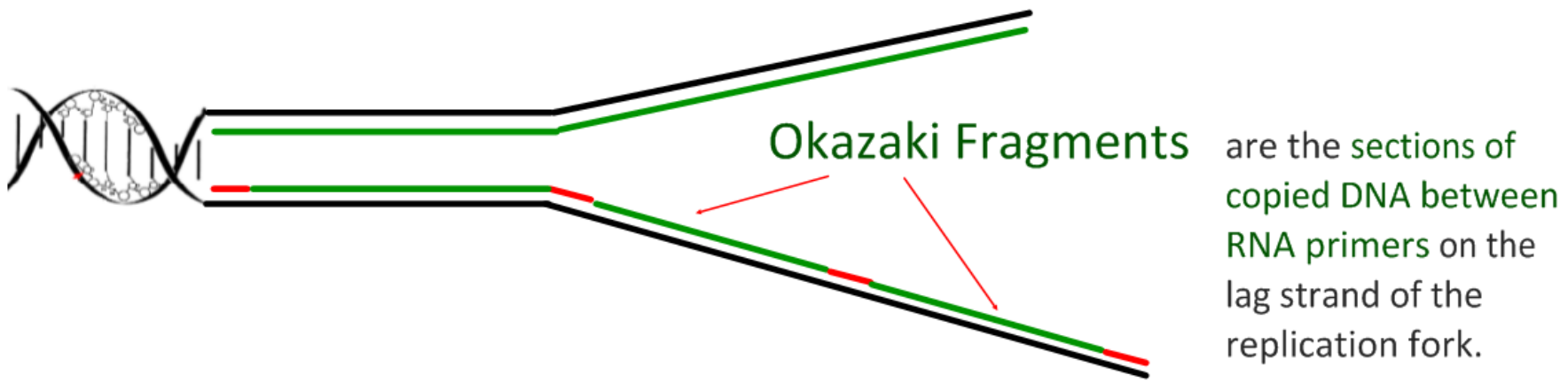
3. **RNA Primase** follows helicase, leaving RNA Primers.

These are markers for initiation of **DNA Polymerase** on the lag strand.

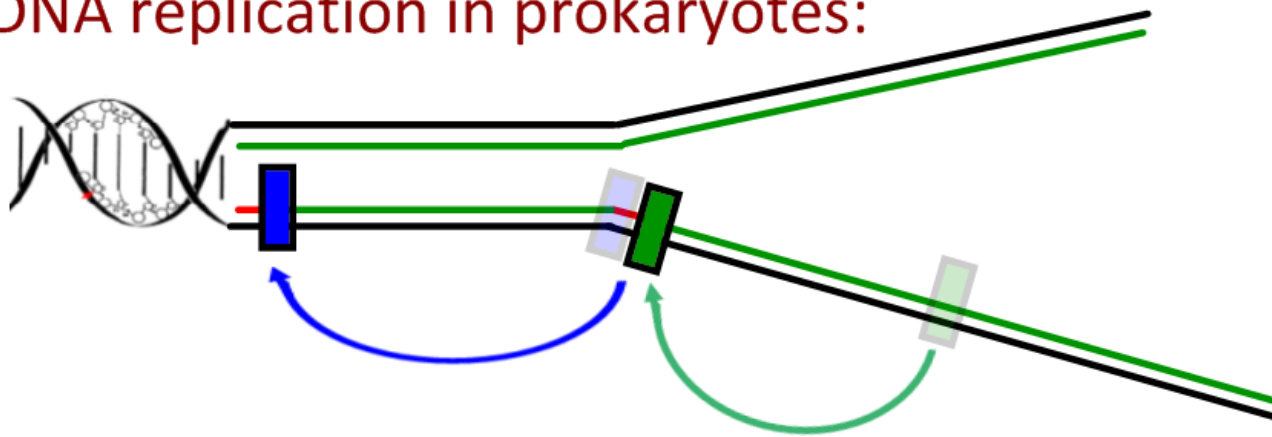
DNA replication in prokaryotes:



- 4. **DNA Polymerase** attaches to an **RNA Primer** and replicates DNA in a 5' to 3' direction.
- 5. When it reaches another **RNA primer**, it **detaches** and 'leapfrogs' to next primer following the helicase.

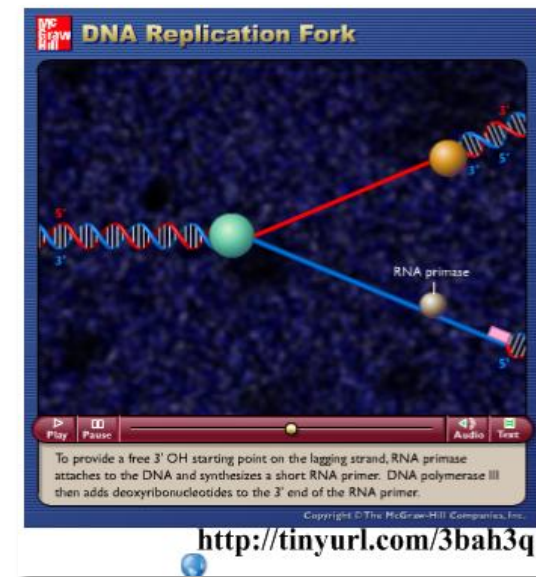


DNA replication in prokaryotes:

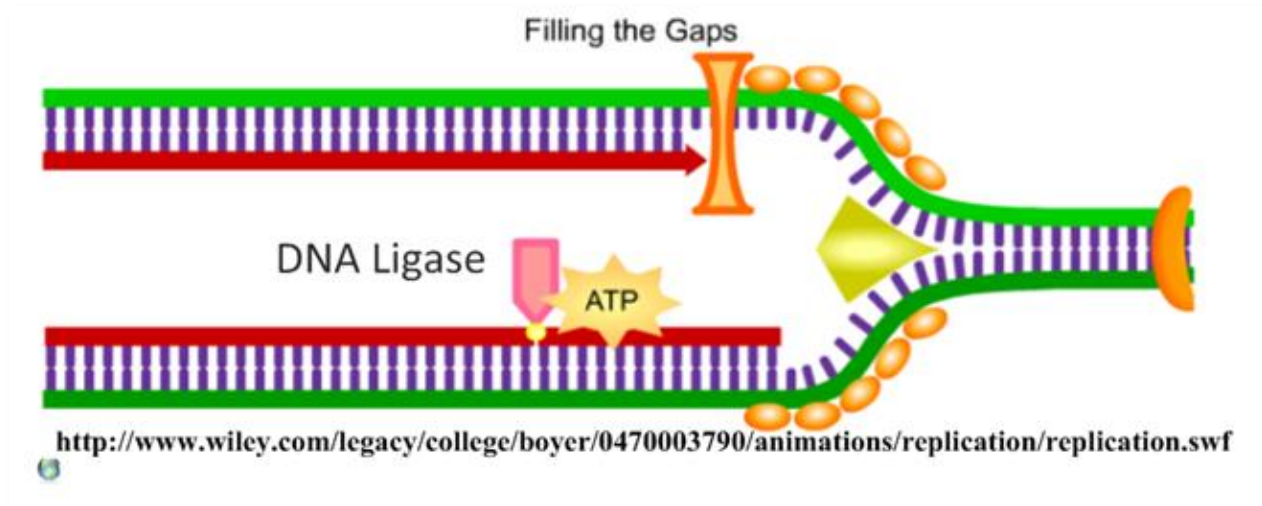


6. **DNA Polymerase I** moves along the replication fork removing the **RNA primers**.

7. **DNA Ligase** attaches the **Okazaki fragments** into a continuous strand of DNA.



This process uses ATP.



<http://www.wiley.com/legacy/college/boyer/0470003790/animations/replication/replication.swf>

The Enzymes and Molecules of DNA replication:

Helicase Unwinds DNA and breaks H-bonds between base pairs

DNA Polymerase III

RNA Primase

RNA Primers

Okazaki fragments

DNA Polymerase I

DNA Ligase

Sections of new DNA on the lag strand

Leaves RNA primers on the lag strand

Attaches Okazaki fragments together

Attaches nucleotides in a 5' - 3' direction

Removes RNA primers

Initiation sites for DNA polymerase III on the lag strand

The Enzymes and Molecules of DNA replication:

Helicase Unwinds DNA and breaks H-bonds between base pairs

DNA Polymerase III Attaches nucleotides in a 5' - 3' direction

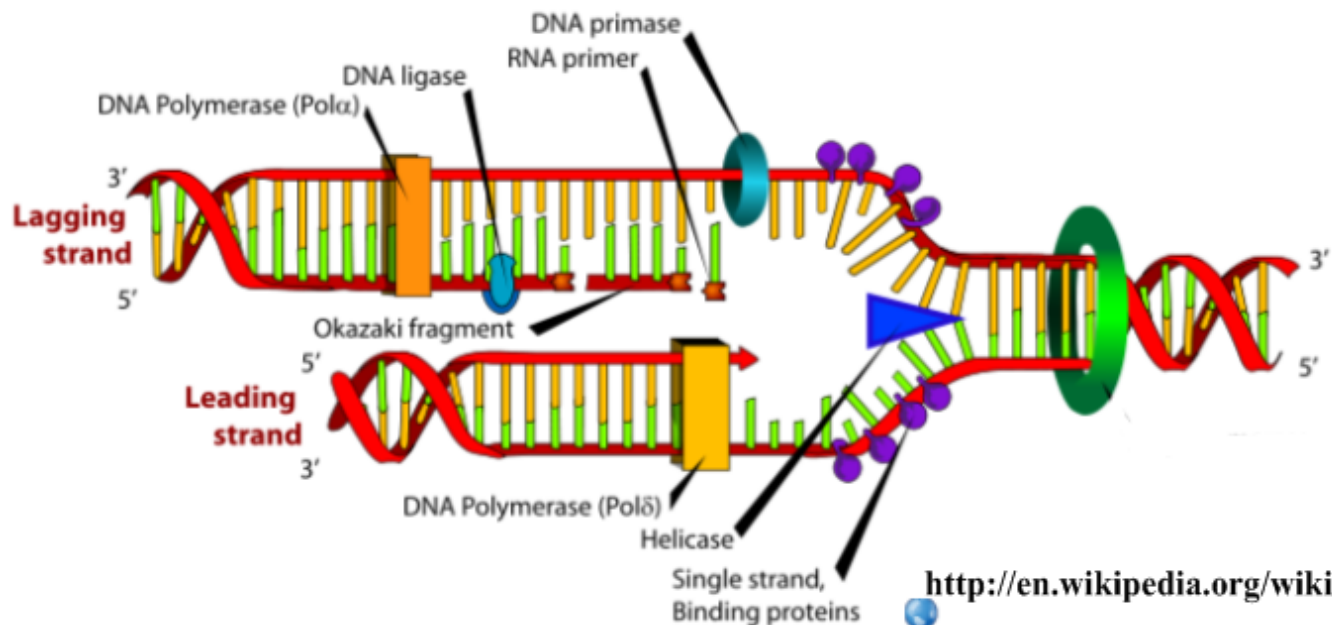
RNA Primase Leaves RNA primers on the lag strand

RNA Primers Initiation sites for DNA polymerase III on the lag strand

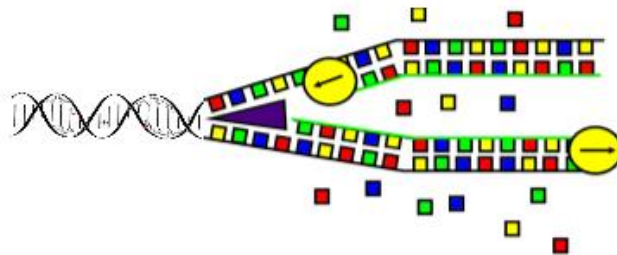
Okazaki fragments Sections of new DNA on the lag strand

DNA Polymerase I Removes RNA primers

DNA Ligase Attaches Okazaki fragments together



http://en.wikipedia.org/wiki/DNA_replication



For more IB Biology resources:
<http://sciencevideos.wordpress.com>