Chapter 8 - From DNA to Proteins

8.1 Identifying DNA as the Genetic Material

I. What is DNA?

- DNA determines an organism's ***traits***.
- DNA achieves it control by determining the ***structure of proteins***.
- Living things contain proteins, ***skin, muscles, and bones*** all contain proteins.
- All actions, such as ***eating, running, thinking***, depend on proteins called enzymes.
- Within the structure of ***DNA*** is the information of life, the complete instructions for manufacturing all the ***proteins*** for an organism.

II. DNA as the Genetic Material

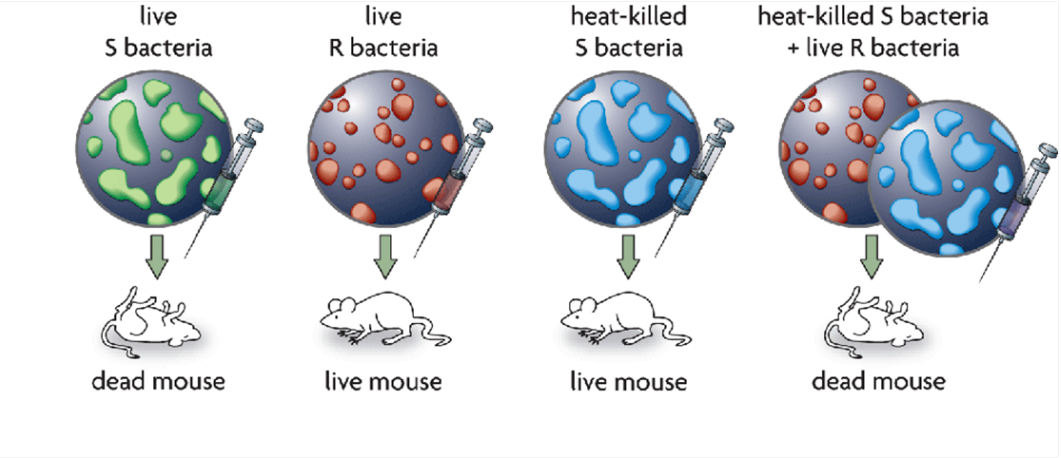
- Scientists wanted to know if it was ***proteins or DNA*** that stored the genetic code.
- Answers came from medical studies involving two forms, or strains, of bacterium *Pneumococcus*. One strain is ***virulent,*** or disease causing, and caused pneumonia. The other strain is ***nonvirulent***, or harmless.

1. Griffith finds a transforming principle

- In 1928 in London, Frederick ***Griffith***, a bacteriologist was working out a way to identify two strains of *Pneumococcus*.

- His experiments showed that nonvirulent bacteria could acquire the ability to cause disease from virulent bacteria. This process is called ***transformation*****.**
- ***Heat*** played an important role in this experiment. DNA tolerates ***90° C*** without altering; and protein can only tolerate ***60° C*** before denaturing.
- What effect did this have on the experiment? The DNA ***survived the heat that killed the bacteria*** and continued the process of ***transformation***.
- **However, there were skeptics.**

Griffith's Transformation Experiment



2. Avery identifies DNA as the transforming principle.

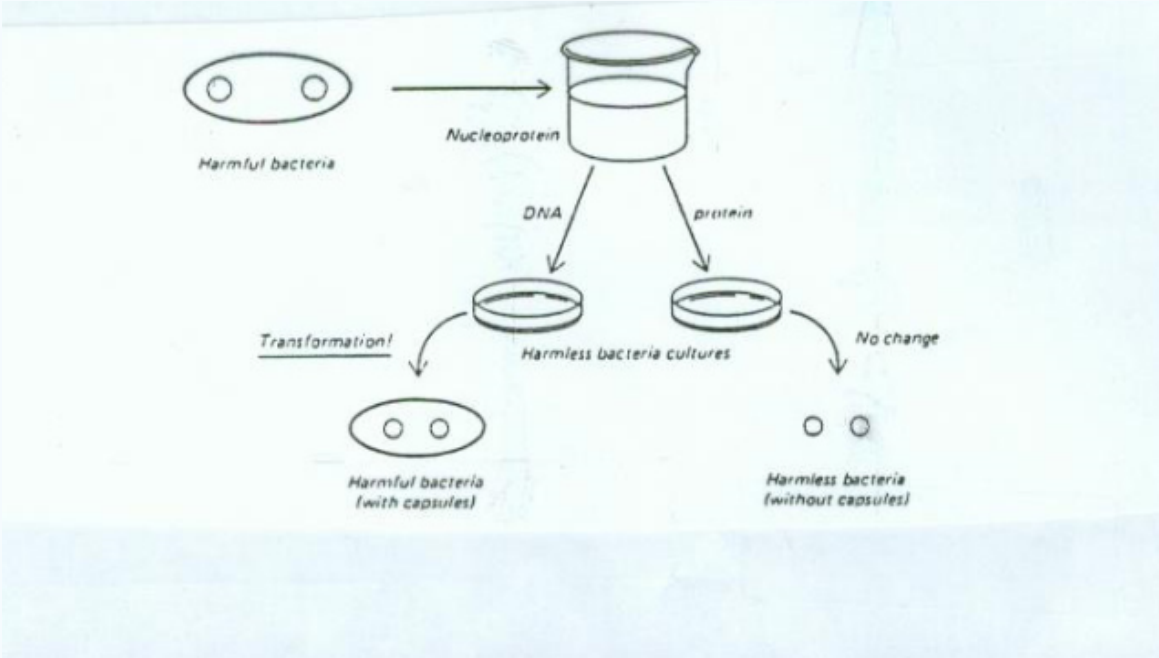
- In 1944 in New York, Oswald ***Avery*** wanted to identify the substance that made the ***nonvirulent*** bacteria become ***virulent***.

- Avery and two colleagues modified Griffith's experiment. Working with **smooth and rough** colonies of bacteria, they found when mixing the colonies that the smooth ones transformed the rough ones to become smooth. When they added ***protein***-destroying enzymes to bacteria, transformation ***continued to occur***.
- In a separate experiment, Avery found that when he added ***DNA***-destroying enzymes to bacteria, transformation ***did not occur*.**
- Avery's work provided clear evidence that ***DNA*** was the genetic material in these bacteria.
- **And there were still skeptics!**

CHEMICAL ANALYSIS OF TRANSFORMING PRINCIPLE

	% Nitrogen (N)	% Phosphorus (P)	Ratio of N to P
Sample A	14.21	8.57	1.66
Sample B	15.93	9.09	1.75
Sample C	15.36	9.04	1.69
Sample D	13.40	8.45	1.58
Known value for DNA	15.32	9.05	1.69

DNA and its Structure



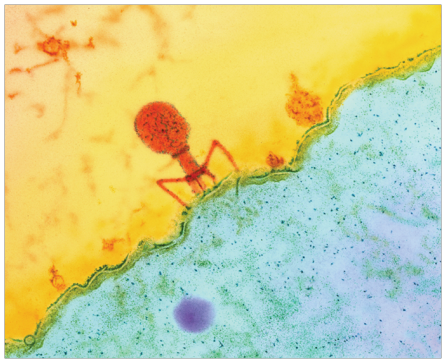
3. Hershey and Chase confirm that DNA is the genetic material.

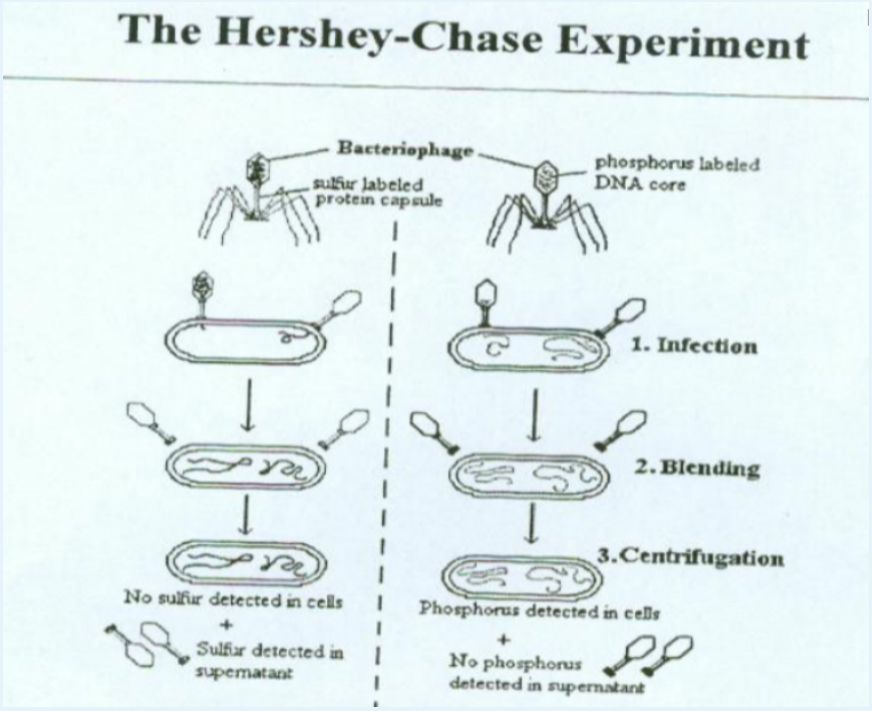
- In 1952 in New York, these two scientists, Alfred Hershey and Martha Chase, performed an experiment using viruses**,** called ***bacteriophages*** **,** that infect bacteria.

- These viruses, which are made of ***DNA*** surrounded by a ***protein coat***, attach to the surfaces of bacteria and inject their ***hereditary information*** into the cells and attach it with the cell's own DNA within its nucleus. Once inside the bacteria, this info directs the production of hundreds of new viruses. When the new viruses are mature, they burst out of the infected bacteria and attack new cells.

- To identify the heredity material Hershey and Chase did the following:

1. They used ***radioactive*** elements to label the ***DNA*** and the ***protein coats*** of viruses. ***Sulfur*** for the protein material and ***phosphorus*** for the DNA material.
2. Next they ***infected*** bacteria with the radioactive viruses. When sufficient time had passed, they used a blender to detach the remains of the viruses.
3. After examining the remains, they found the ***DNA***, ***not protein***, was injected into the cell.





The skeptics were finally satisfied!

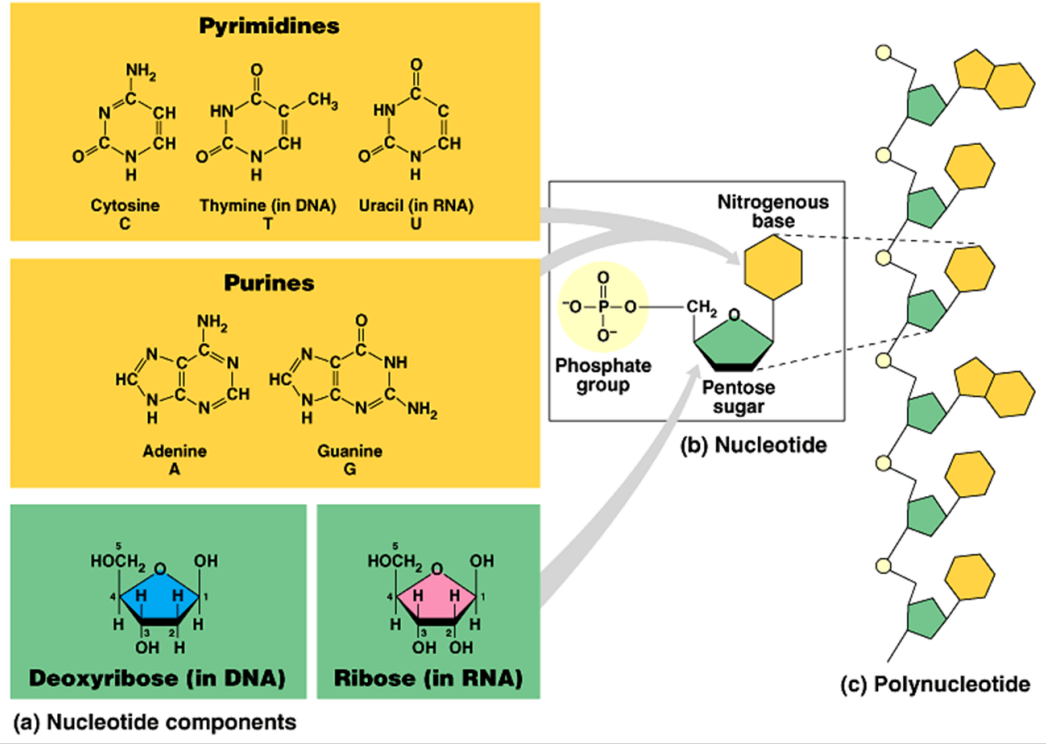
8.2 The Structure of Nucleotides

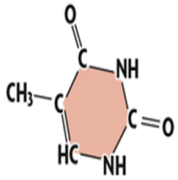
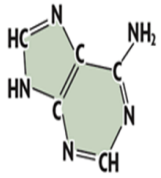
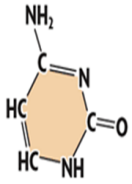
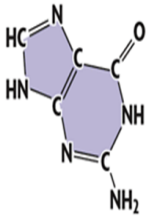
- **DNA is a *polymer* (or long molecule) made up of repeating units of nucleotides.**

*It is capable of holding all its information because of its ***length*** (there is ***2.3*** meters **or about 7 feet** of DNA in each cell).*

A nucleotide has three parts:

1. A 5-carbon sugar ***(deoxyribose)***
2. A ***phosphate*** group
3. A nitrogen base **-Four types of bases:**
   a. ***purines*** = ***adenine and guanine*** (the larger bases, double ring of carbon and nitrogen atoms)
   b. ***pyrimidines*** = ***cytosine and thymine*** (the smaller bases, single ring of carbon and nitrogen atoms)

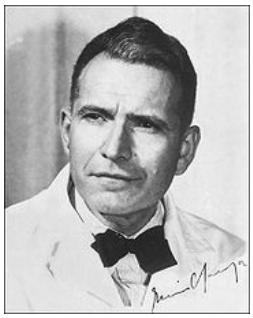


PYRIMIDINES = SINGLE RING			PURINES = DOUBLE RING		
Name of Base	Structural Formula	Model	Name of Base	Structural Formula	Model
thymine			adenine		
cytosine			guanine		

A. The Structure of DNA

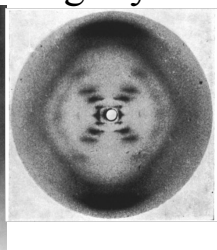
1. Chargaff's rules

- In 1949, a biochemist in New York found out that the amount of ***adenine*** in a DNA molecule always ***equals*** the amount of ***thymine*** (A=T). Likewise, the amount of ***guanine*** always ***equals*** the amount of ***cytosine*** (G=C). These base-pairing rules still apply today.



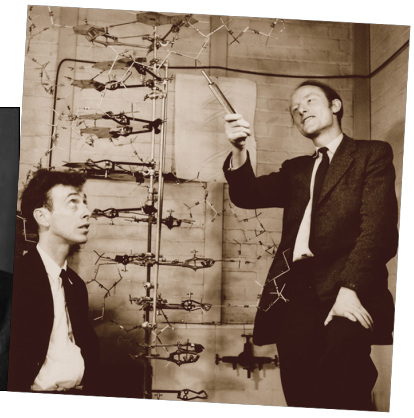
2. Rosalind Franklin and Maurice Wilkins

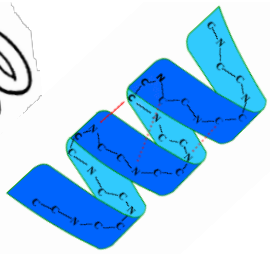
- A chemist and physicist working in London, which was working on the structure of DNA using ***X-ray diffraction*** (when a **beam of X-rays is focused at an object and they bounce off the object and are scattered in a pattern onto a piece of film**).
- By analyzing the picture, a scientist is able to determine the structure of a molecule. Franklin's famous ***photo 51*** of DNA showed that the DNA molecule resembled a tightly coiled spring, a shape called a ***helix***.

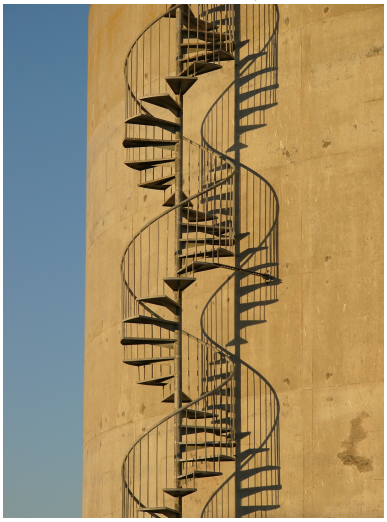

3. James Watson and Frances Crick build a model showing DNA's structure

- In the early 1950's in England, these two men attempted to construct a ***model of DNA***. They applied the clues provided by Chargaff's rules and Franklin's X-ray diffraction photos.
- In 1953, they published a letter that the structure of the DNA molecule is a ***double helix*****,** a spiral staircase, or long zipper, composed of two strands of nucleotides, running in opposite directions or ***anti-parallel*****,** whose bases face each other and are complementary. The double helix is held together by weak ***hydrogen*** bonds between the bases (which makes it easy to "unzip").
- Watson, Crick, and Wilkins were awarded the Nobel Prize in ***1962*****.**



helix

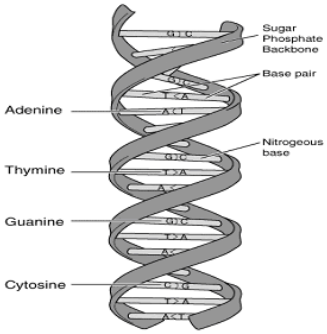


double helix

The structure of DNA

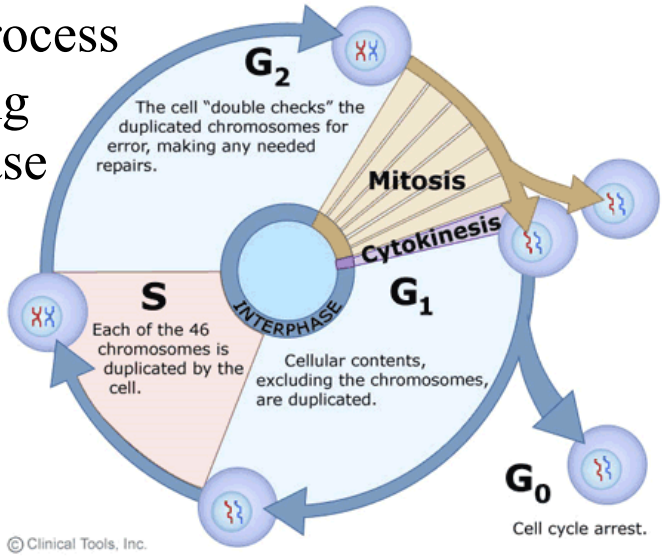
B. The importance of nucleotide sequences.

- The sequence of nucleotides forms the ***unique*** genetic information of an organism.
  Ex: Nucleotide sequence of ***ATTGC*** carries different information from a sequence of ***TGCATC***.
- The ***closer*** the relationship is between two organisms, the more ***similar*** their DNA nucleotide sequence will be.
- Scientists use nucleotide sequence to determine ***evolutionary*** relationships among organisms.



8.3 DNA Replication

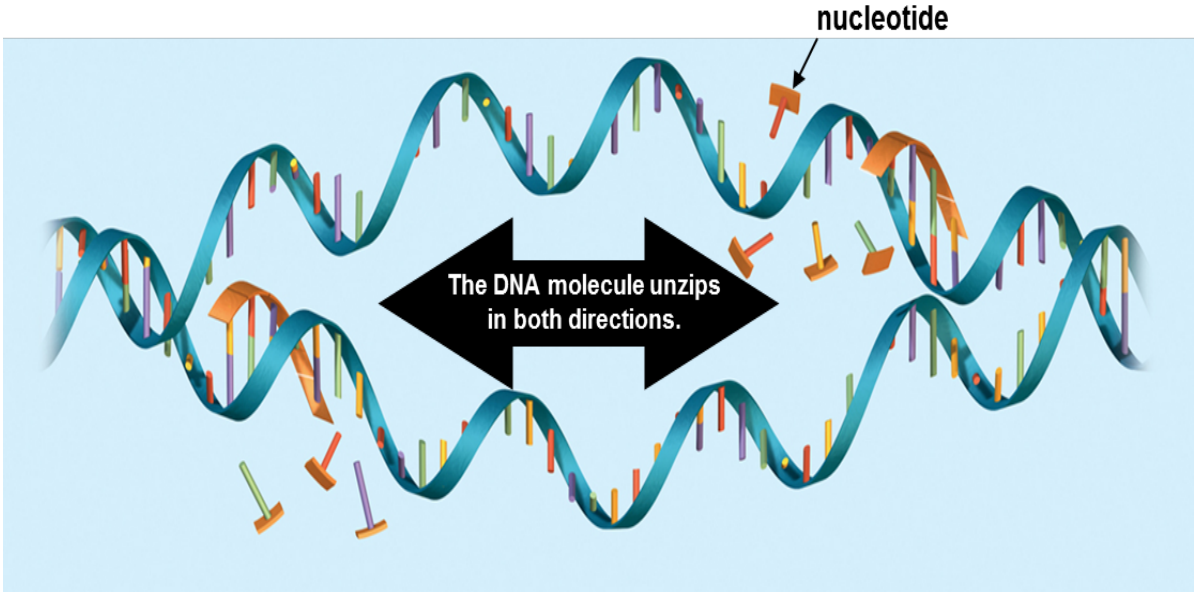
- **Replication** = the process of ***copying DNA,*** during the ***S phase*** of interphase of the cell cycle.



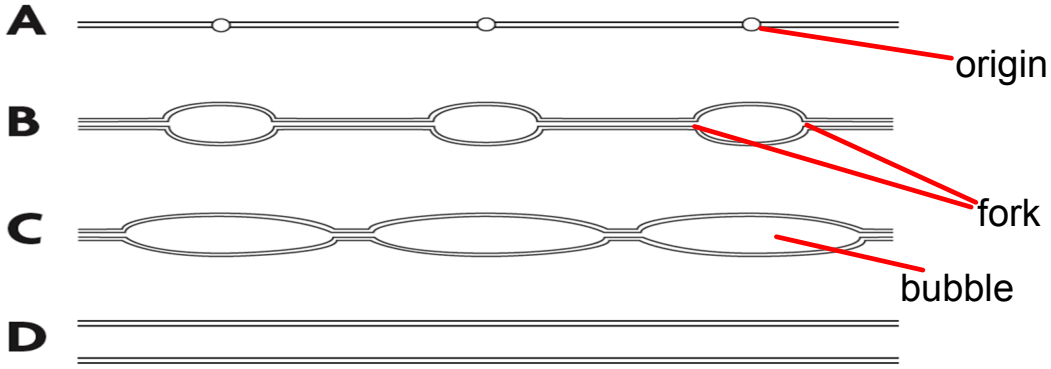
- Without DNA replication, new cells would have only ***half*** the DNA of parents. Species could not ***survive***.
- All organisms undergo ***DNA replication***.

A. How DNA replicates

- During replication, each strand serves as a pattern, or ***template***, to make a new DNA molecule.
- Replication begins as an enzyme, ***Helicase***, breaks the hydrogen bonds between bases that hold the two strands together, thus unzipping the DNA.

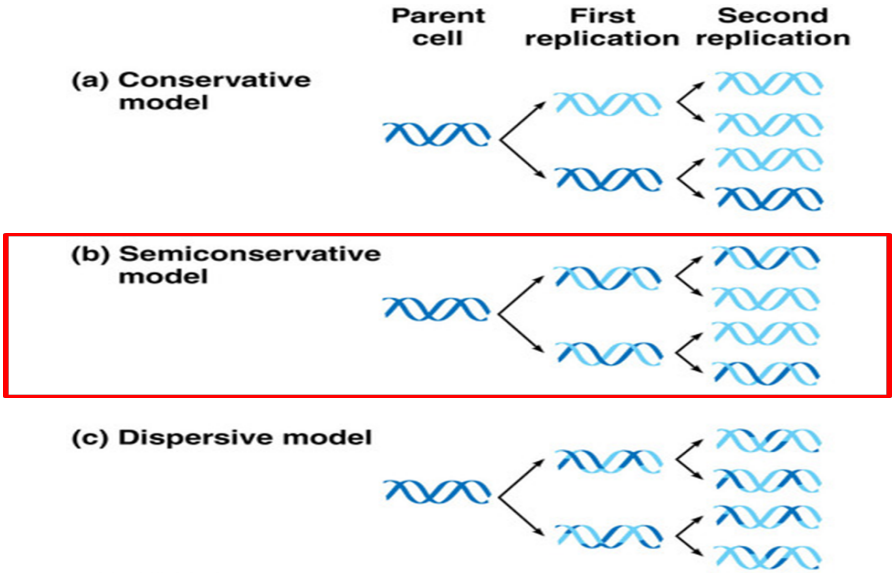


- There is ***more than one Helicase*** unzipping DNA in numerous places along the strand, these locations are referred to as the ***"origins of replication".***
- There are multiple **"replication forks"** and ***"replication bubbles"*** during the replication process.

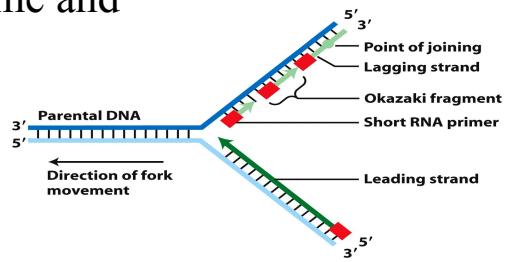


- As the DNA continues to unzip, nucleotides that are ***free floating*** in the surrounding medium are attached to their base pair. ***Triple hydrogen*** bonds are joined between G-C and ***double hydrogen*** bonds between A-T.
- Another enzyme, ***DNA polymerase,*** bonds these nucleotides into a chain. DNA polymerase runs ***5' to 3'*** (one direction). This includes a continuous synthesis, called the ***leading strand.***
- A discontinuous synthesis, called the ***lagging strand,*** has ***DNA Ligase*** as the bonding enzyme.
- Ligase ***fills in the gaps*** that DNA polymerase leaves **"*open*"** on lagging strand.
- **DNA Polymerases** then ***go back*** one more time to ***"proofread"*** and ***correct errors*** along the base pairs.

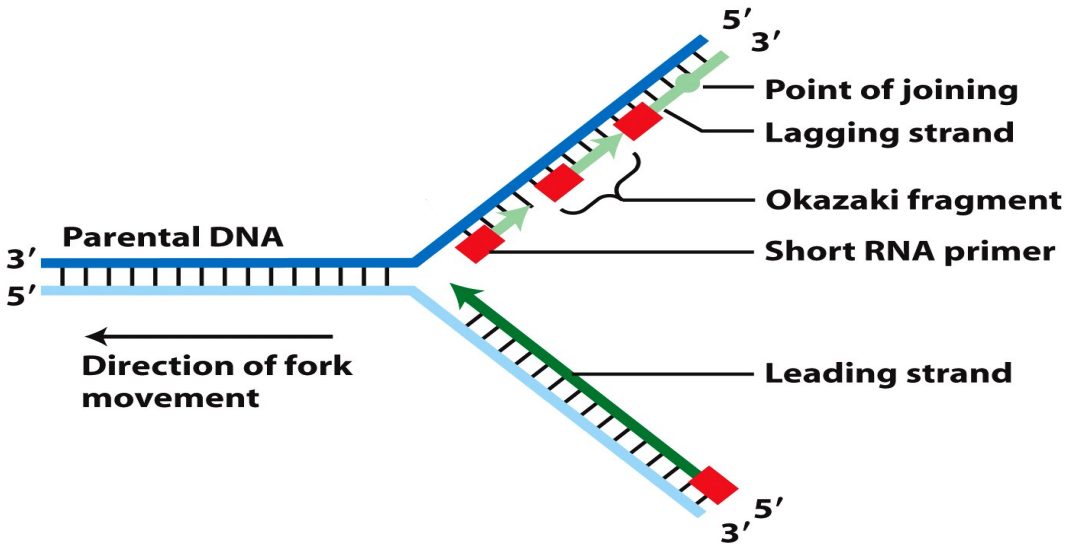
- The lagging strands are referred to as ***Okazaki fragments, between the "gaps".***
- This process continues until the ***entire molecule*** has been unzipped and replicated. Each new strand formed is a complement of one of the original strands. The result is the formation of ***two DNA molecules***, each of which is ***identical*** to the original DNA molecule.
- ***DNA is*** referred to as ***semiconservative molecule*** because an ***original strand is conserved and one new strand is made.***

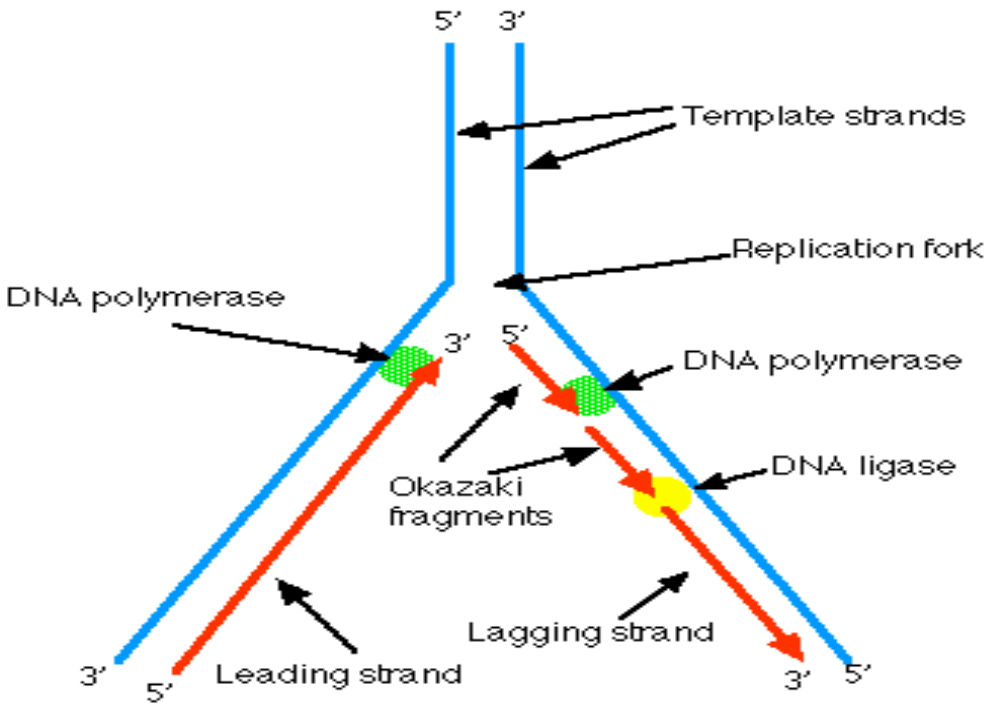


DNA polymerase, attaches to new DNA nucleotides of an existing strand of nucleotides. Therefore, ***RNA primase*** functions by synthesizing (adding) ***short RNA sequences that are complementary to a single-stranded piece of DNA***, so serves as its template, thus serves to prime and lay a foundation for DNA synthesis.



B. Replication preserves the sequence of bases in an organism's DNA.




5′ 3′
Template strands
Replication fork
DNA polymerase
3′ 5′
DNA polymerase
DNA ligase
Okazaki fragments
Lagging strand
Leading strand
3′ 5′
3′ 5′

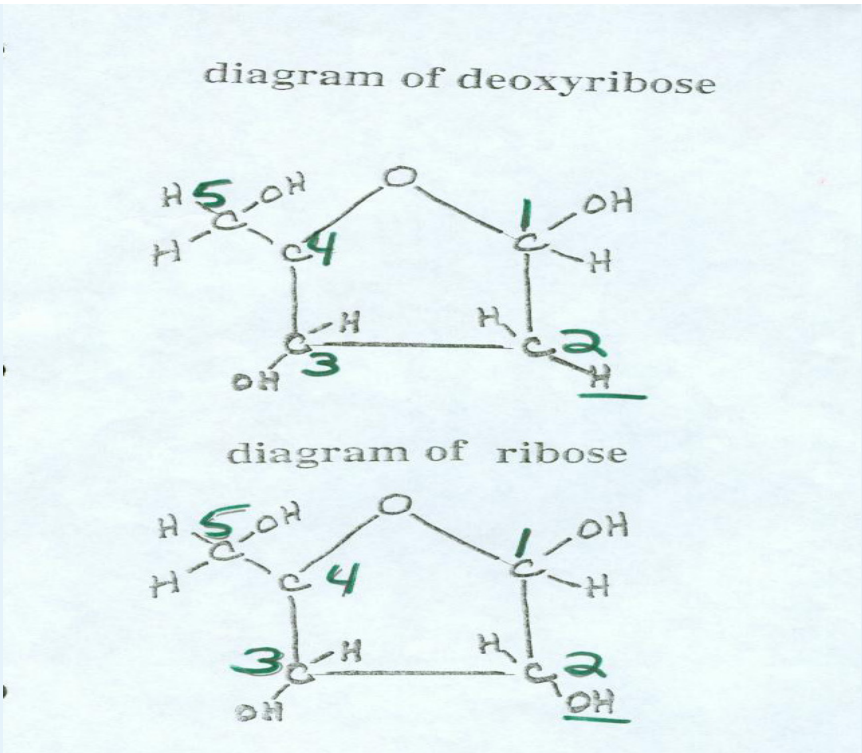
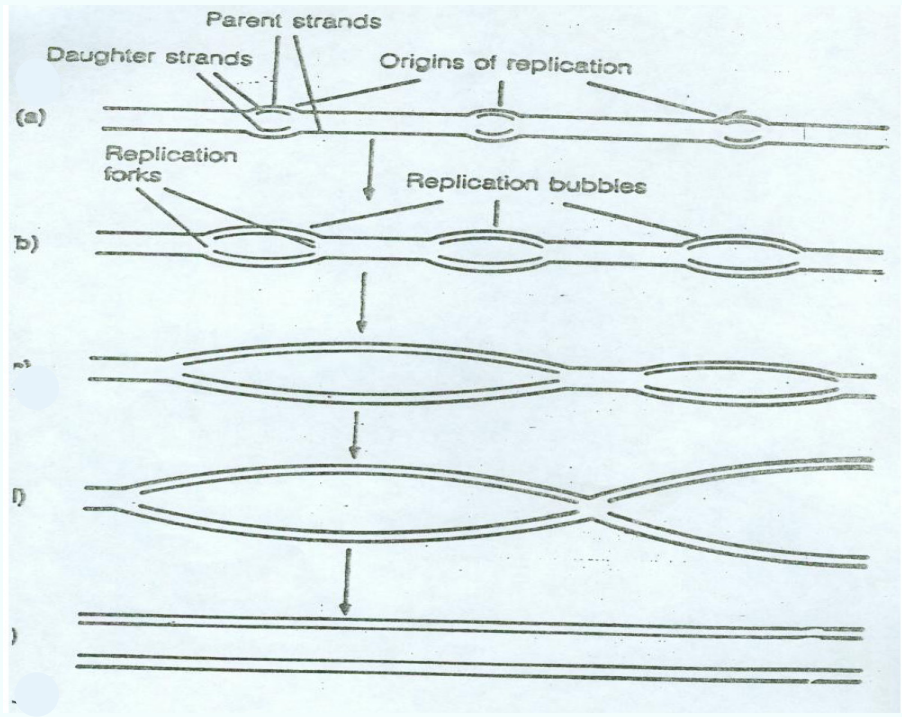
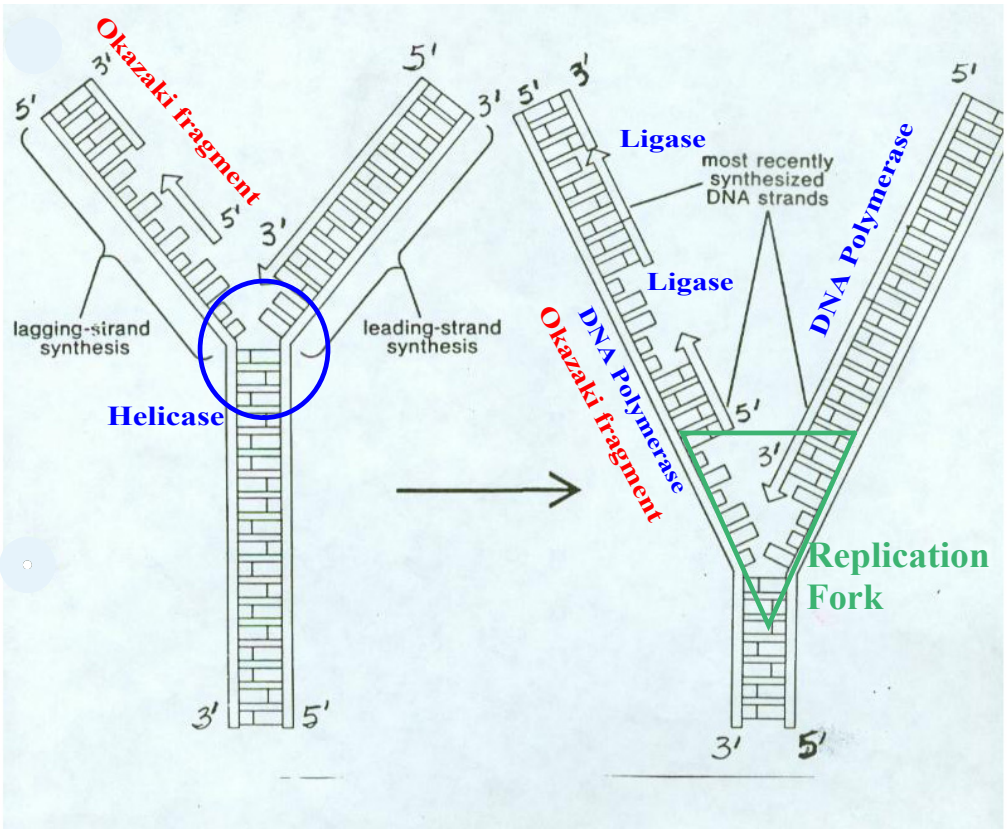
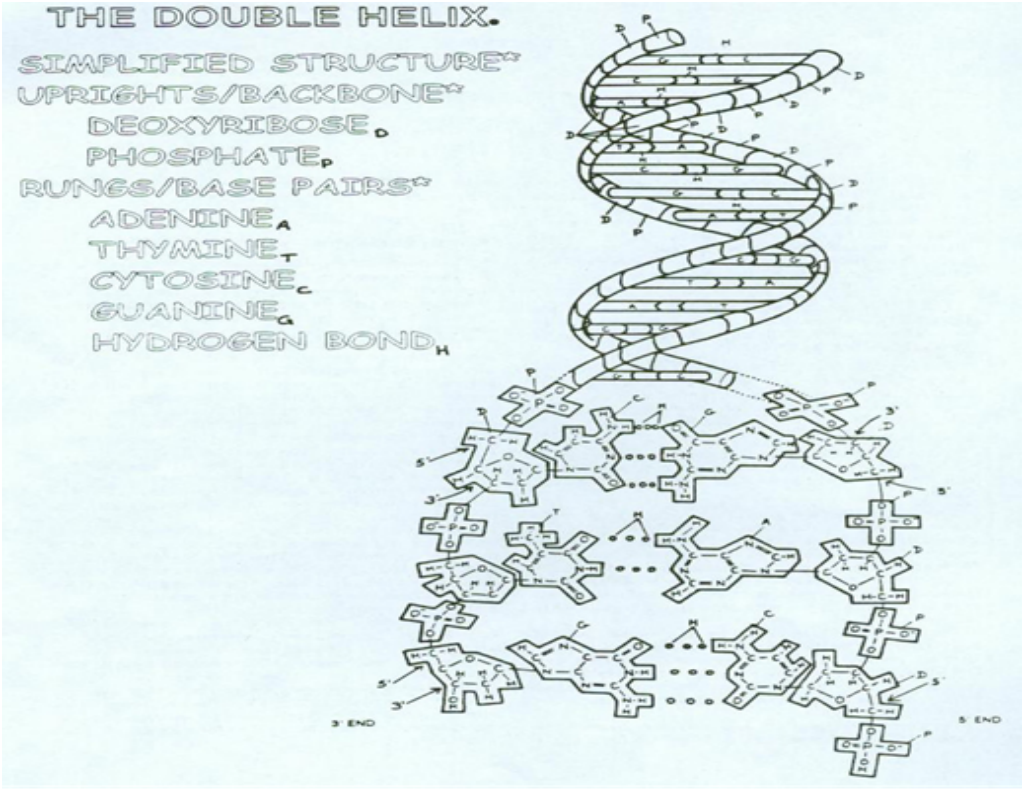


diagram of deoxyribose
diagram of ribose


Parent strands
Daughter strands
Origins of replication
(a)
Replication forks
Replication bubbles
b)


Okazaki fragment
5'
3'
lagging-strand synthesis
leading-strand synthesis
Helicase
Ligase
most recently synthesized DNA strands
Ligase
DNA Polymerase
DNA Polymerase
Okazaki fragment
Replication Fork



DNA Replication