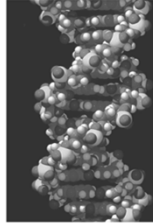


Introduction to Genetics/DNA Replication

The DNA molecule is found in the nucleus and is composed of nucleotides



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Nucleotide

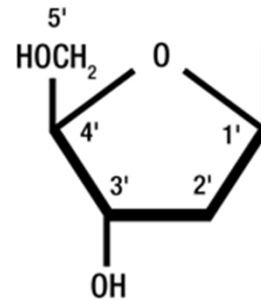
- A nucleotide is composed of three parts
 - Phosphate group
 - Pentose sugar (5 carbons)
 - Nitrogen containing base

Phosphate Group



Phosphate group

Pentose Sugar-Watch the Numbers



Nitrogen Containing Bases

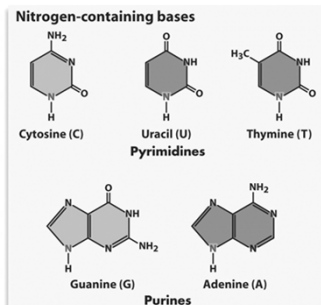


Figure 4.11. Biological Science, 3/e

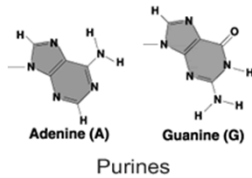
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Purine vs. Pyrimidine

- Purines contain 2 fused rings that will form hydrogen bonds with a single ringed pyrimidine.
- Pyrimidines contain 1 ring that will form hydrogen bonds with a double ringed pyrimidine.

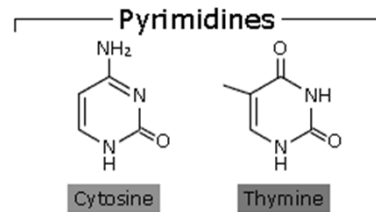
Purines

- Purines consist of a six-membered and a five-membered nitrogen-containing ring, fused together.
- Caffeine and Uric Acid are Purines

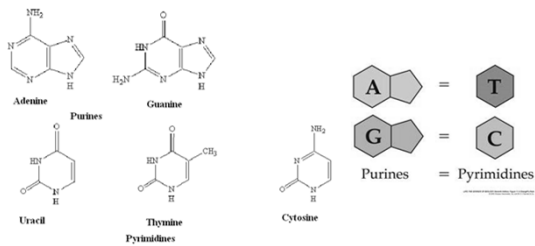


Pyrimidines

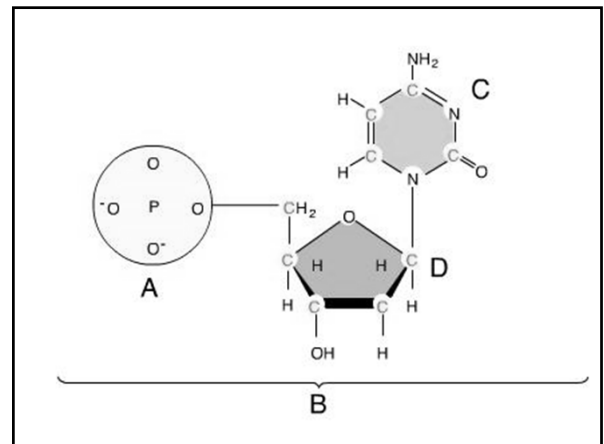
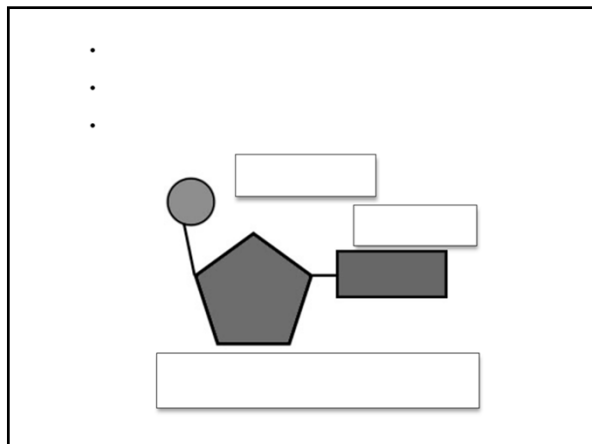
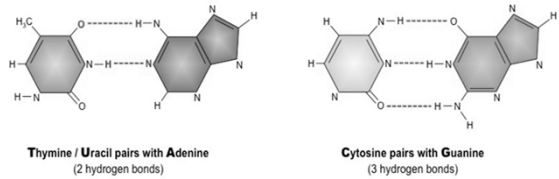
- Pyrimidines have only a six-membered nitrogen-containing ring.



Purines vs. Pyrimidines

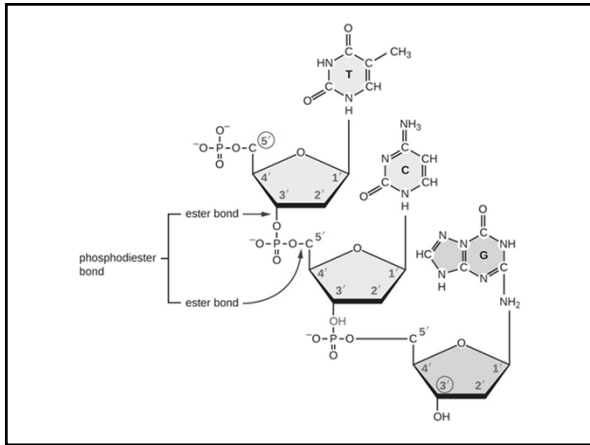
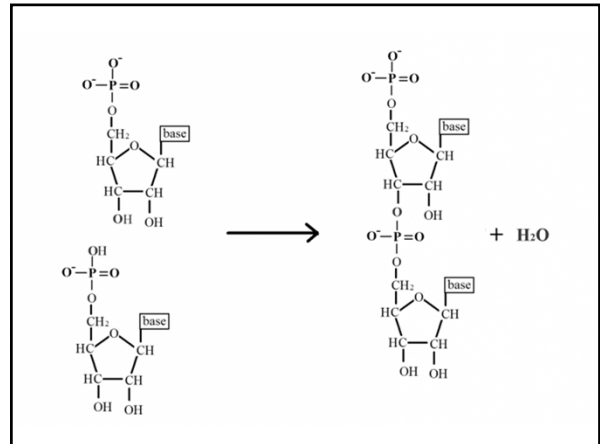


Hydrogen Bonding



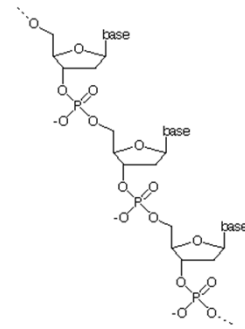
Building The Macromolecule

- A nucleic acid is composed of monomers called nucleotides.
- The 3' carbon is linked to the phosphate group linked to the 5' carbon.
- This bond is called a phosphodiester bond forming the BACKBONE.

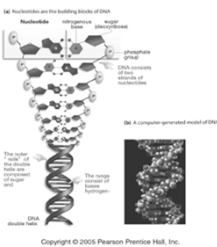


Backbone

- DNA backbone is repeating phosphates and sugars held together by phosphodiester bonds.

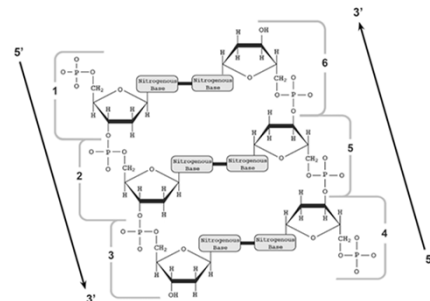


The DNA Molecule

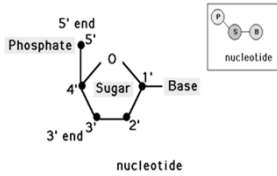


- Composed of 2 polymers of nucleotides
- Polymers are oriented in anti-parallel (opposites so the bases are considered complementary)
- Molecule resembles a spiral staircase of complementary base pairs.

What does it mean to be anti-parallel and how did they name the 5' and 3' ends?



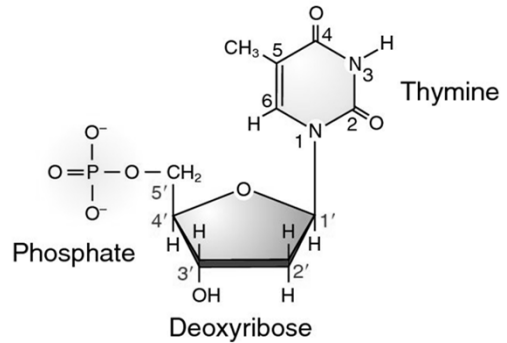
Nucleotide Structure of DNA



- Each nucleotide of DNA contains:
 - Deoxyribose sugar (5 carbon [pentose] sugar) composed of H,C and O
 - Phosphate group
 - Nitrogen containing base (either A, G, C, T)

Deoxyribose is a component of DNA which lacks -OH (alcohol group) on the 2' carbon ring

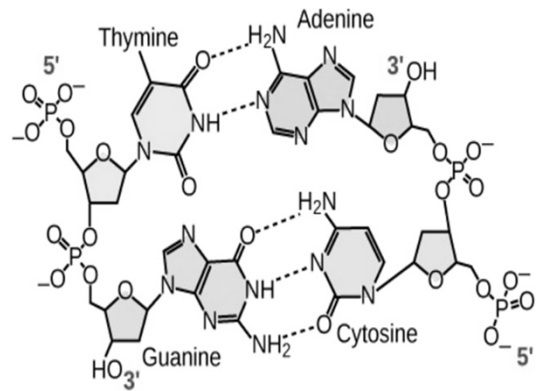
Deoxyribose Sugar Lacks 2' OH



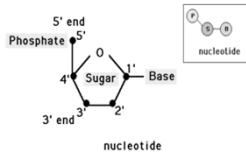
Deoxyribonucleic Acid (DNA)

- Bases
- Adenine
- Thymine
- Cytosine
- Guanine
- A
- T
- C
- G

The two strands of the DNA are held together by hydrogen bonds.



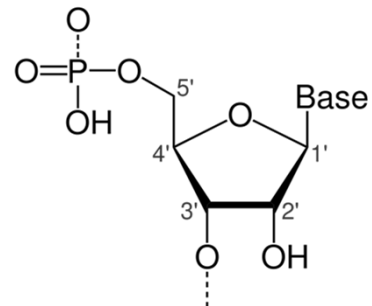
Nucleotide Structure of RNA



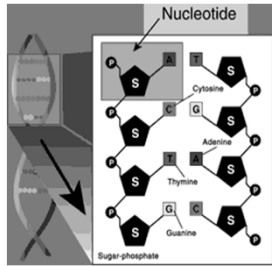
- Each nucleotide of RNA contains:
 - Ribose sugar (5 carbon sugar) composed of C,H and O
 - Phosphate
 - Nitrogen base (either A, G, C, U*)
- *contains Uracil instead of Thymine

Ribose is a component of RNA which contains -OH group on the 2' carbon ring

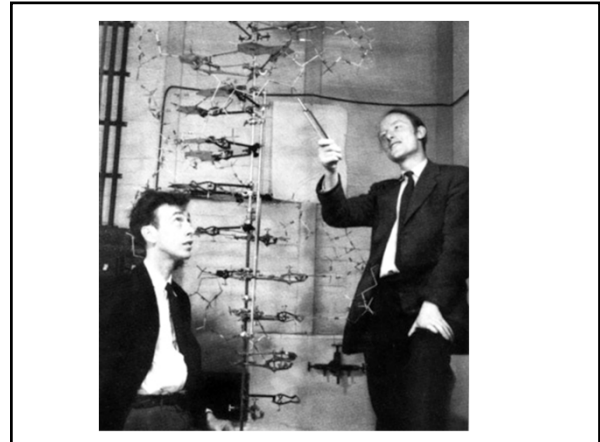
Ribose Sugar Has the OH on the 2' Carbon



DNA Structure Discovered



- “Double helix” proposed by Watson and Crick (1953)
- Antiparallel backbones
- Complementary base pairing:
 - Adenine to Thymine
 - Cytosine to Guanine

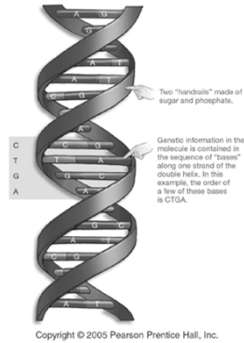


Rosalind Franklin

- Franklin is best known for her work on the X-ray diffraction images of DNA which led to discovery of DNA double helix. Her data, according to Francis Crick, was "the data we actually used" to formulate Crick and Watson's 1953 hypothesis regarding the structure of DNA.



DNA Structure



In humans one DNA strand can reach 1 meter in length.

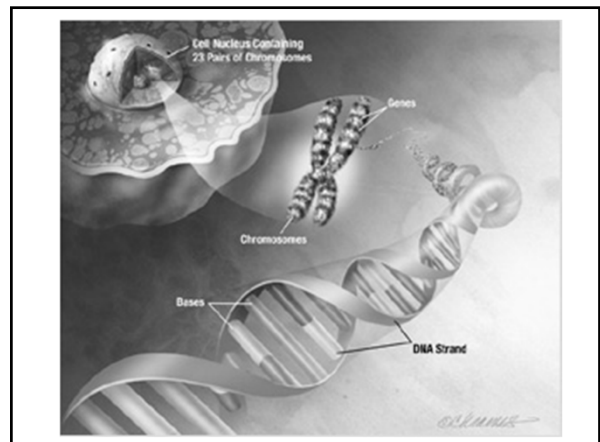
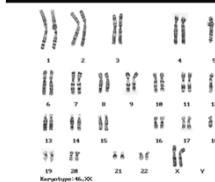
There are 10 bases in each turn of the DNA molecule.

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Chromosomes vs Genes



- A **chromosome** constitutes an entire DNA molecule which is composed of genetic material.
- Supercoiled DNA in the nucleus.
 - Humans contain 46 such molecules (23 pairs)
 - 44 somatic chromosomes
 - 2 sex chromosomes (X + Y)



Karyotype

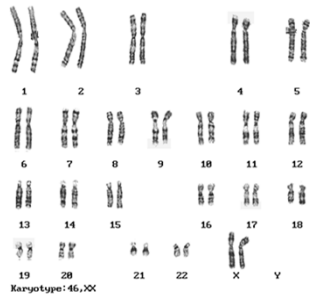
- Photograph showing the paired chromosomes.
- Abnormalities involving more or less than the normal amount of chromosomes can be easily seen.
- Abnormalities in structure can also be seen.
- Sex can be determined.

BOY XY

GIRL XX

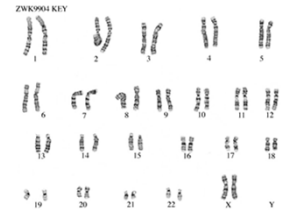


One From Mom and One From Dad



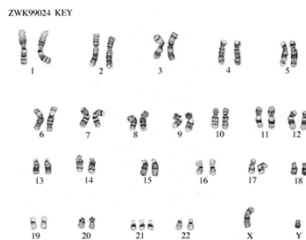
Normal Female

- 46 chromosomes
- The 23rd chromosome is XX

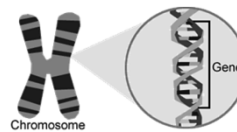


Affected Male

- Male
- The 23rd chromosome is XY
- 47 total chromosomes
- Extra is at 21, this man has Down's Syndrome.



Chromosomes vs Genes

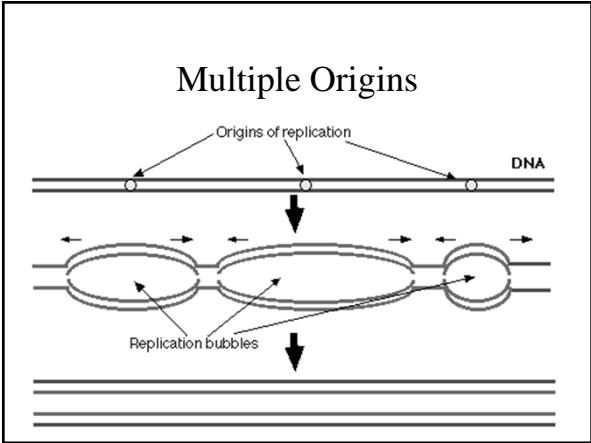


- **Genes** constitute distinct regions on the chromosome
- Each gene codes for a protein product or enzymes
- DNA -> RNA -> protein
- Differences in proteins brings about differences between individuals and species.

DNA REPLICATION

Speed of Replication

- The average human chromosome contains 150×10^6 nucleotide pairs which are copied at about 50 base pairs per second.
- At this rate, the process would take a month rather than an hour.
- How can the cells speed the process?



How do chromosomes become double stranded?
Answer: DNA replication

When chromosomes are preparing to divide the DNA replicates itself into two strands called chromatids

- During the life of the cell, each chromosome of DNA makes a copy of itself.
- This must occur prior to cell division to insure each daughter cell gets a complete set
- [Mitosis Video](#)

Therefore, prior to dividing, any cell must first replicate DNA

The flowchart shows a single DNA molecule (represented as a grey oval) replicating into two DNA molecules. This process is repeated, showing the exponential growth of DNA molecules.

- Each single-stranded (SS) chromosome duplicates to become a double-stranded (DS) chromosome
- Example:
 - A human cell is formed with 46 SS chromosomes
 - Each chromosome replicates to produce 46 DS chromosomes

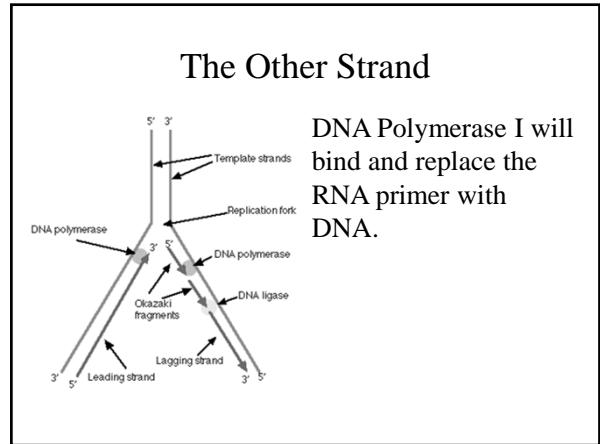
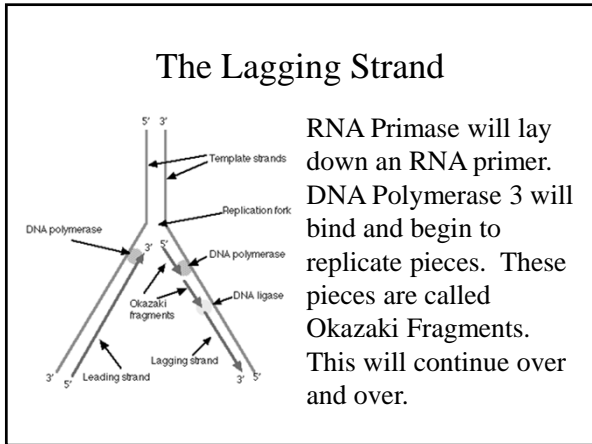
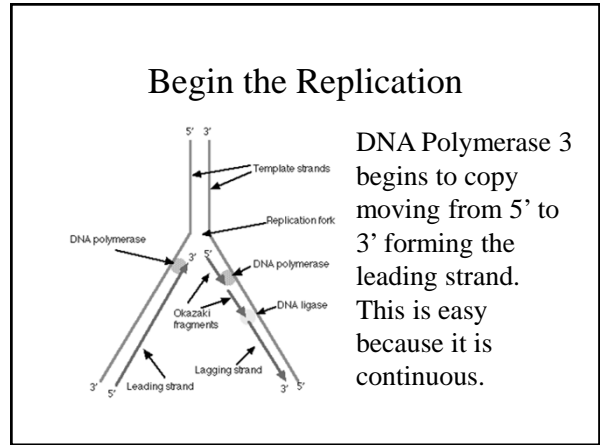
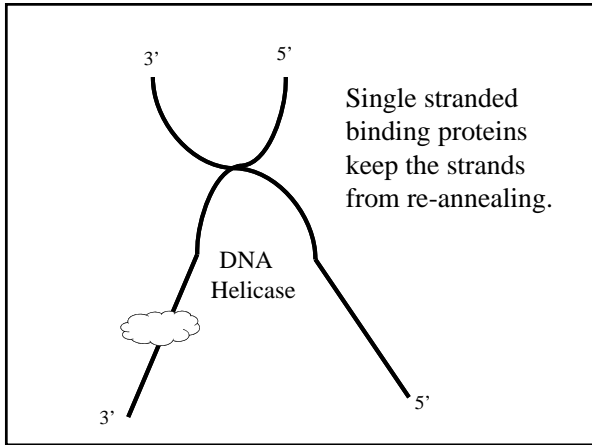
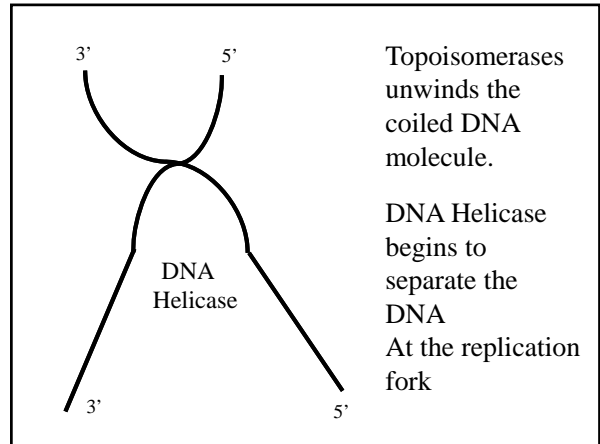
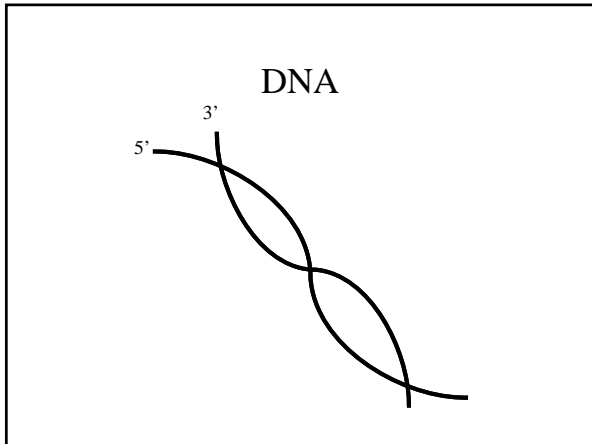
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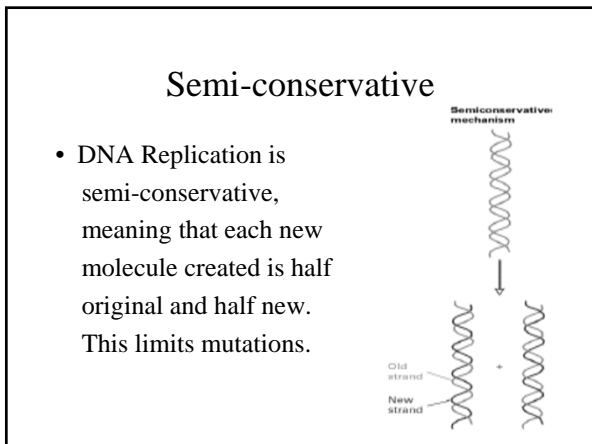
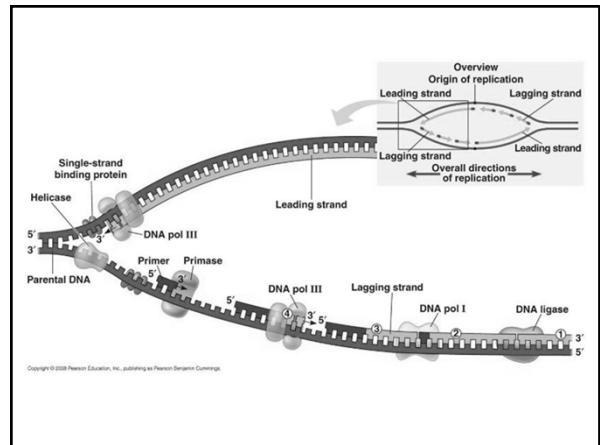
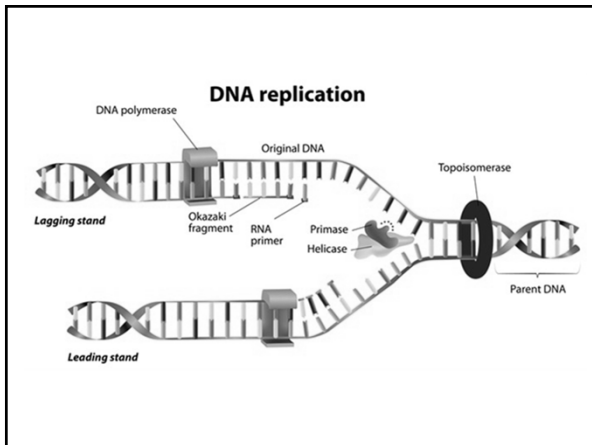
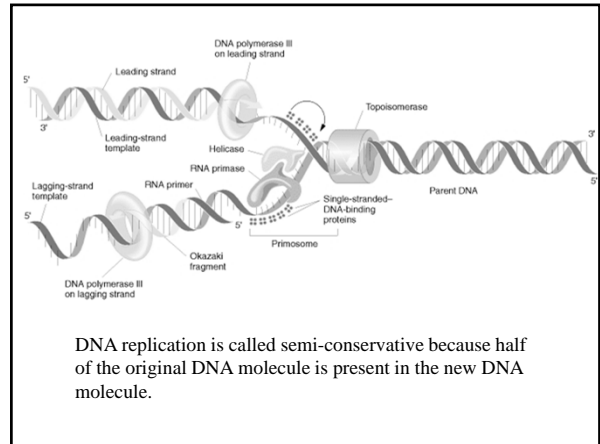
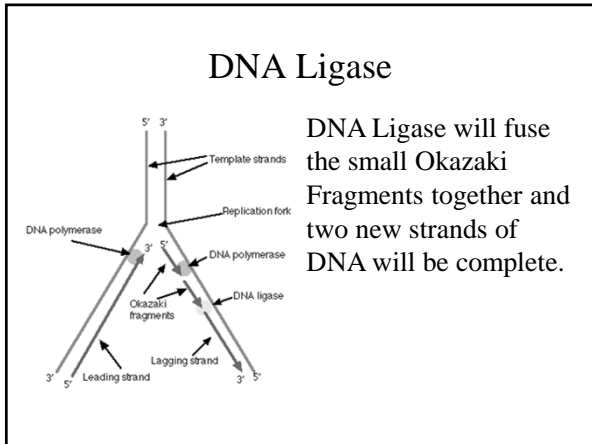
DNA Replication

The diagram shows a DNA double helix unwinding. Two new DNA strands are synthesized from the two original strands, creating two identical DNA molecules.

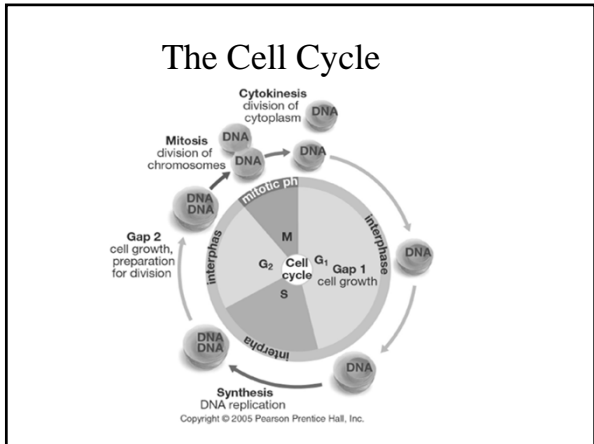
Six enzymes responsible for the DNA replication are Topoisomerases, Helicase and DNA Polymerase 3, RNA Primase, DNA Polymerase 1 and DNA Ligase.

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- ### DNA replication occurs during the life of a cell = the **Cell Cycle**
- DNA replicates (makes a copy of itself) to produce double stranded chromosomes
 - During this time, the cytoplasmic contents also duplicate
 - Spindle tubules form to aid in the process of cell division
 - Mitosis in body cells
 - Meiosis in sex cells



Cancer

- A group of abnormal body cells that undergoes rapid cell division in places where it should not.

The two photographs illustrate the clinical presentation of skin cancer. The left image shows a large, dark, irregular lesion on the bridge of a nose, characteristic of basaloid carcinoma. The right image shows a smaller, raised, and somewhat cauliflower-like lesion on the chin, which could be a squamous cell carcinoma or another type of skin cancer.

