DNA and Replication

TEKS

(6) Science concepts. The student knows the mechanisms of genetics, including the role of nucleic acids and the principles of Mendelian Genetics. The student is expected to:

(A) identify components of DNA, and describe how information for specifying the traits of an organism is carried in the DNA;

(B) recognize that components that make up the genetic code are common to all organisms

Vocabulary

- Nucleic Acid
- Nucleotide
- Base pairing
- Complementary
- Template Strand
- Semiconservative
- Replication
- DNA Polymerase
- Helicase
- Antiparallel

Prerequisite Questions

1. What are the monomer molecules that make up nucleic acids?

2. What are the 3 structures of a nucleotide?

3. What is the purpose of DNA?

Essential Question #1

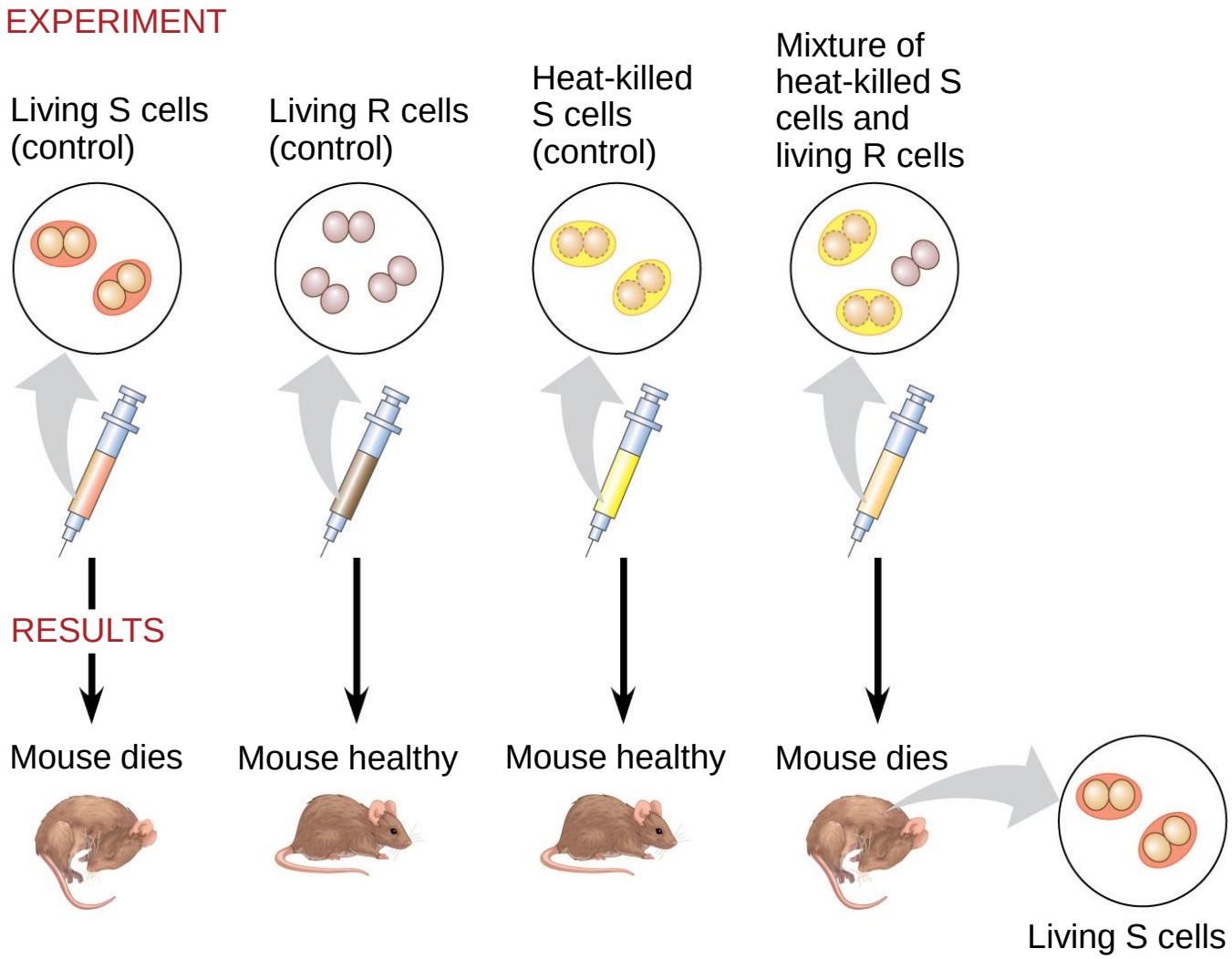
- How was DNA determined to be the hereditary molecule?

History of DNA

- 70 years ago, DNA was a mystery to most scientists
- Scientists knew of its existence, but not of its purpose.
- The following slides are just some of the major experiments that helped to define the role of DNA in biology

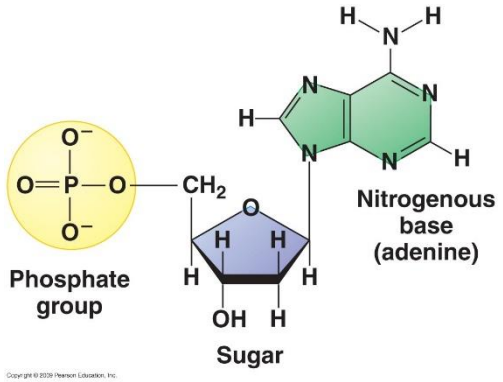
Griffith (1928) and Avery (1944)

- Fredrick Griffith discovers process of transformation in bacteria (1928)
- Oswald Avery re-evaluates Griffith's experiment and states that DNA is responsible for transformation (1944)



Erwin Chargaff (1950)

- Common knowledge that nucleotides consist of phosphate group, a sugar and a nitrogenous base.

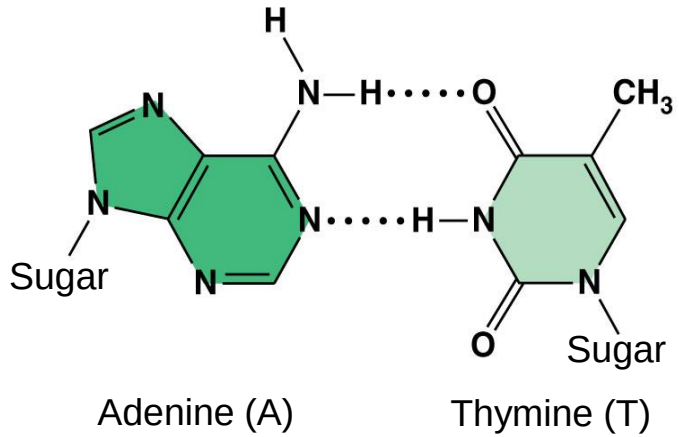


- Compared composition of the 4 bases between many different organisms.

Source	Adenine	Guanine	Cytosine	Thymine
E. coli	24.7%	26.0%	25.7%	23.6%
Wheat	28.1	21.8	22.7	27.4
Sea urchin	32.8	17.7	17.3	32.1
Salmon	29.7	20.8	20.4	29.1
Human	30.4	19.6	19.9	30.1
Ox	29.0	21.2	21.2	28.7

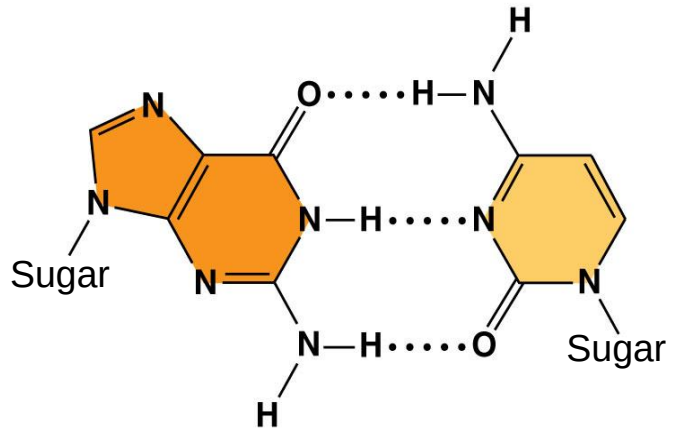
Erwin Chargaff (1950)

- Stated what we know today as **Chargaff's Rules**.
  - Only certain bases pair up.



Adenine (A) Thymine (T)

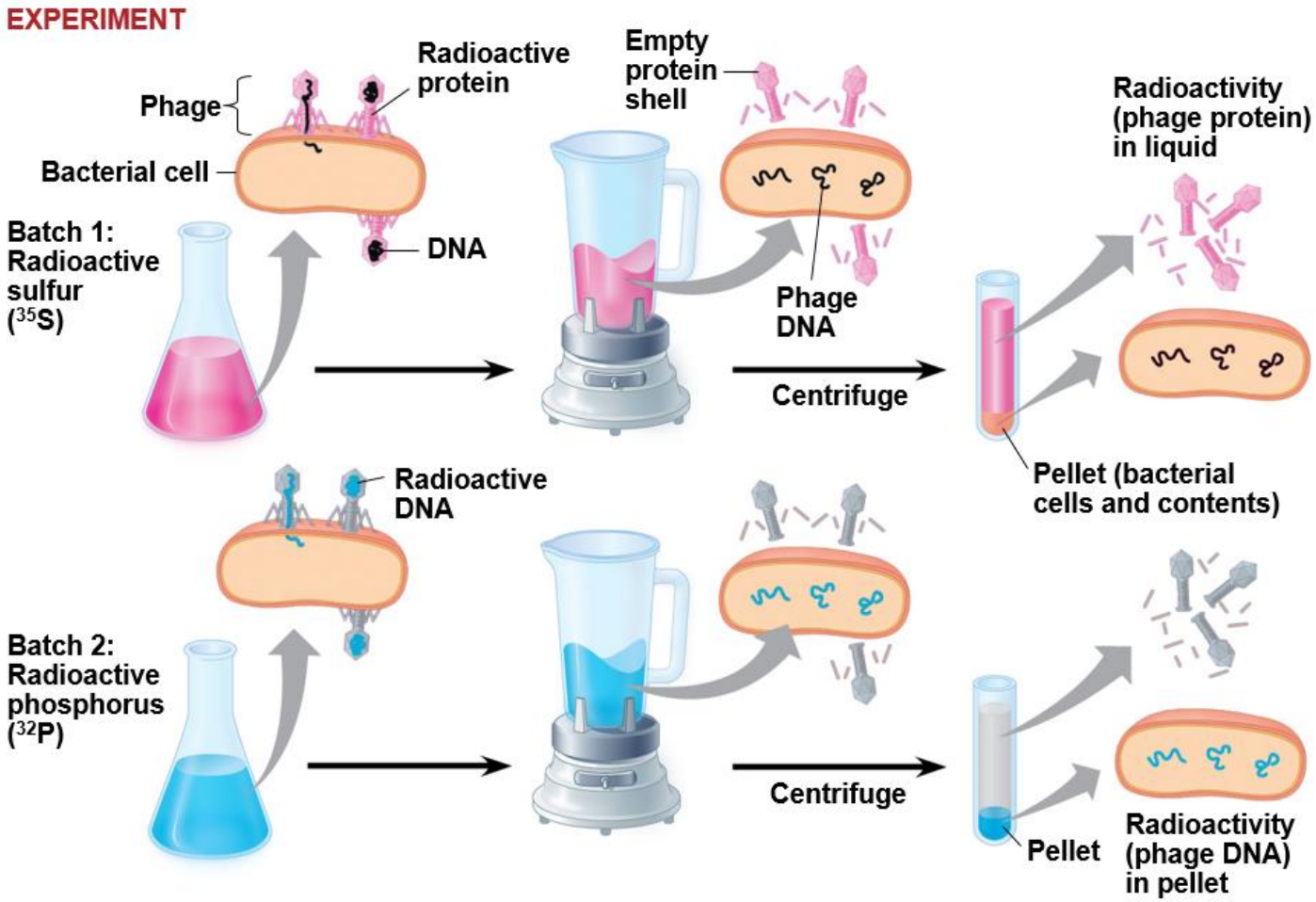
- Adenine pairs with Thymine
- Guanine pairs with Cytosine.



Guanine (G) Cytosine (C)

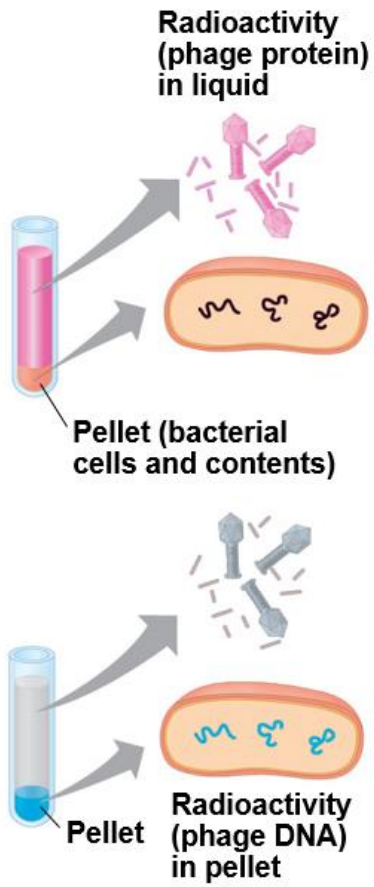
Hershey and Chase (1952)

- Experimented using bacteriophages (virus)
- **Batch 1**: Radioactively labeled S in amino acids (tracked proteins)
- **Batch 2**: Radioactively labeled P in nucleotides (tracked nucleic acid/DNA)



Hershey and Chase (1952)

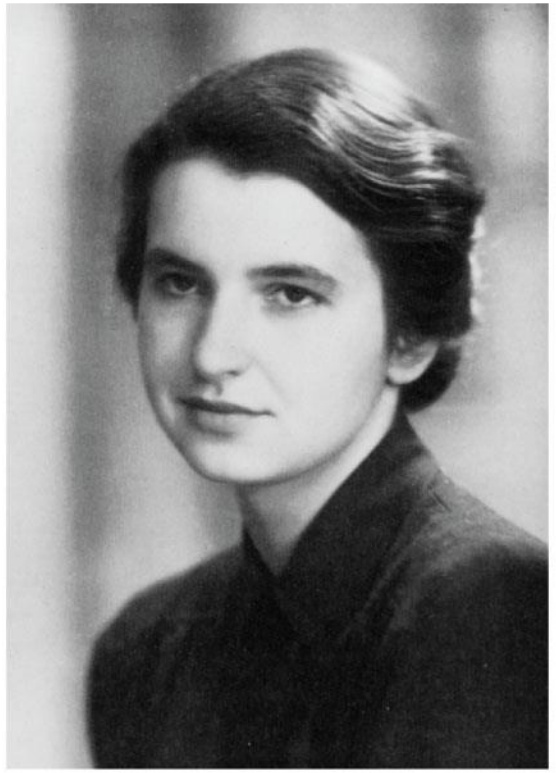
- Centrifuging in the middle step separated the viral capsids from the bacteria
- Whatever batch (S or P) that caused the bacteria to become radioactive provided the evidence for the molecule of genetic transfer.
- Stated that DNA was the source of heredity



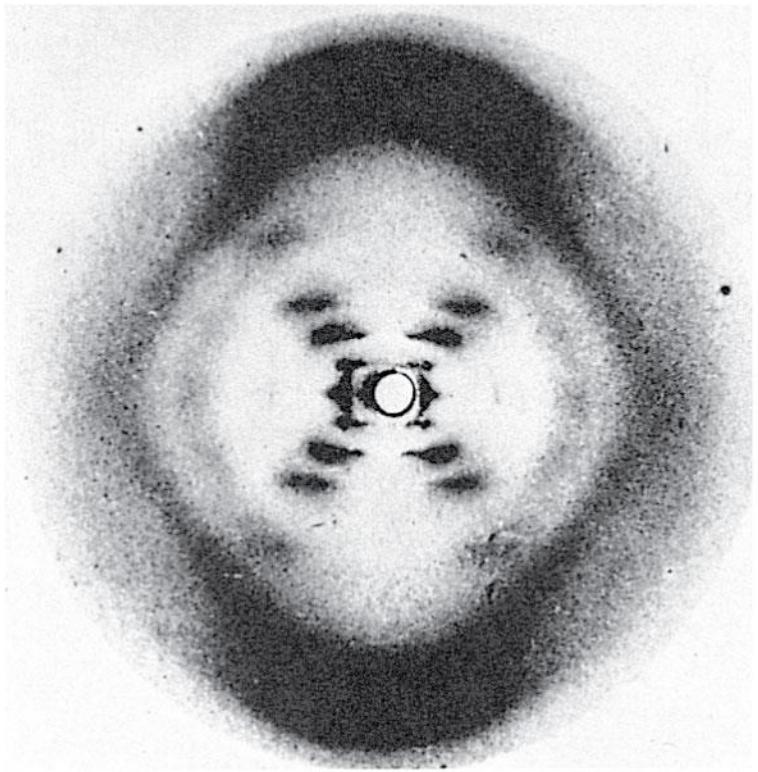
Rosalind Franklin (1952)

- Used an X-ray technique to photograph DNA

- Saw that DNA had:
  - 2 spiraling components
  - Fixed width
  - Alternating “rung” pattern



(a) Rosalind Franklin

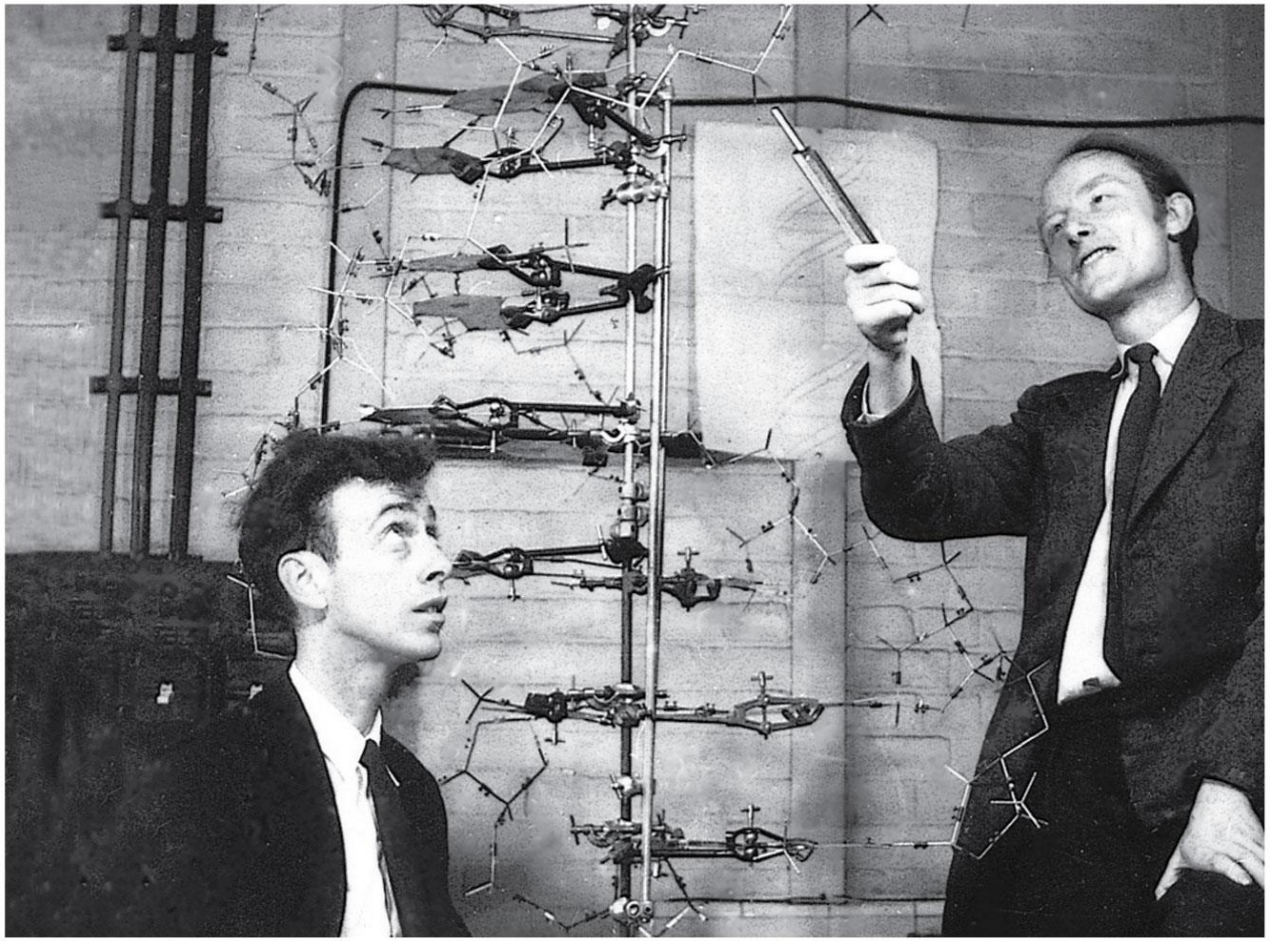


(b) Franklin’s X-ray diffraction photograph of DNA

Watson and Crick (1953)

- Used evidence from previous scientists to build a model of DNA.

- Won the Nobel prize in 1962

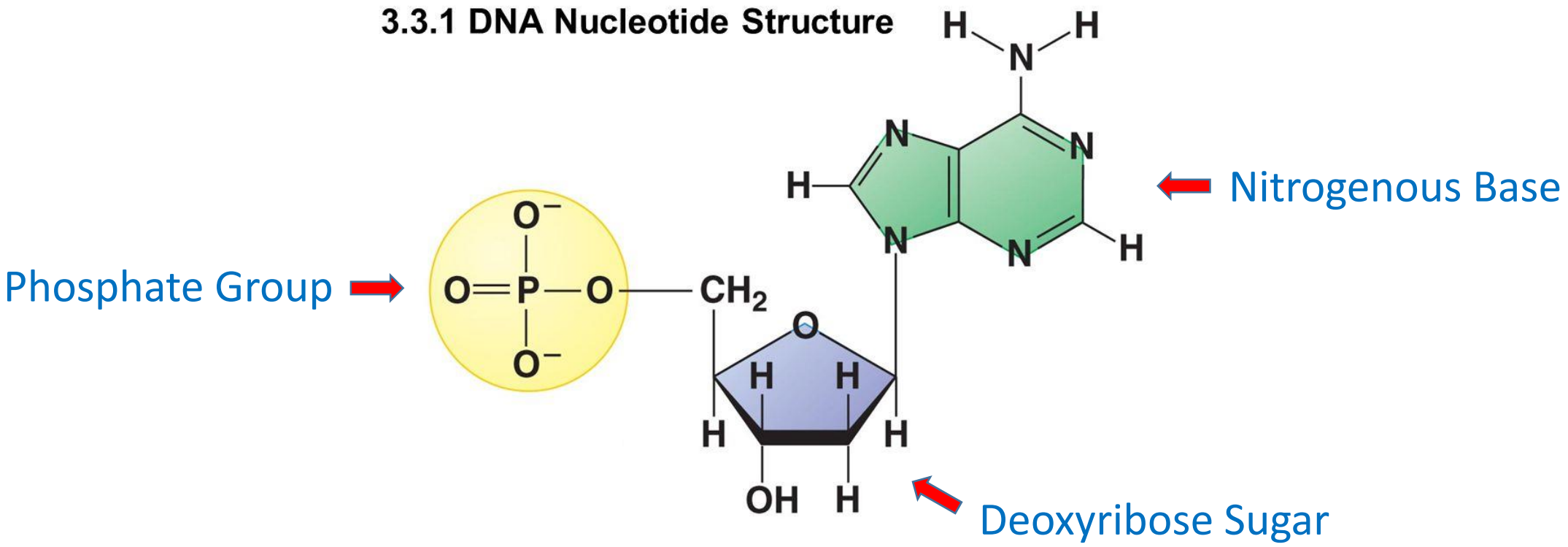


Essential Question #2

- Why is DNA replication essential to the cell cycle?

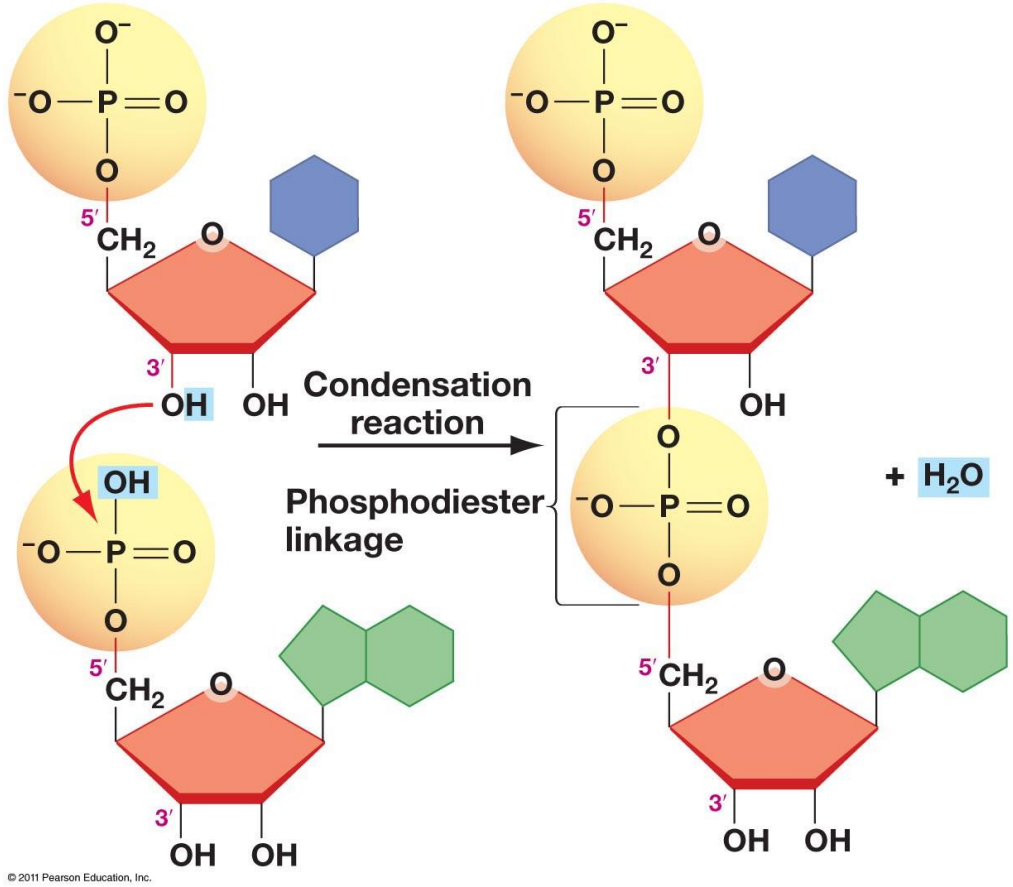
Nucleotide structure

- Nucleotides are the monomers that make up the Nucleic Acid polymer.



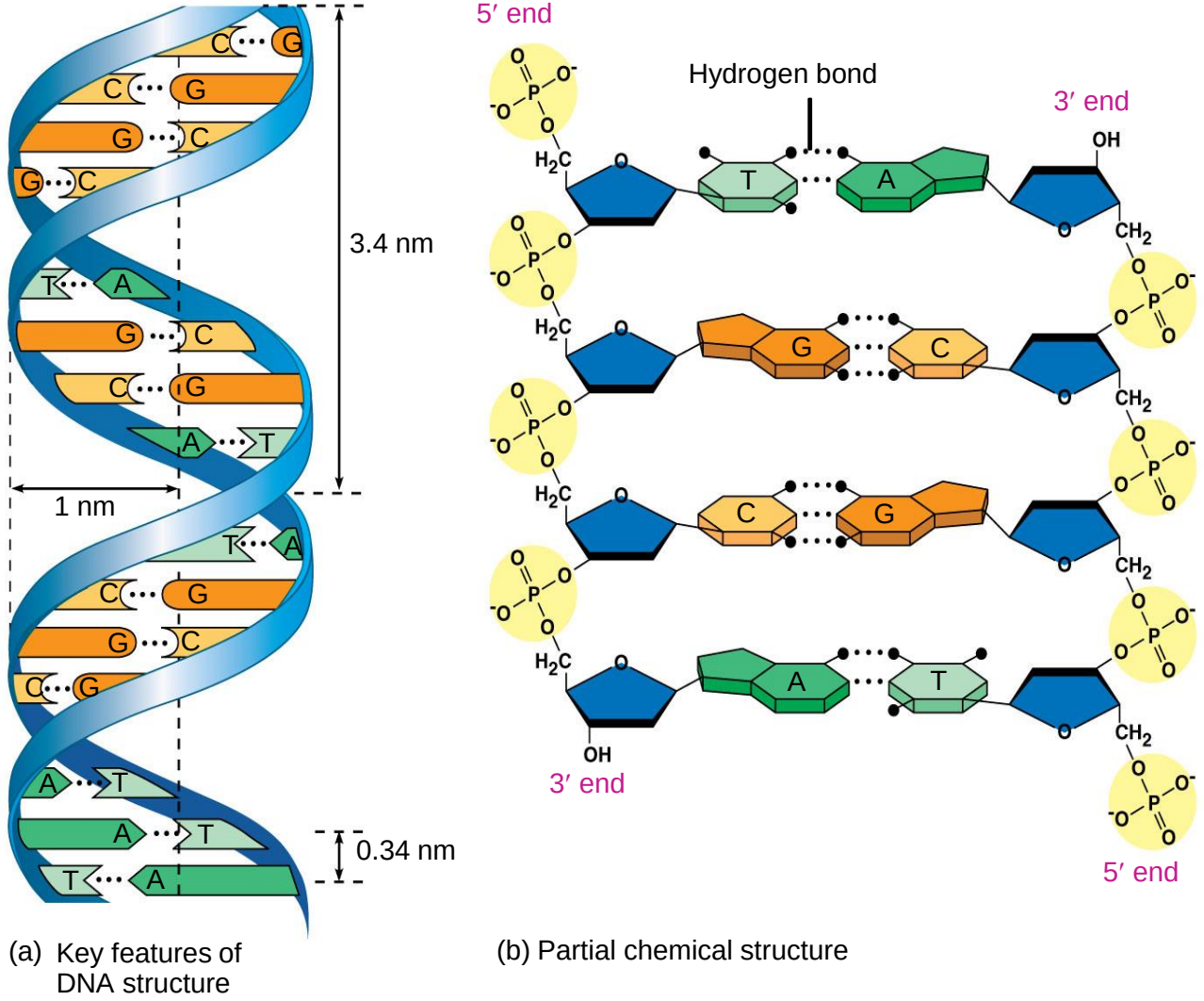
Building DNA

- The sugar of one nucleotide connects to the phosphate group of another nucleotide to create the sugar-phosphate backbone of DNA
- This is done by dehydration synthesis.



DNA structure

- DNA is a double helix
- The “backbone” is made of alternating phosphate groups and deoxyribose sugars
- The bases in the middle pair A to T and G to C



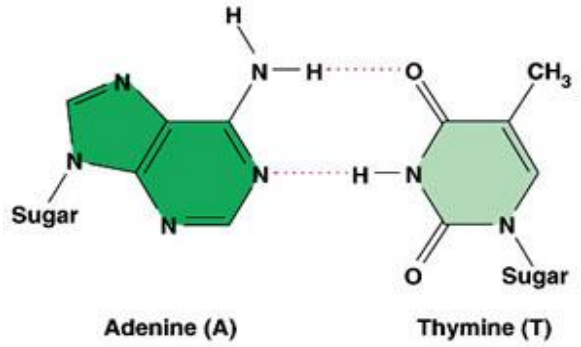
(a) Key features of DNA structure

(b) Partial chemical structure

Nitrogenous Base Pairing

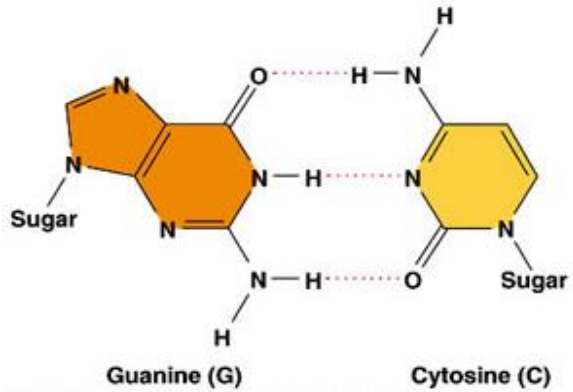
- Chargaff's Rules

Adenine pairs with Thymine



A ⋯ T

Guanine pairs with Cytosine



G ⋯ C

Forms of Eukaryotic DNA

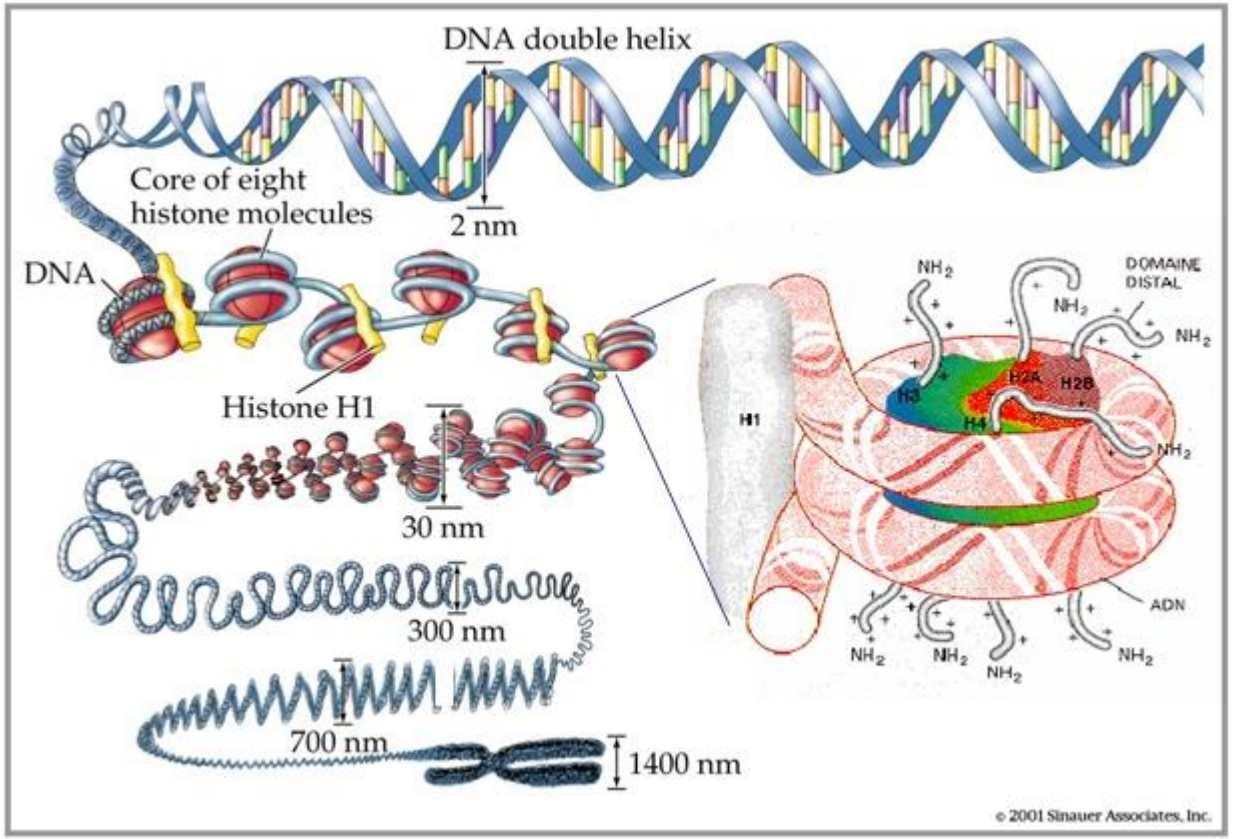
- Eukaryotic DNA comes in two forms:

1) **Chromatin** – nucleic acid strands are unwound and in a “spaghetti” arrangement
    - Found only during Interphase

2) **Chromosome** – nucleic acid strands are tightly wound around histone proteins, and folded on scaffolding proteins
    - Found only during Mitotic stages

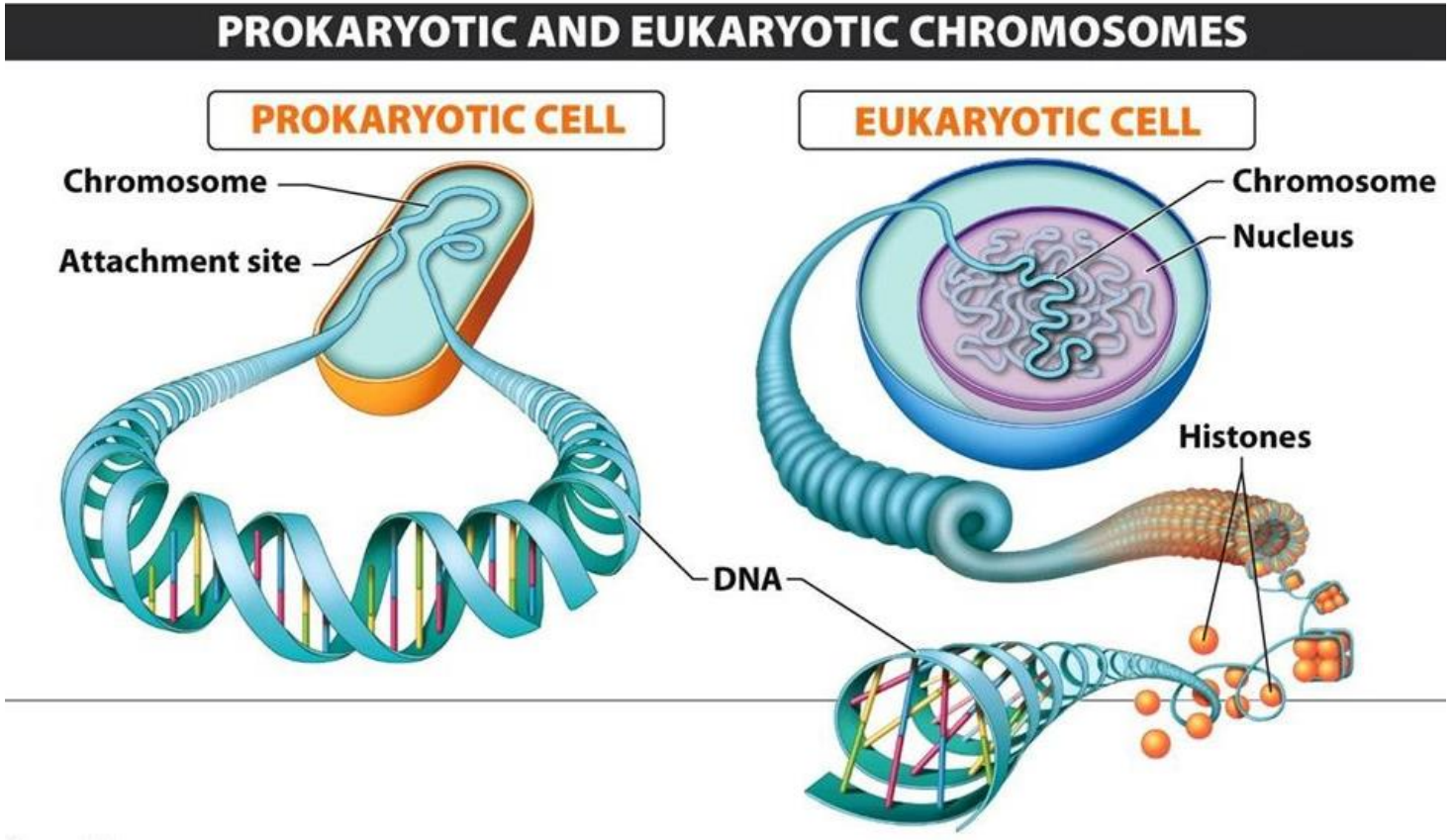
Chromosome

- DNA molecule is wrapped around proteins called histones.
- This allows for DNA to be packed for easy movement during Mitotic stages of the cell cycle.



Prokaryote vs. Eukaryote DNA

- Prokaryotes have a single loop of DNA
- Eukaryotes have multiple strands/strings of DNA



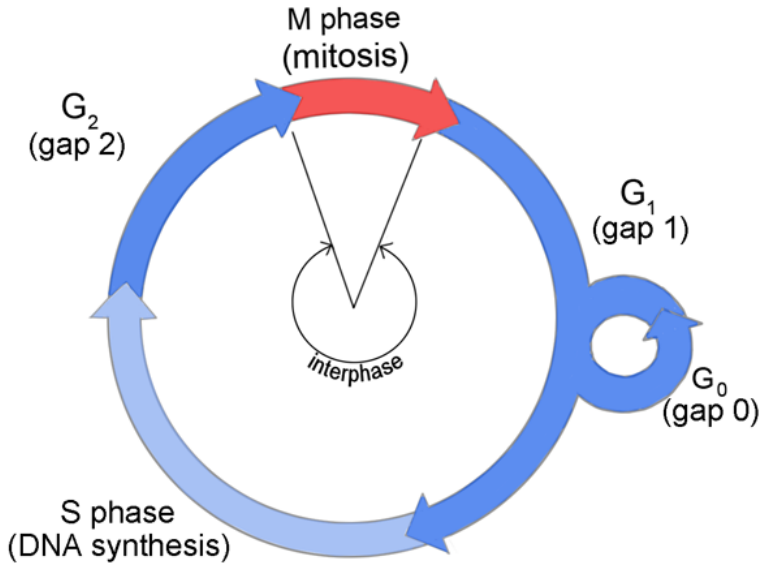
Replication

- The process of creating new, IDENTICAL copy of DNA from a template
- The copies are identical to each other and to the original DNA

When and Where does Replication Happen?

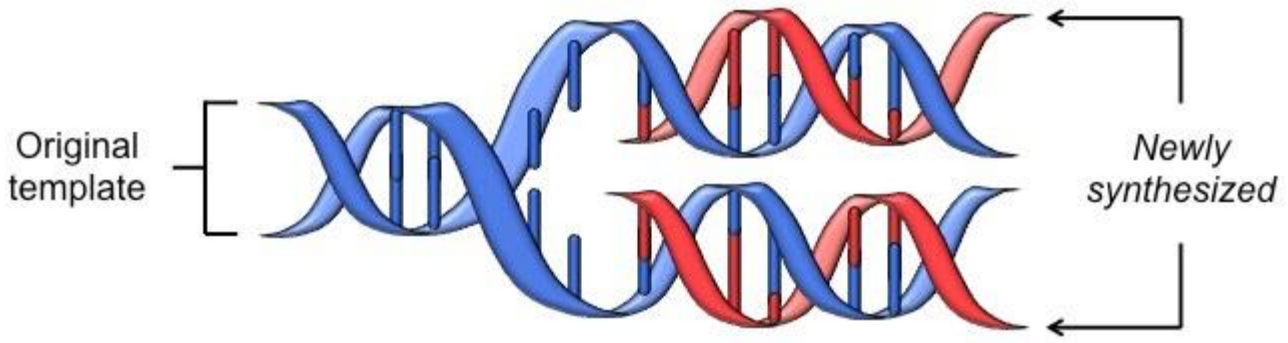
- Replication happens in the Nucleus.

- Replication takes place during the S-phase of Interphase
  (S stand for synthesis, which means “to make”)

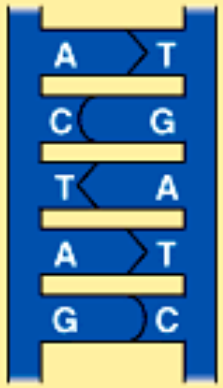


DNA Replication is Semiconservative

- Half of each new DNA strand is the original DNA template.
- The other half is new complementary DNA nucleotides.

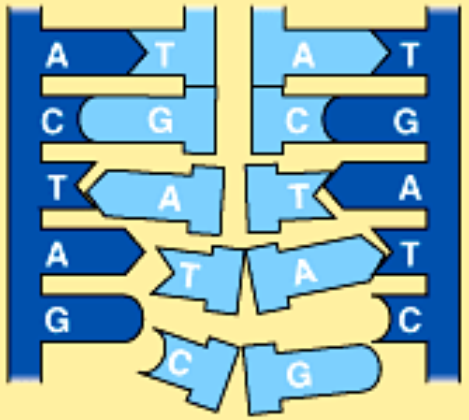


How does Replication Work?

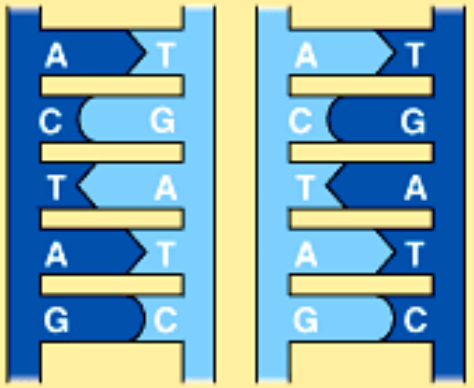


(a) The parent molecule has two complementary strands of DNA. Each base is paired by hydrogen bonding with its specific partner, A with T and G with C.

(b) The first step in replication is separation of the two DNA strands.



(c) Each parental strand now serves as a template that determines the order of nucleotides along a new complementary strand.

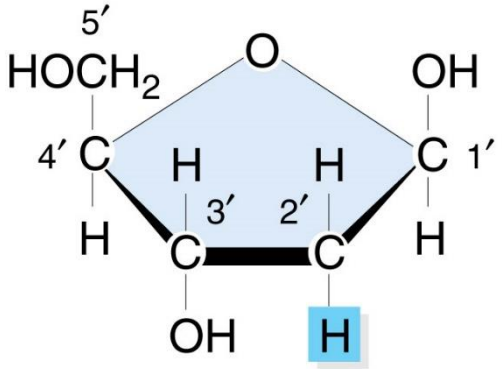


(d) The nucleotides are connected to form the sugar-phosphate backbones of the new strands. Each "daughter" DNA molecule consists of one parental strand and one new strand.

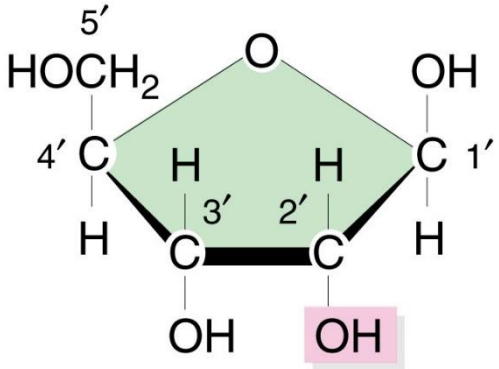
PreAP Biology Replication content

- When DNA is built using nucleotides they are built in a very specific pattern.

- Deoxyribose (and similarly Ribose) have 5 carbons that are labeled 1’ (called one prime) to 5’ (five prime)



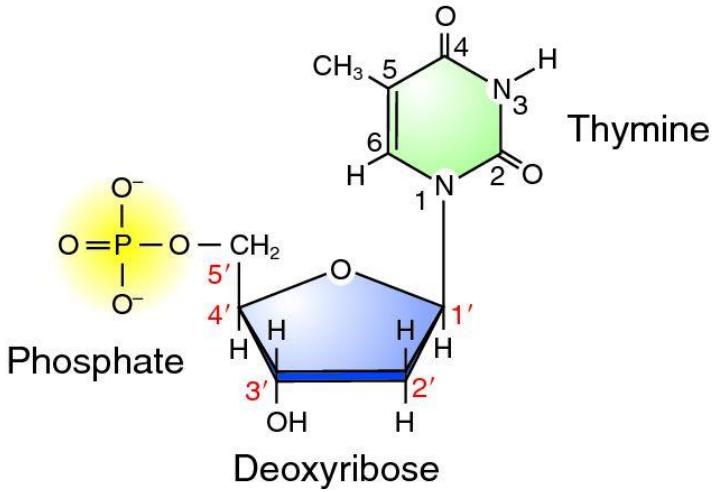
Deoxyribose

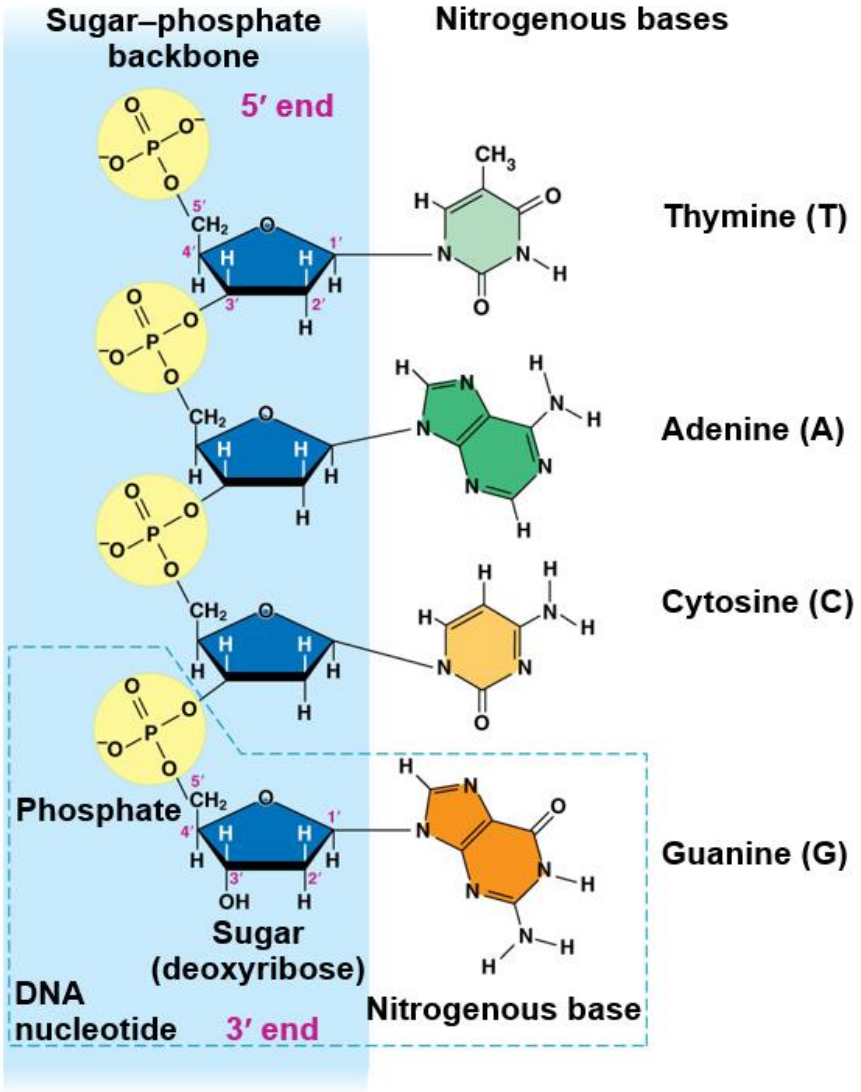


Ribose

5’ to 3’ direction of DNA

- Nucleotides can only be added to the –OH group at the 3’ carbon of the previous DNA strand.

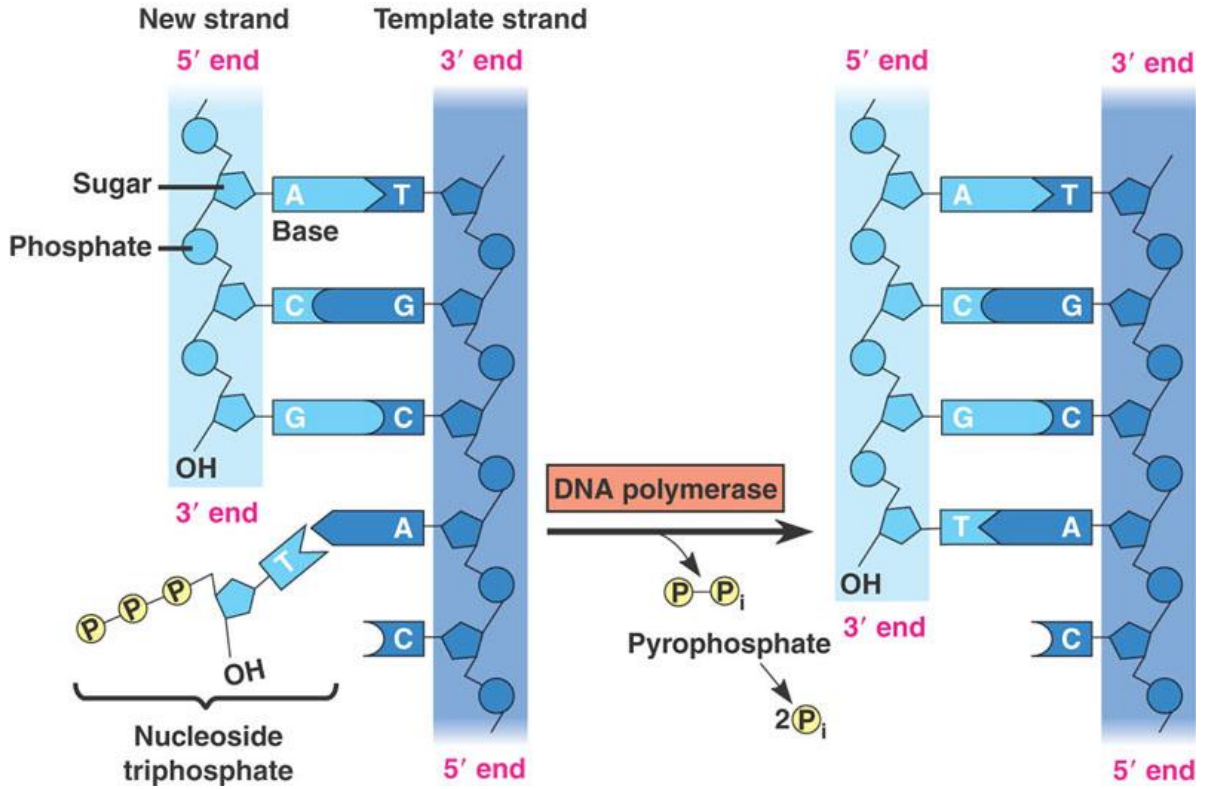




5’ to 3’ direction of DNA

- Because of the way DNA is built (in the 3’ direction) a strand of DNA has two ends: The 5’ end and the 3’ end.

- The two complementary strands run in opposite directions.
  - ❖This is called - **Antiparallel**



Important enzymes and molecules

- **DNA Polymerase** – attaches nucleotides together in replication

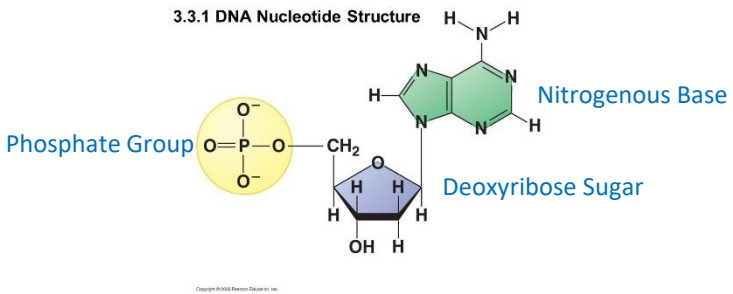
- **Helicase** – unzips the DNA by breaking the hydrogen bonding that holds the two complementary strands together

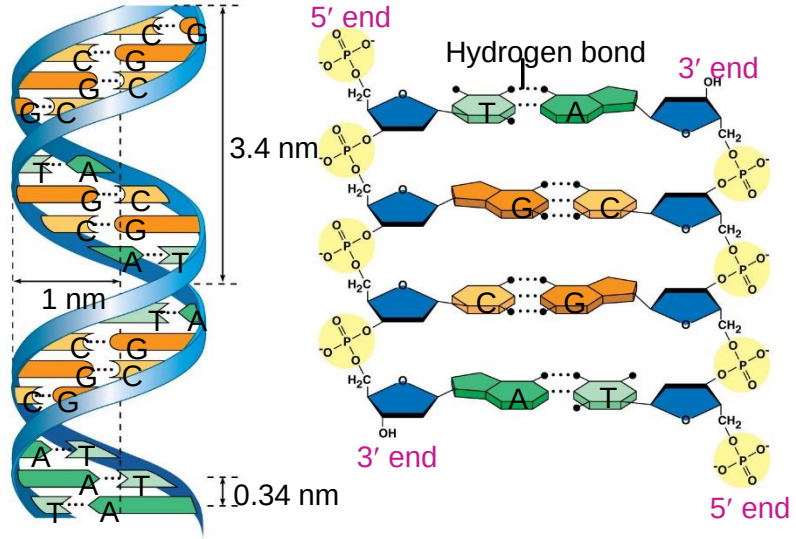
Adenine pairs with Thymine

A T

Guanine pairs with Cytosine

G C





(a) Key features of DNA structure

(b) Partial chemical structure