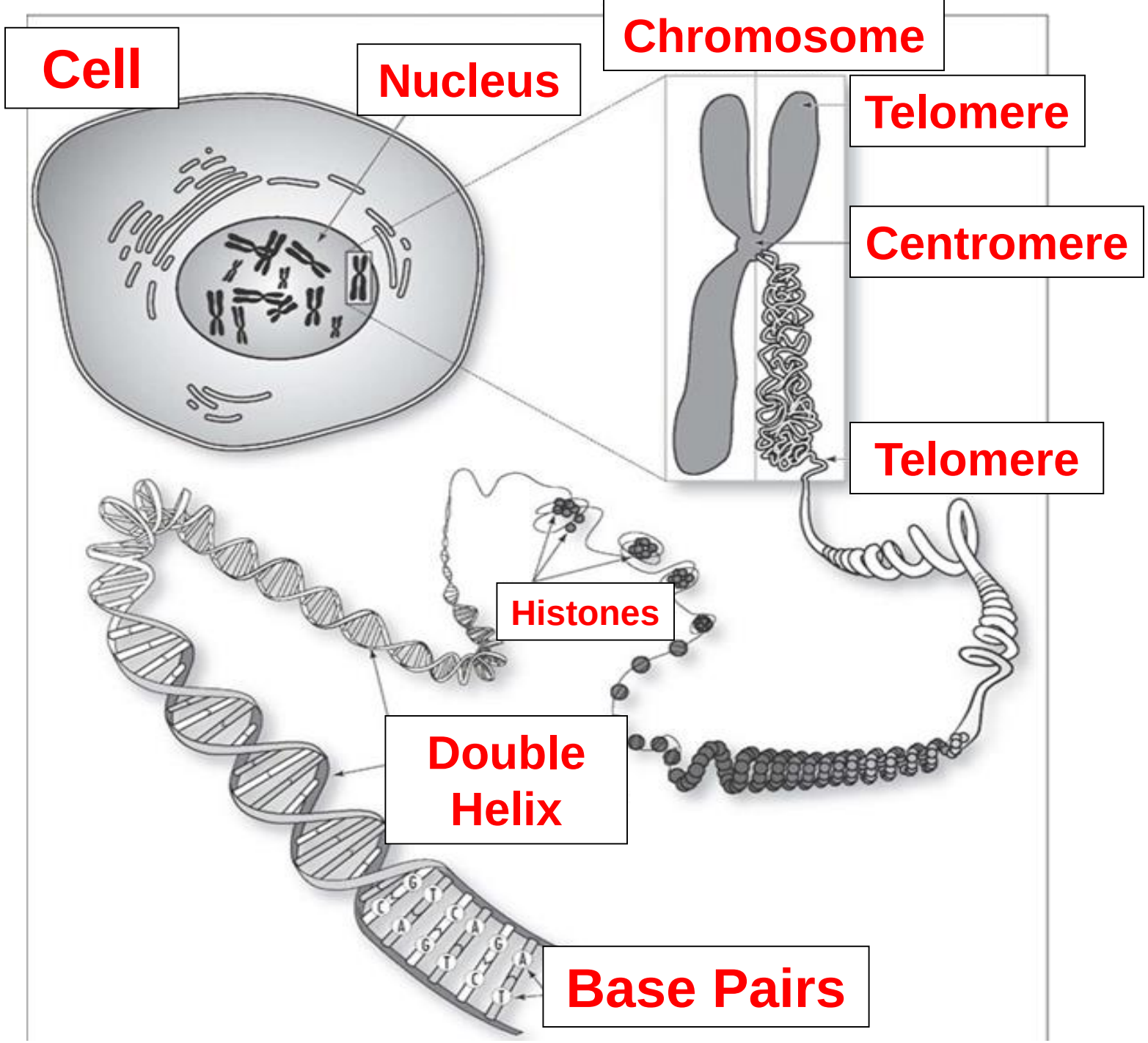
Lesson 1

Historical contributors to DNA

DNA structure

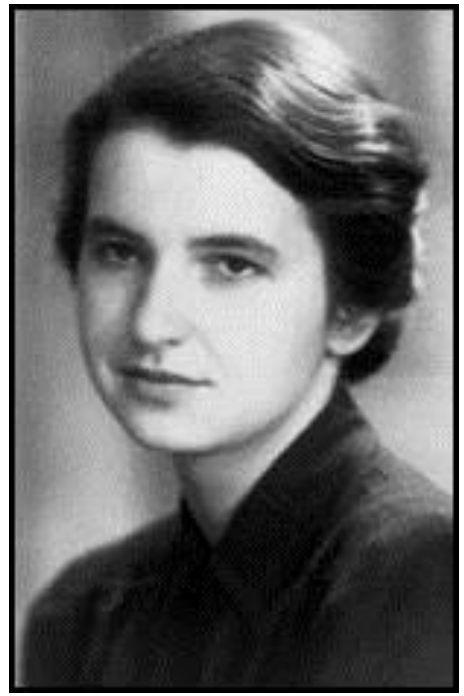
What does DNA look like, and how does it replicate itself?


Cell
Nucleus
Chromosome
Telomere
Centromere
Telomere
Histones
Double Helix
Base Pairs

Unlocking the mystery of DNA

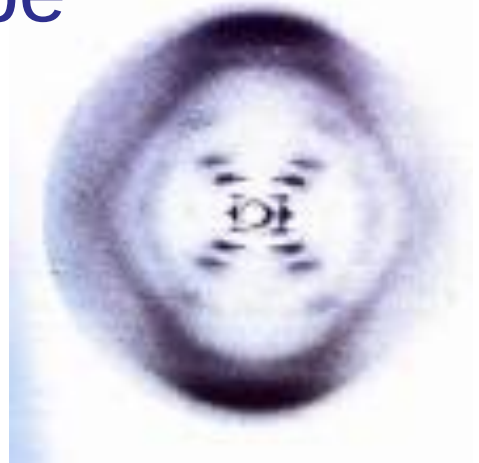
DNA Double Helix Discovery - HHMI (17min)

Discovering the structure of DNA



Rosalind Franklin (1920-1958)

- King's College, London
- Made significant advances in x- ray diffraction techniques with DNA
- Her images suggested that DNA had a helical (spiral) shape



Discovering the structure of DNA

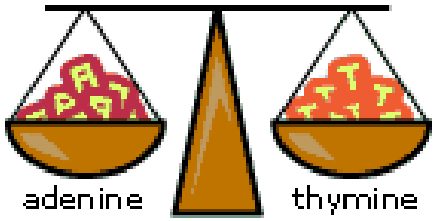
Maurice Wilkins – (1916-2004)

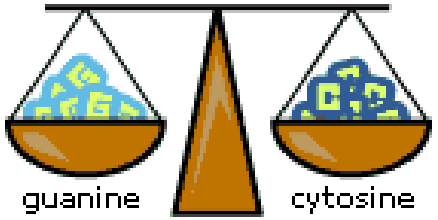
- King's College, London
- Also did X-ray diffraction studies of DNA
- Worked with Rosalind Franklin
- Shared her information with Watson and Crick

Discovering the structure of DNA

Erwin Chargaff – (1905-2002)

- Columbia University, NY
- Investigated the composition of DNA
- His findings by 1950 strongly suggested the base-pairings of A-T & G-C
- Met with Watson and Crick in 1952 and shared his findings
- "Chargaff's rule" A - T & C - G





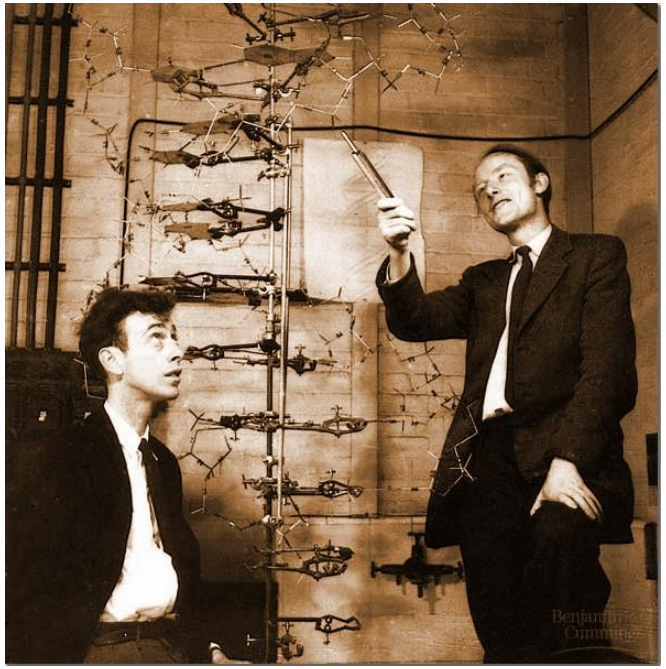
Discovering the structure of DNA

James Watson (1928) and Francis Crick (1916-2004)

•Worked together at Cavendish Laboratory in Cambridge to determine the structure of DNA

•Used work from Franklin, Wilkins, and Chargaff to determine the double helix shape

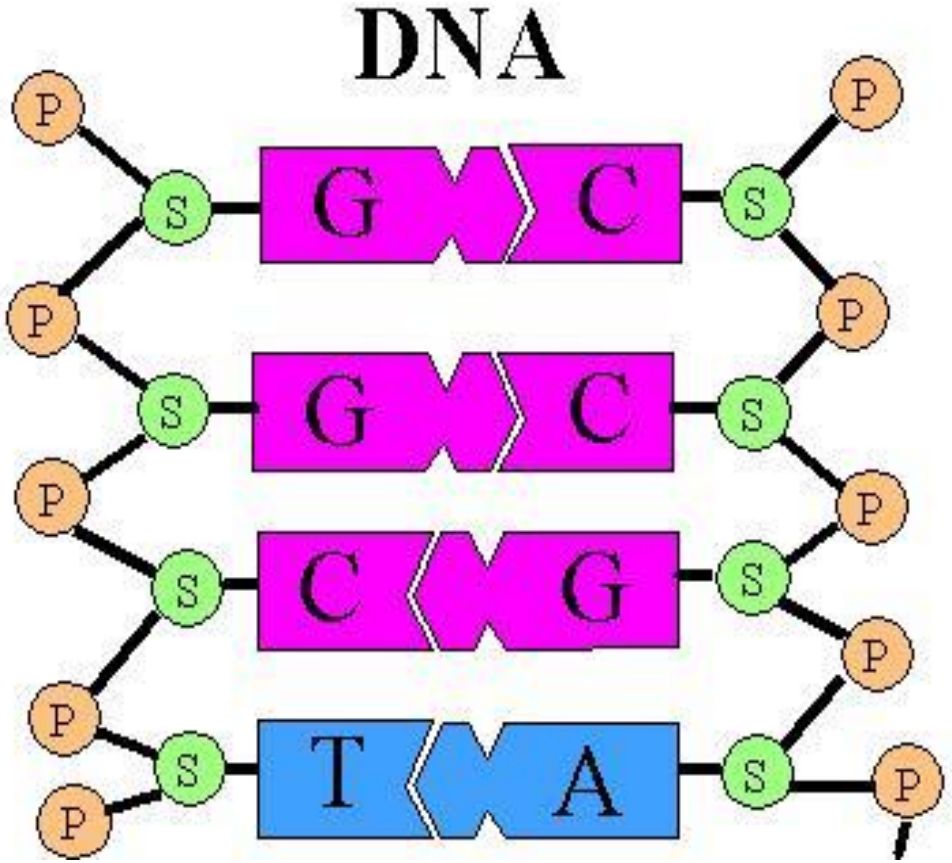
- Watson, Crick, and Wilkins were awarded the Nobel Prize in 1962
- Rosalind Franklin passed away from ovarian cancer in 1958 at the age of 37, before their award



DNA Structure

DNA = **D**eoxyribo**n**ucleic **a**cid

- genetic material, stored as tightly coiled chromosomes
- made up of subunits called nucleotides
- found in the cell nucleus



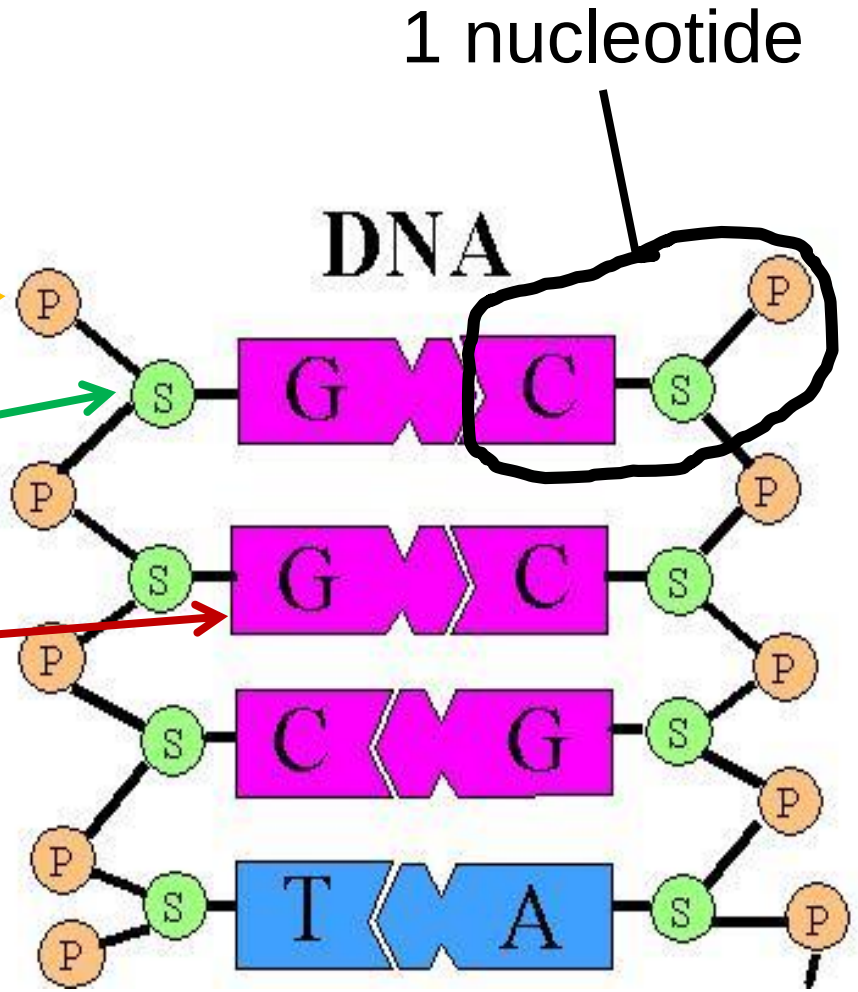
DNA Structure

Nucleotide:

- a DNA subunit that consists of:
  - a phosphate
  - a 5 carbon sugar (deoxyribose)
  - nitrogen base
    - – 4 different paired bases

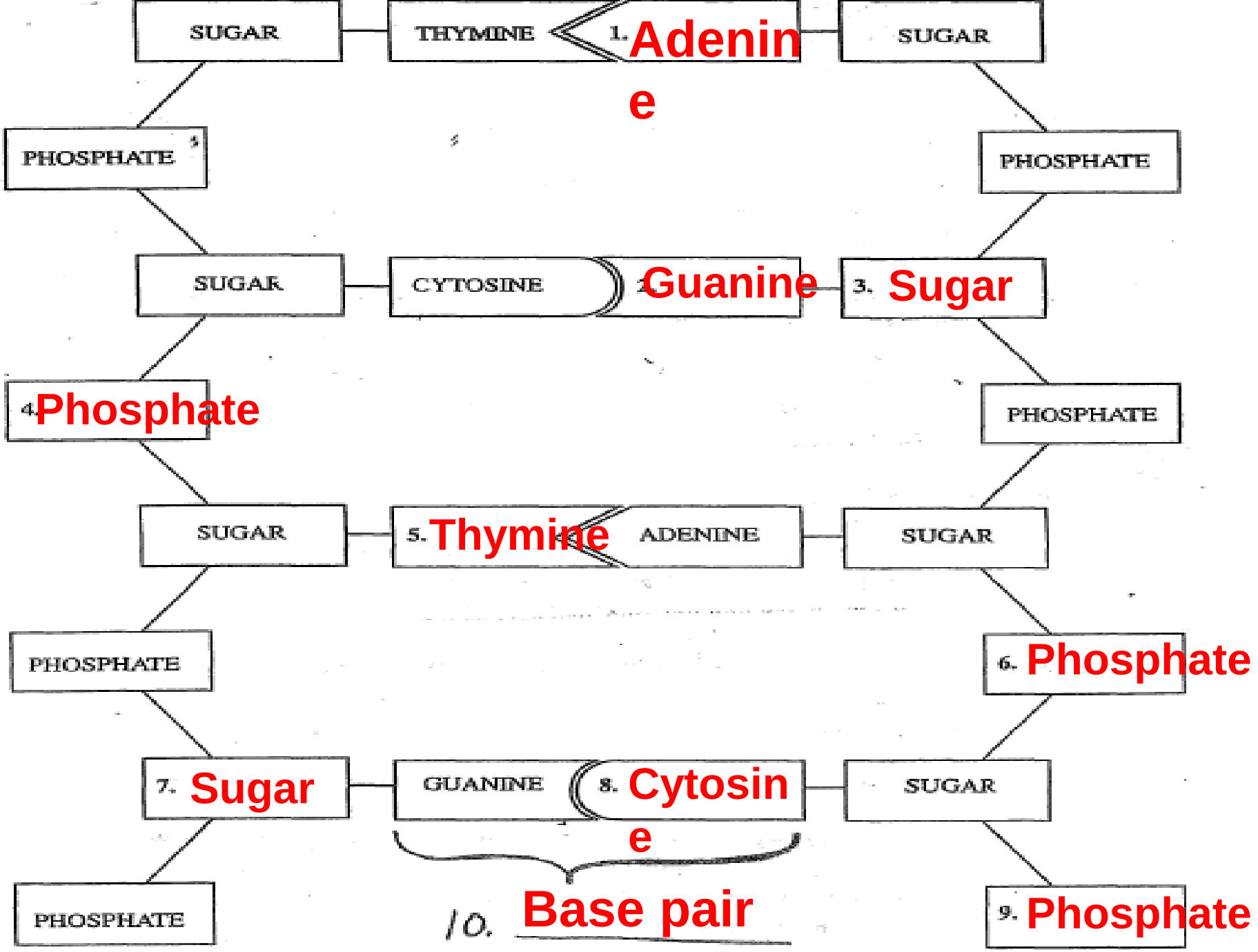
    Adenine (A) and Thymine (T)

    Guanine (G) and Cytosine (C)



Lesson 2

DNA structure & modeling


SUGAR
THYMINE
1. Adenine
SUGAR
PHOSPHATE
PHOSPHATE
SUGAR
CYTOSINE
Guanine
3. Sugar
4. Phosphate
PHOSPHATE
SUGAR
5. Thymine
ADENINE
SUGAR
PHOSPHATE
6. Phosphate
7. Sugar
GUANINE
8. Cytosine
SUGAR
PHOSPHATE
10. Base pair
9. Phosphate

DNA Practice Questions

b

1. Which type of compound is found in every DNA molecule?
   a. Starch
   b. Nitrogenous base
   c. Lipid
   d. Amino acid

c

2. The "ribo" part in the name deoxyribonucleic acid refers to the
   a. Rungs of the spiral ladder
   b. Bonds that hold two strands together
   c. Sugar component of DNA
   d. Type of helical arrangement

c

3. A molecular group consisting of a sugar molecule, a phosphate group, and a nitrogen base is a
   a. Nucleoprotein
   b. Nucleic acid
   c. Nucleotide
   d. Nucleolus

c

4. A nucleotide of DNA could contain
   a. Adenine, ribose and phosphate
   b. Nitrogenous base, phosphate and glucose
   c. Phosphate, deoxyribose and thymine
   d. Uracil, deoxyribose and phosphate

a

5. A nucleotide would *least* likely contain the element
   a. Sulfur
   b. Carbon
   c. Nitrogen
   d. Phosphorous

d

6. In a DNA molecule, a base pair normally could be composed of
   a. Adenine and guanine
   b. Adenine and cytosine
   c. Thymine and guanine
   d. Guanine and cytosine

Base pairing in DNA

Purines (larger)

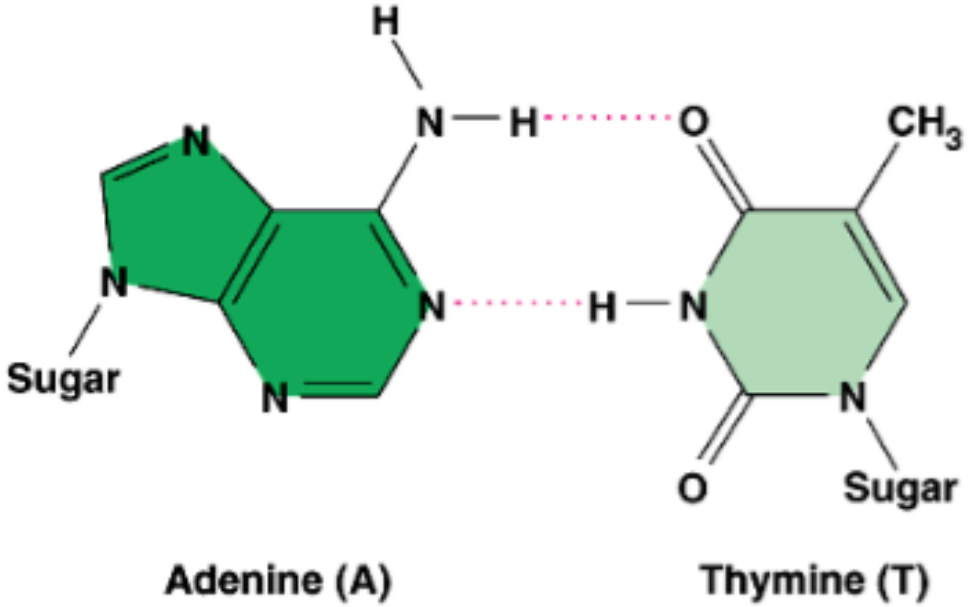
- adenine (A)
- guanine (G)

Pyrimidines (smaller)

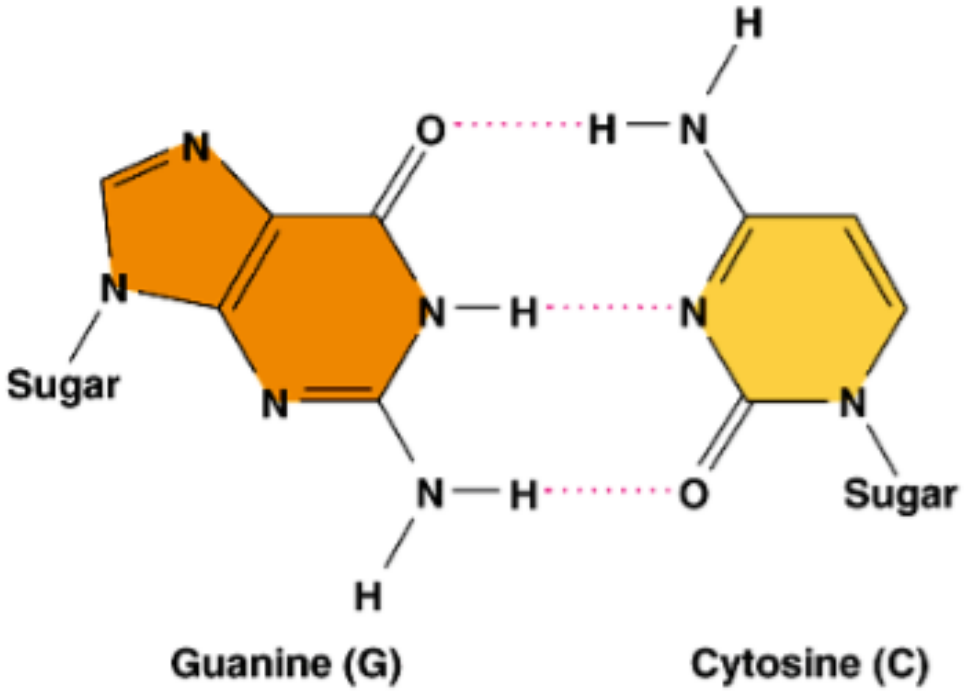
- thymine (T)
- cytosine (C)

Hydrogen Bonds (weak)

- A with T (2 bonds)
- C with G (3 bonds)



Adenine (A) Thymine (T)



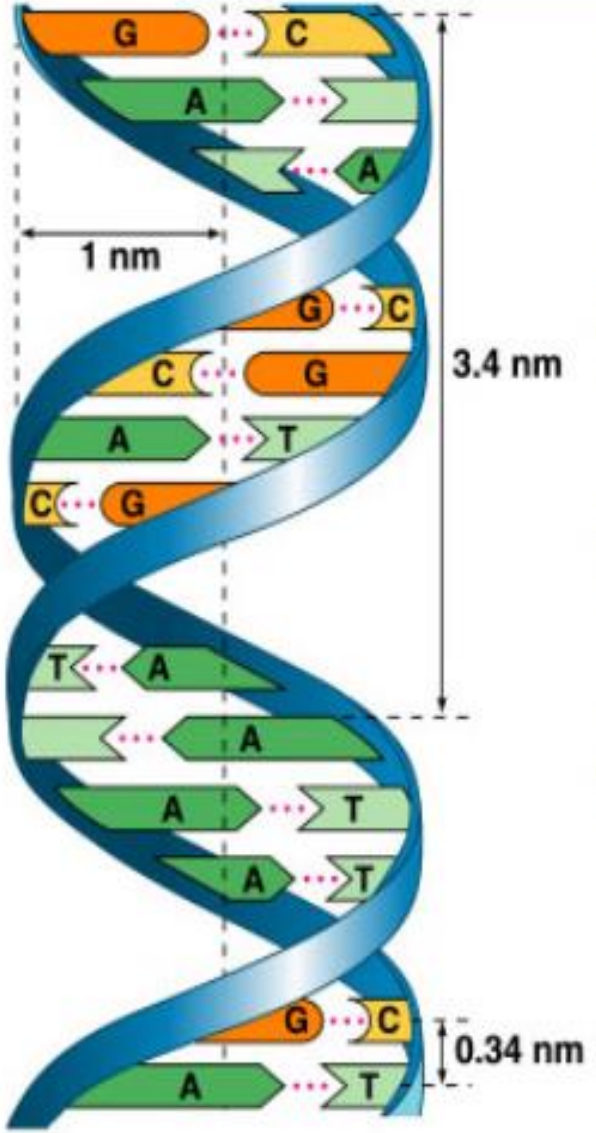
Guanine (G) Cytosine (C)

Practice DNA Base Pairs

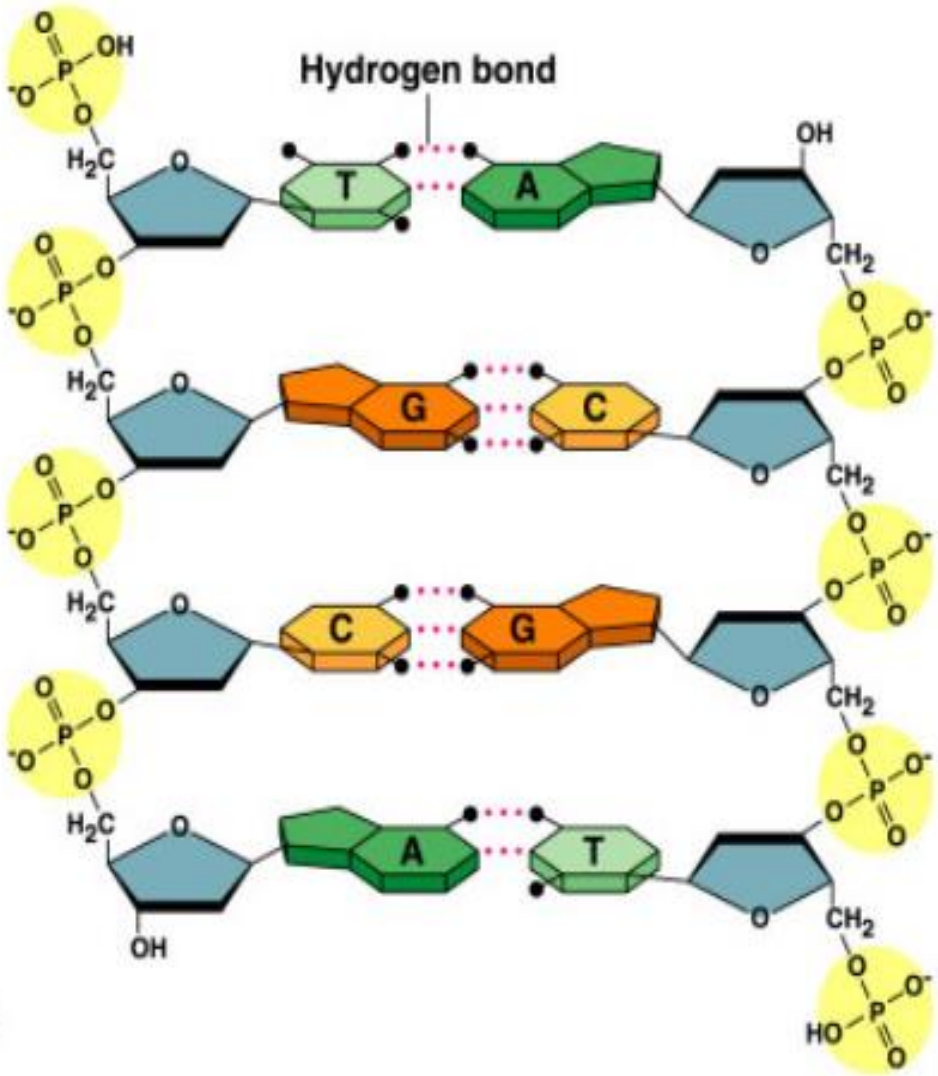
G A T T A C A

C T A A T G T

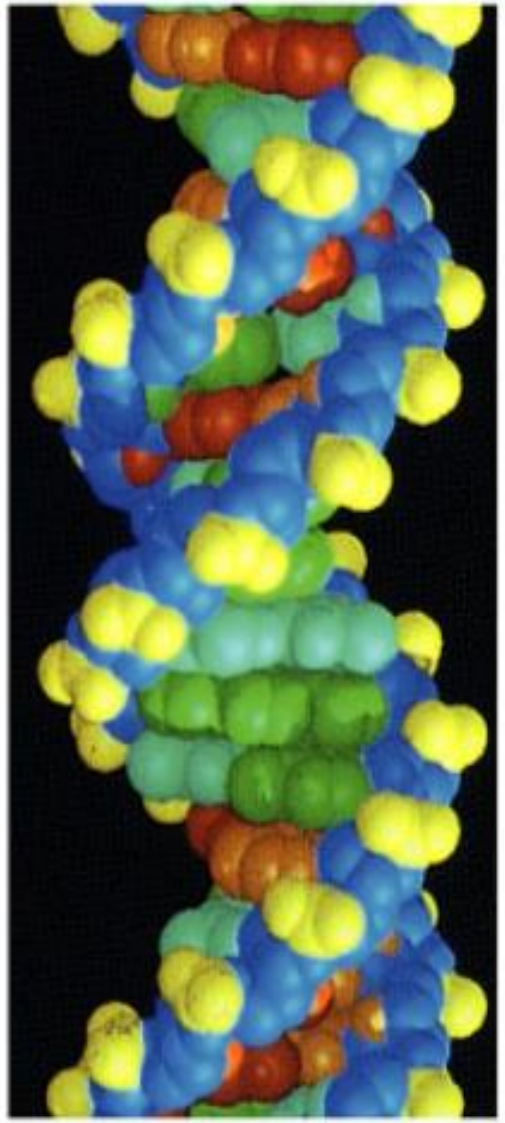
Double Helix Structure of DNA



(a) Key features of DNA structure



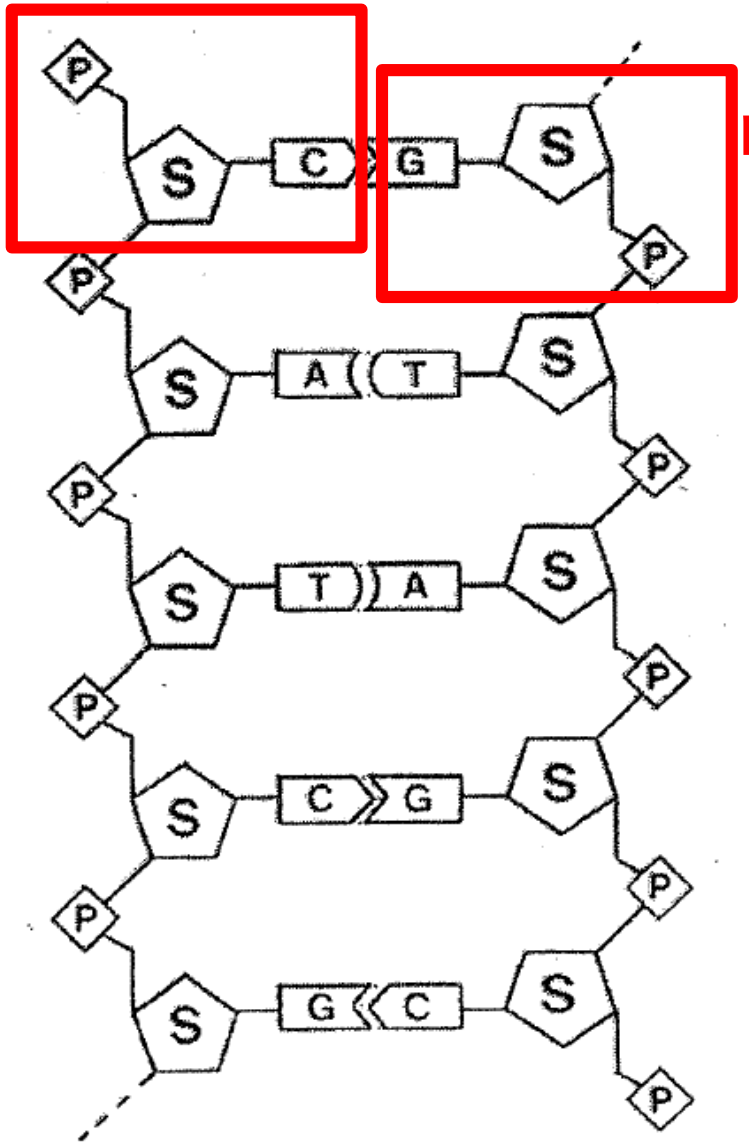
(b) Partial chemical structure



(c) Space-filling model

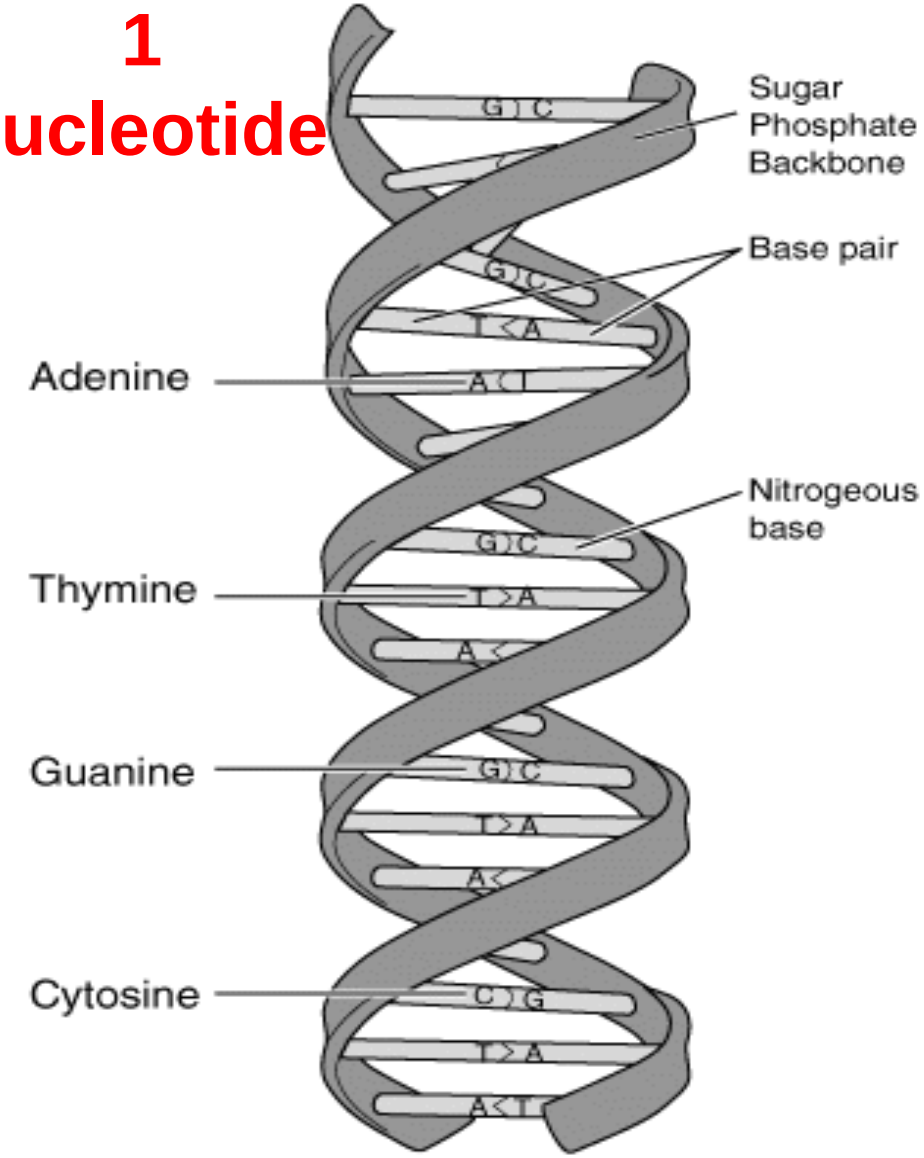
DNA Structure

1 nucleotide



(untwisted diagram of DNA)

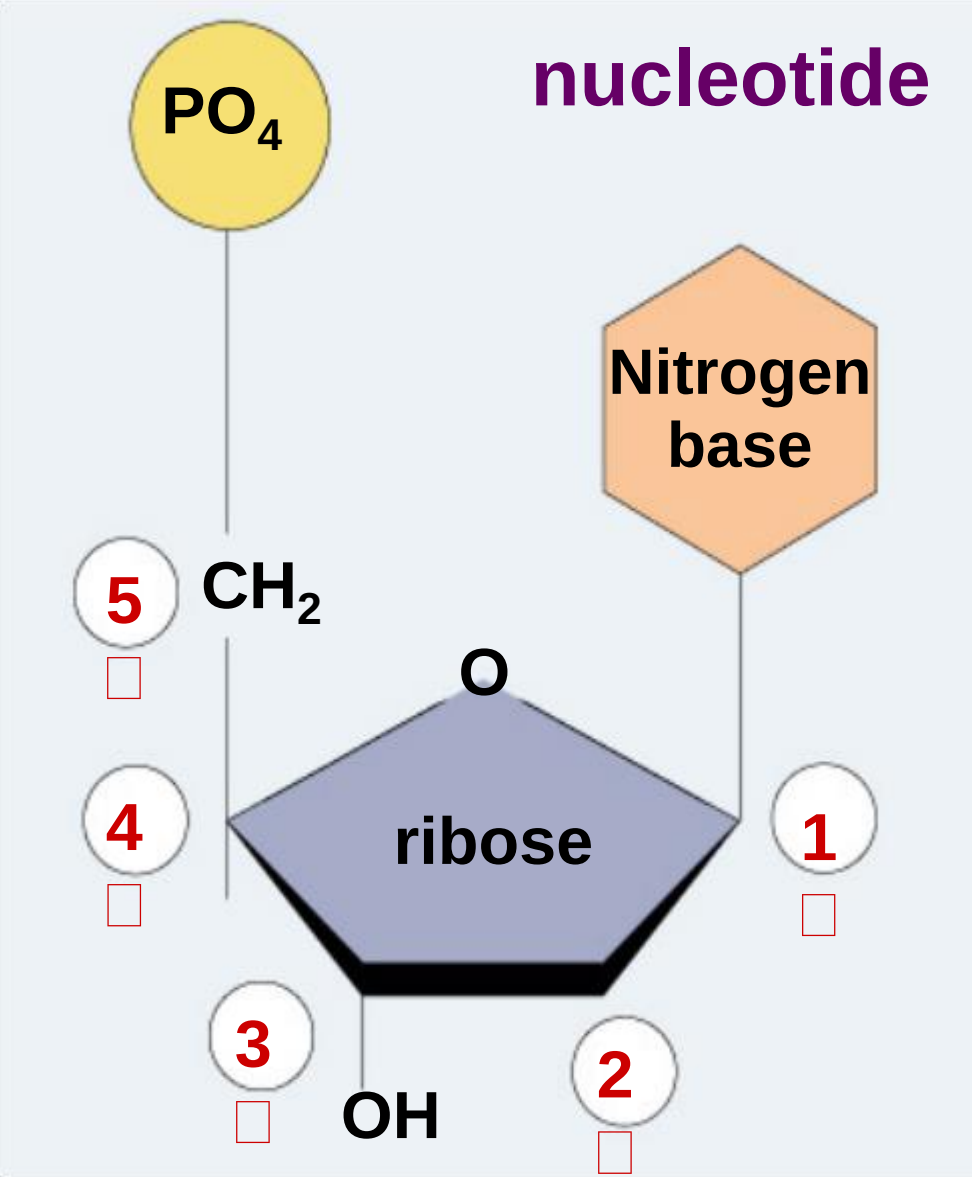
1 nucleotide



(twisted diagram of DNA)

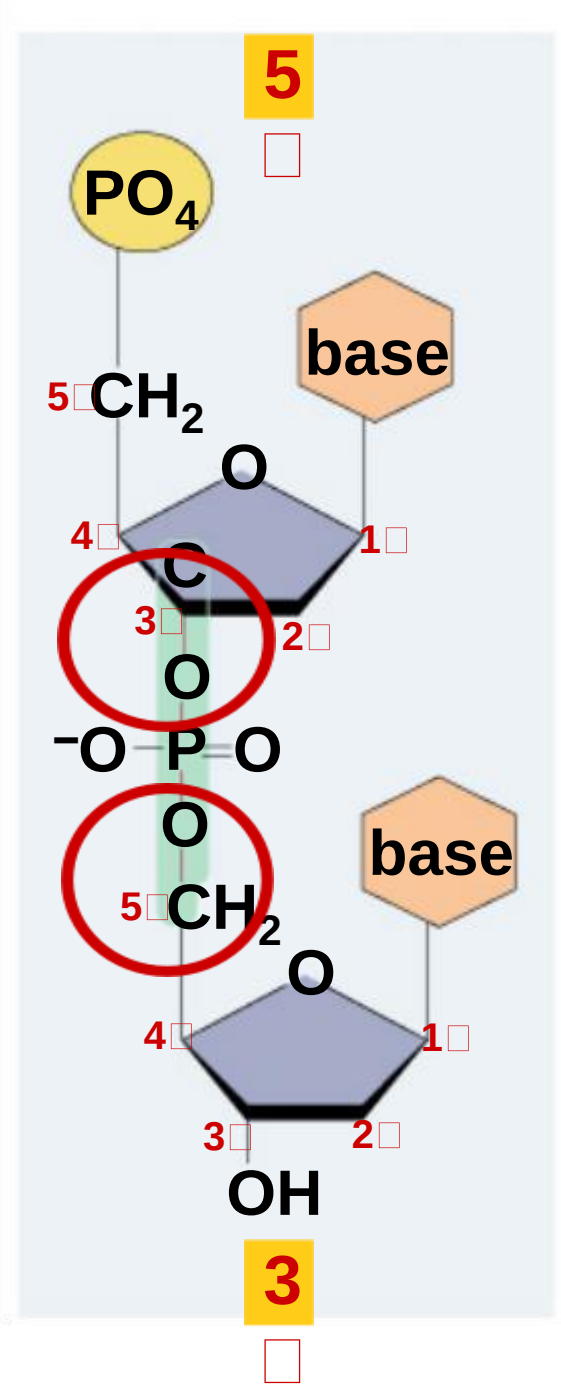
Directionality of DNA

- Draw the nucleotide
- Number the carbons
  - #1 attaches to the nitrogen base
  - then work your way around



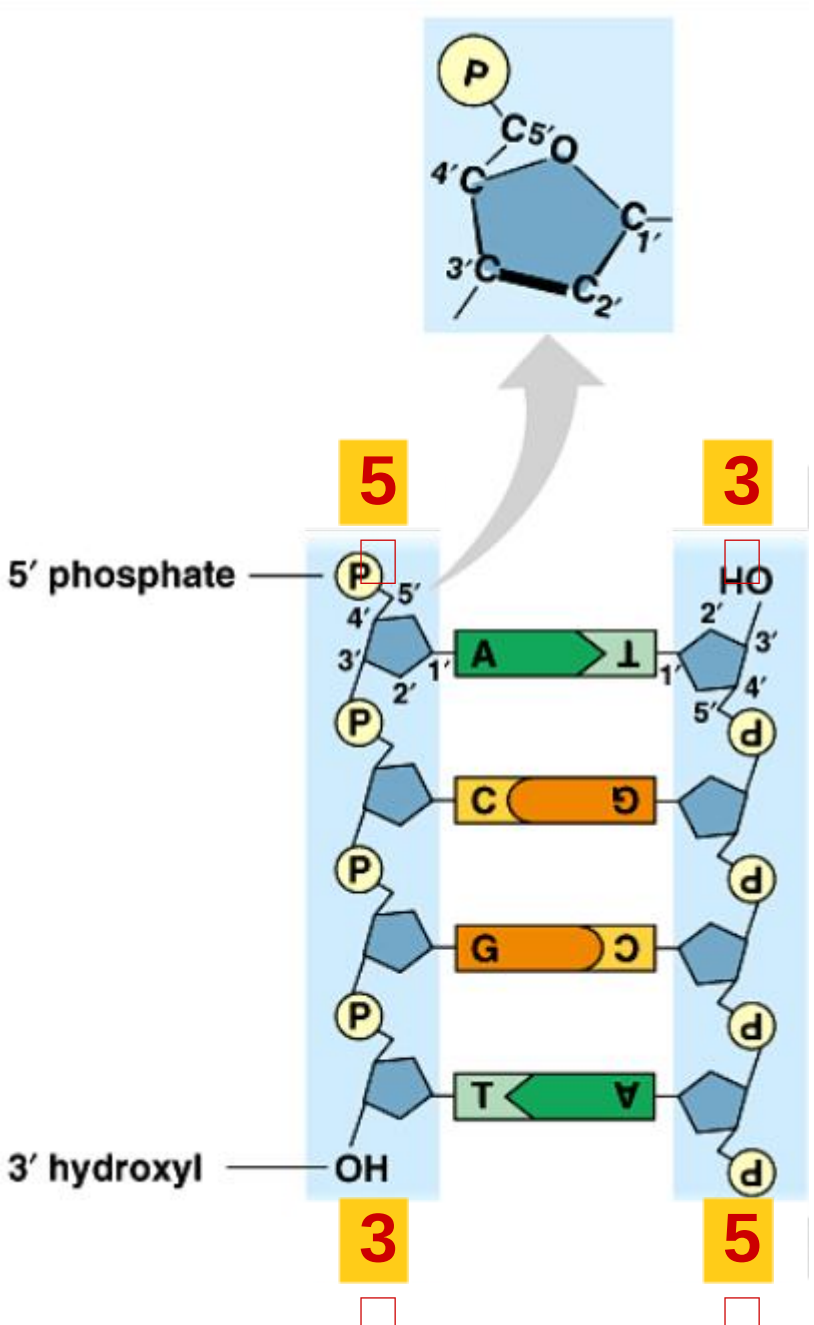
The DNA Backbone

- Nucleotides bond from <u>phosphate to sugar</u> between Carbons 3 & 5
- Strong covalent bonds



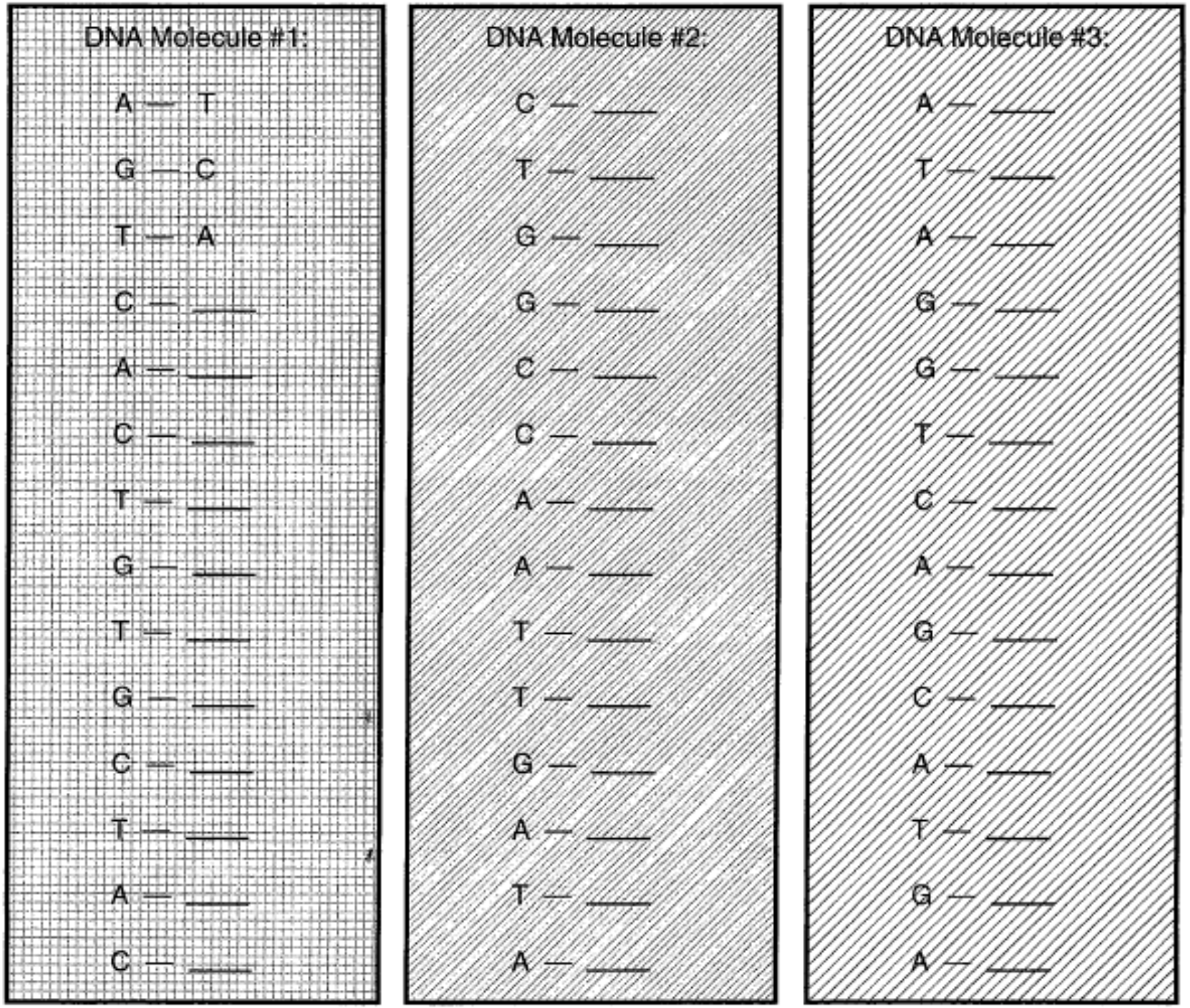
Anti-Parallel Strands

- DNA molecule has "direction"
- Complementary strands run in opposite directions
- 5' to 3' (read as 5 prime to 3 prime) is "right side up"
- 3' to 5' is "upside down"



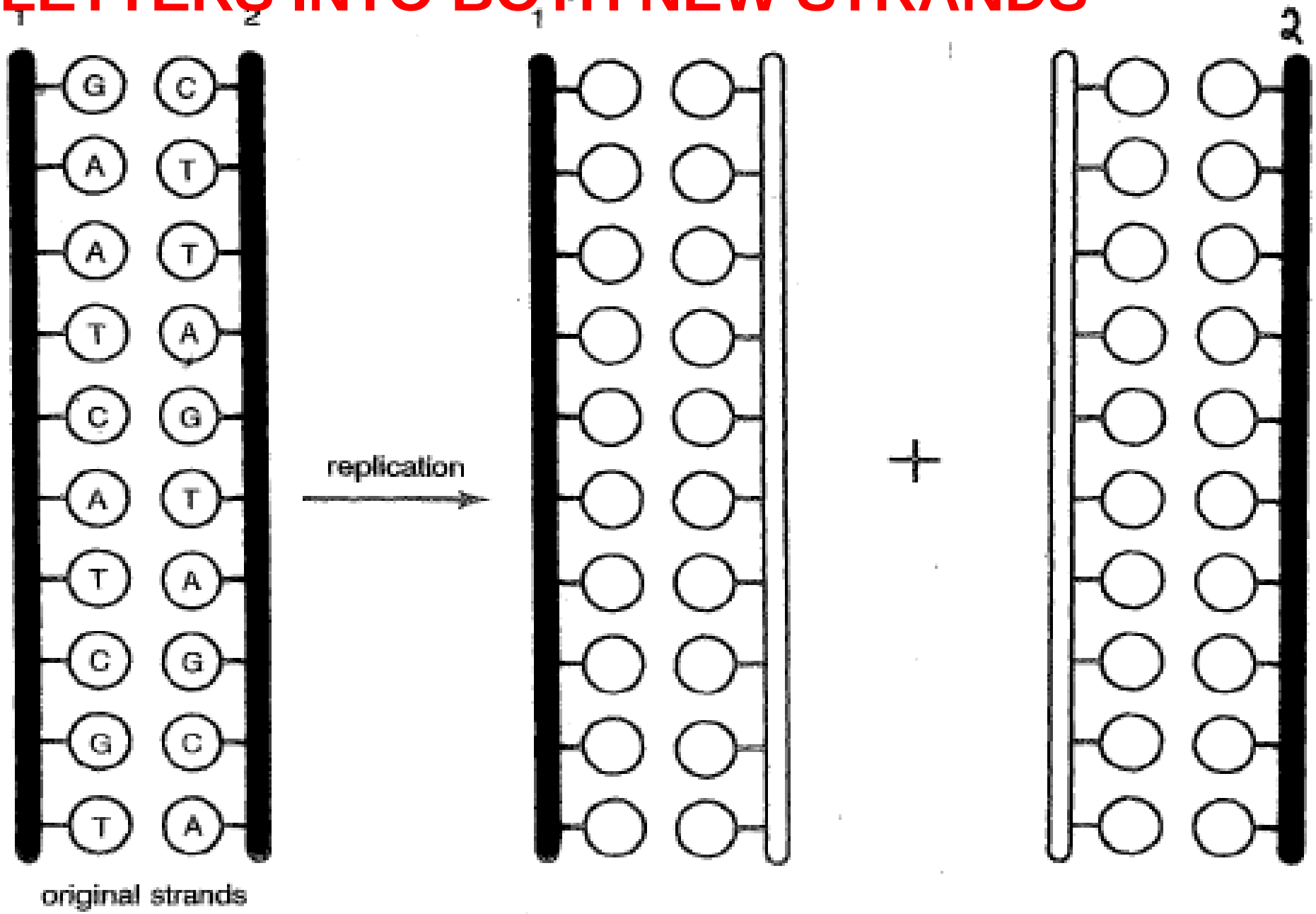
Lesson 3

DNA Replication


DNA Molecule #1:
A — T
G — C
T — A
C — ____
A — ____
C — ____
T — ____
G — ____
T — ____
G — ____
C — ____
T — ____
A — ____
C — ____
DNA Molecule #2:
C — ____
T — ____
G — ____
G — ____
C — ____
C — ____
A — ____
A — ____
T — ____
T — ____
G — ____
A — ____
T — ____
A — ____
DNA Molecule #3:
A — ____
T — ____
A — ____
G — ____
G — ____
T — ____
C — ____
A — ____
G — ____
C — ____
A — ____
T — ____
G — ____
A — ____

COPY LETTERS INTO BOTH NEW STRANDS

DNA replication is "<u>semi-conservative</u>": Each molecule is made up of 1 old strand and 1 new strand



QUESTIONS:

1- Which bonds are broken during DNA replication? hydrogen bonds between bases

2- What determines the linear sequence of nucleotides in the new strands?

The sequence of bases in the template (original) strand

3- When replication is complete, how many double-stranded DNA molecules are formed?

2

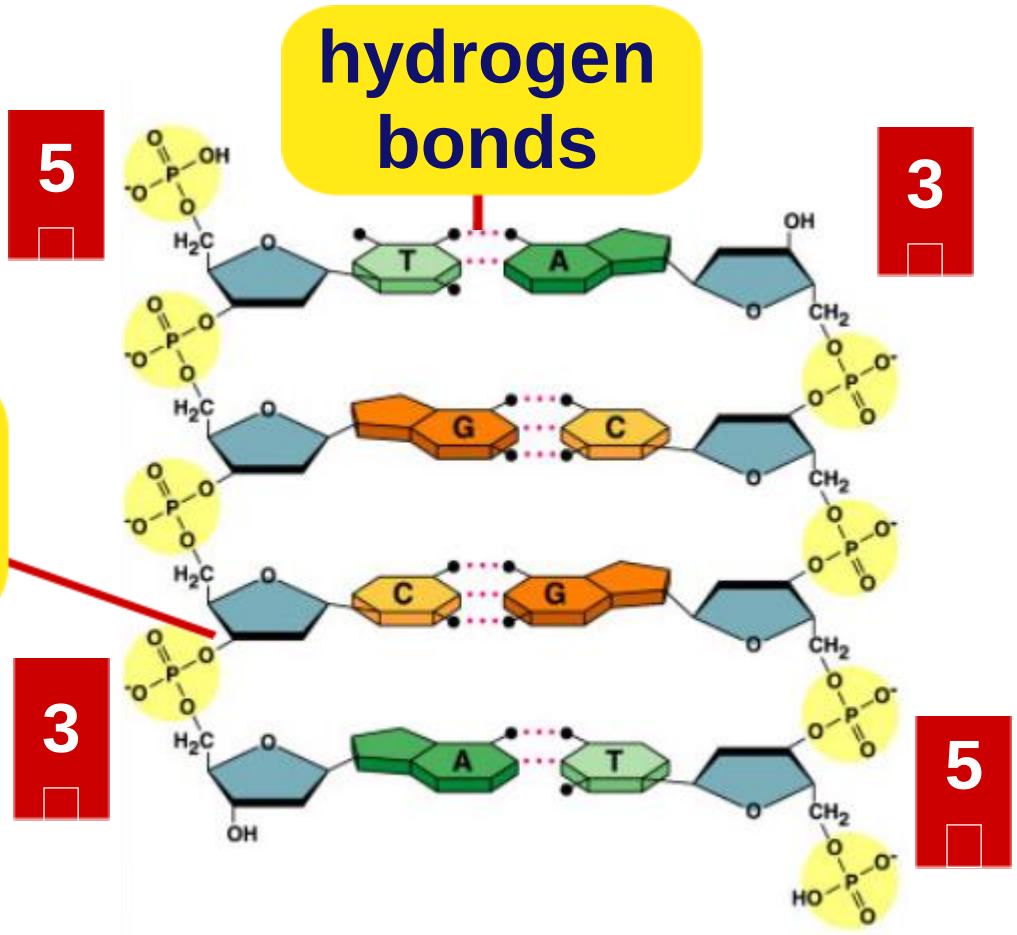
4- How do the two new DNA molecules compare to the original one?

They are identical

5- The process by which new molecules of DNA are formed is called replication

Bonding in DNA

STRONG covalent phosphodiester bonds between phosphate and sugar backbone



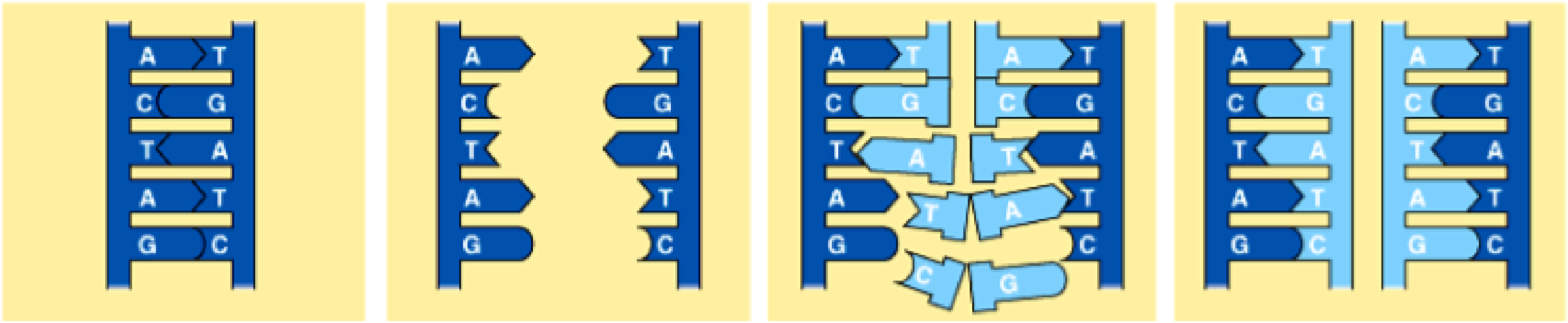
WEAK hydrogen bonds between bases are easily separated for DNA Replication

….strong or weak bonds?

How do the bonds fit the mechanism for copying DNA?

DNA Replication

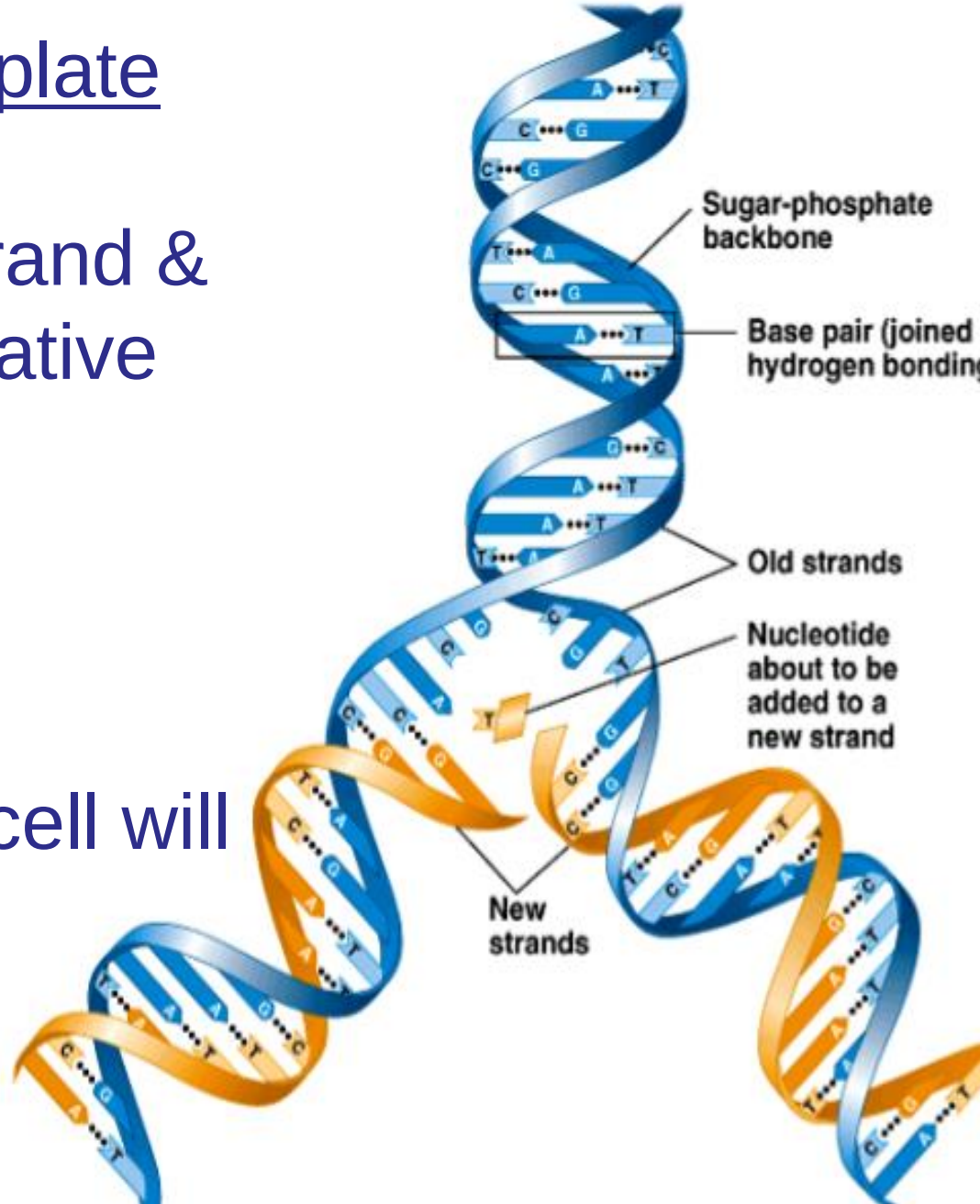
"It has not escaped our notice that the specific pairing we have postulated immediately suggests a possible copying mechanism for the genetic material." Watson & Crick



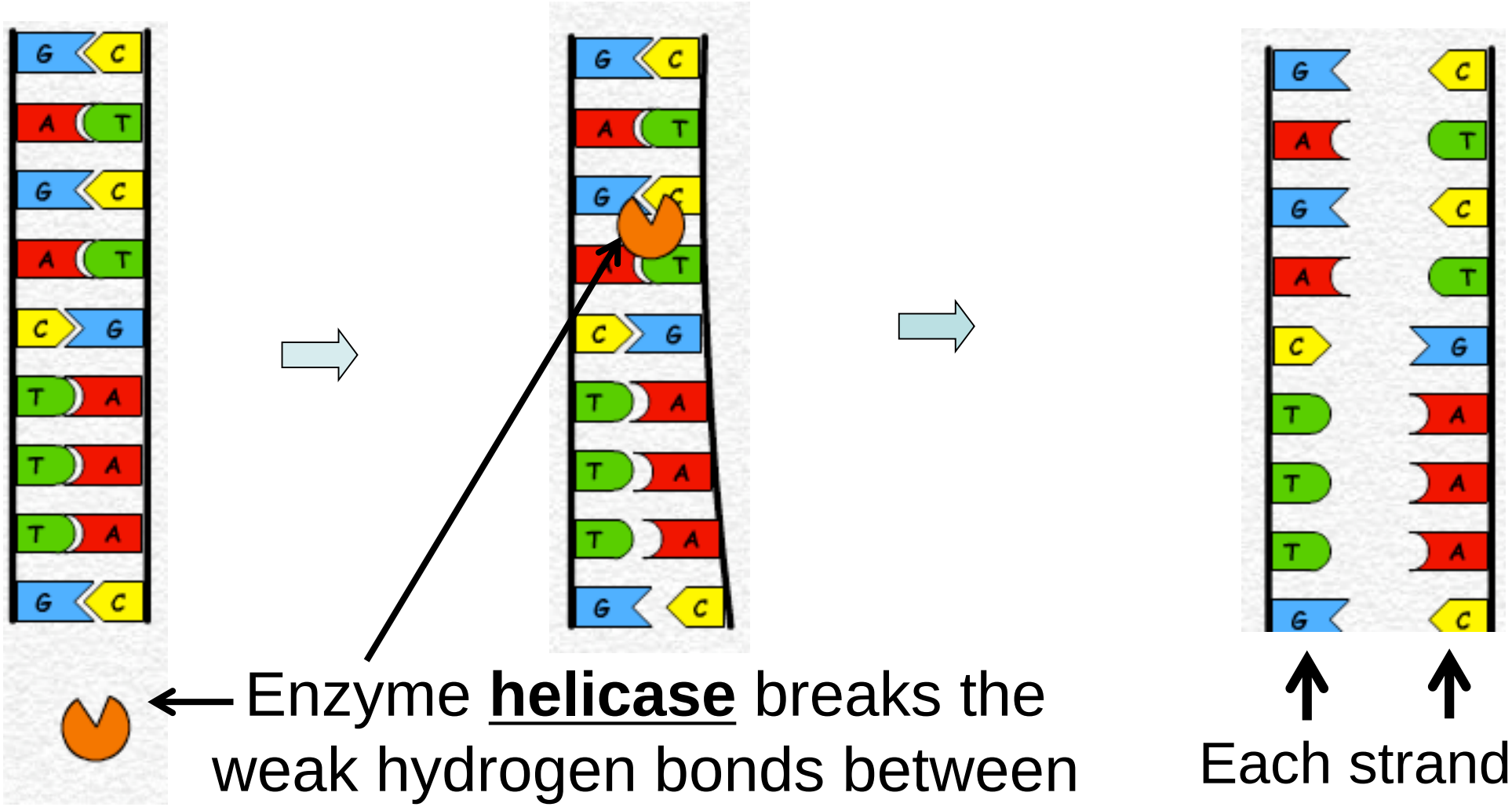
DNA Replication overview (simple schematic)

Replication (copying DNA)

- Each strand serves as a template (model) for a new strand
- New strand is half original strand & half new DNA (semi-conservative model)
- Coordinated by enzymes
- Occurs before cell division (mitosis and meiosis)
- Ensures that each daughter cell will have a complete set of DNA



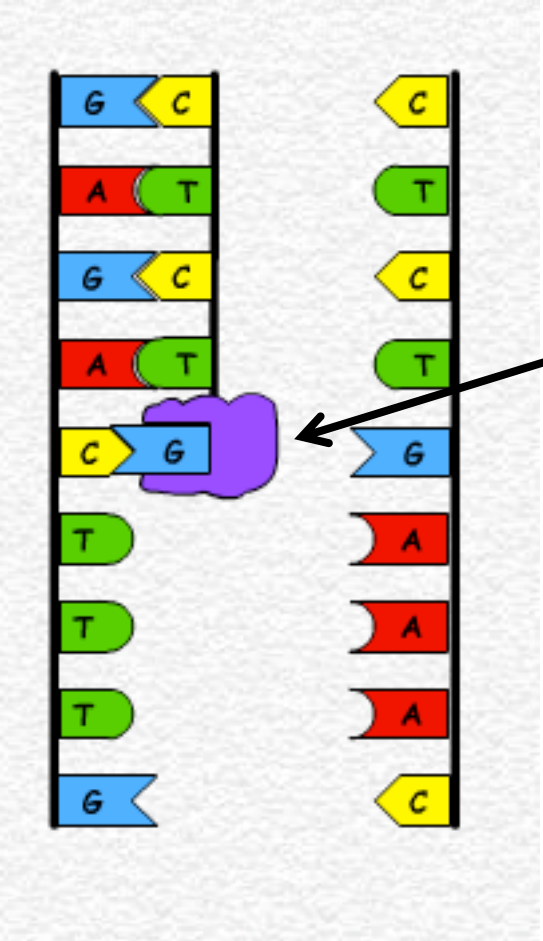
DNA Replication – strands unzip and separate



← Enzyme **helicase** breaks the weak hydrogen bonds between base pairs, separating ("unzipping") the 2 strands

↑ ↑ Each strand is now a template

DNA Replication cont.



Enzyme **DNA Polymerase** adds new DNA nucleotides to match exposed bases

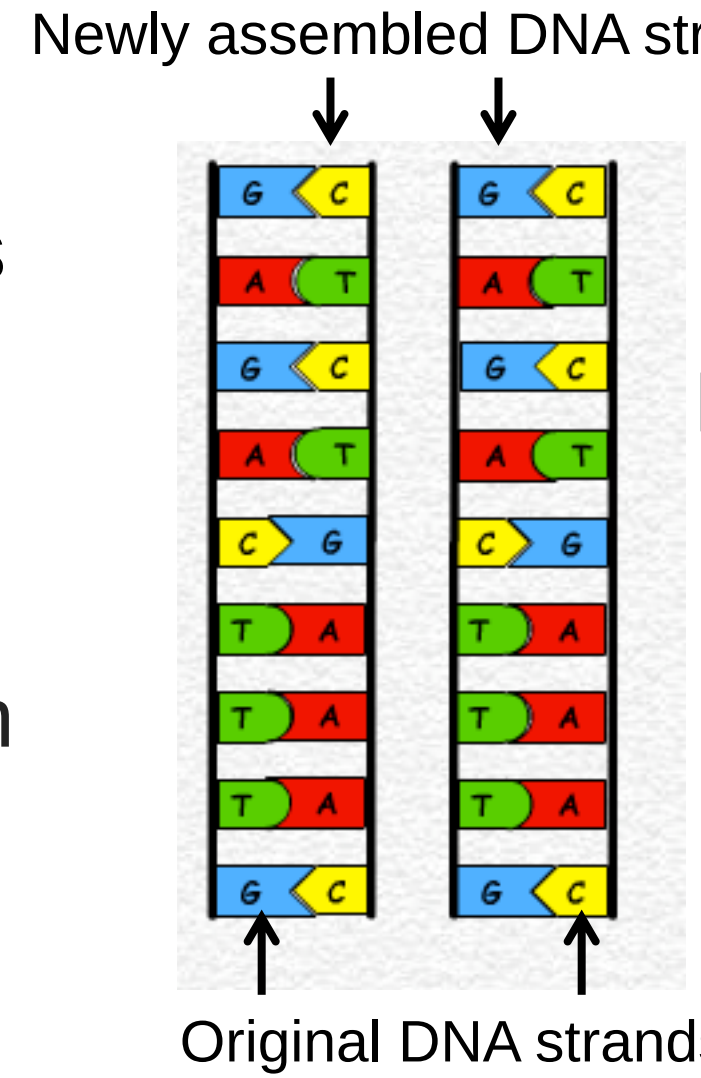
HHMI DNA Replication Basic

HHMI DNA Replication Advanced

DNA Replication – 2 identical strands of DNA

Other enzymes involved:

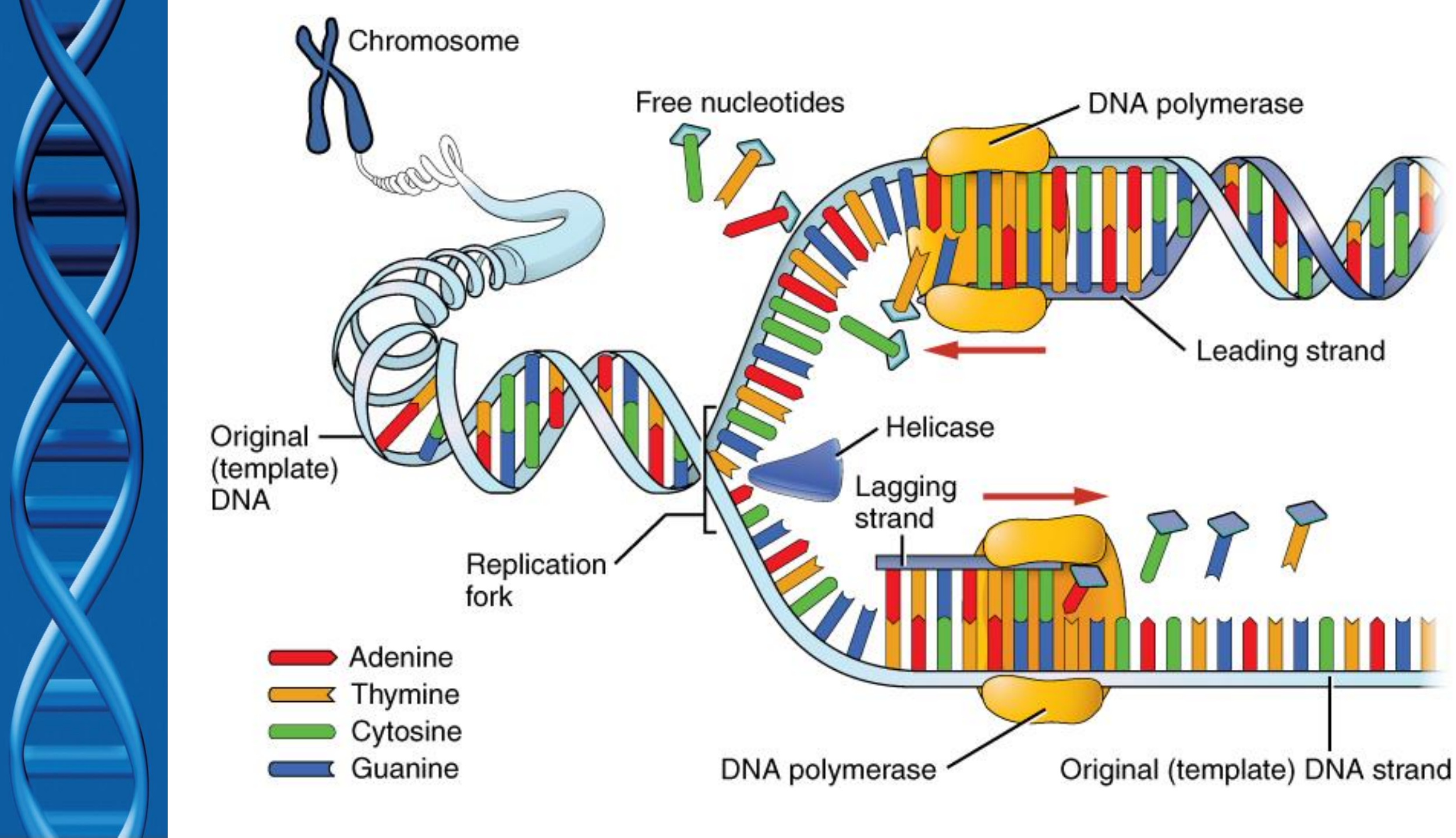
- **Primase** makes primers - short RNA sequences which mark a starting point for replication.
- **Ligase** repairs breaks in the sugar-phosphate backbone of **DNA** molecules.



END RESULT is 2 identical strands of DNA

HHMI DNA Replication Basic

HHMI DNA Replication Advanced


Chromosome
Free nucleotides
DNA polymerase
Leading strand
Original (template) DNA
Helicase
Lagging strand
Replication fork
Adenine
Thymine
Cytosine
Guanine
DNA polymerase
Original (template) DNA strand

Summary - Video Tutorial of DNA Replication

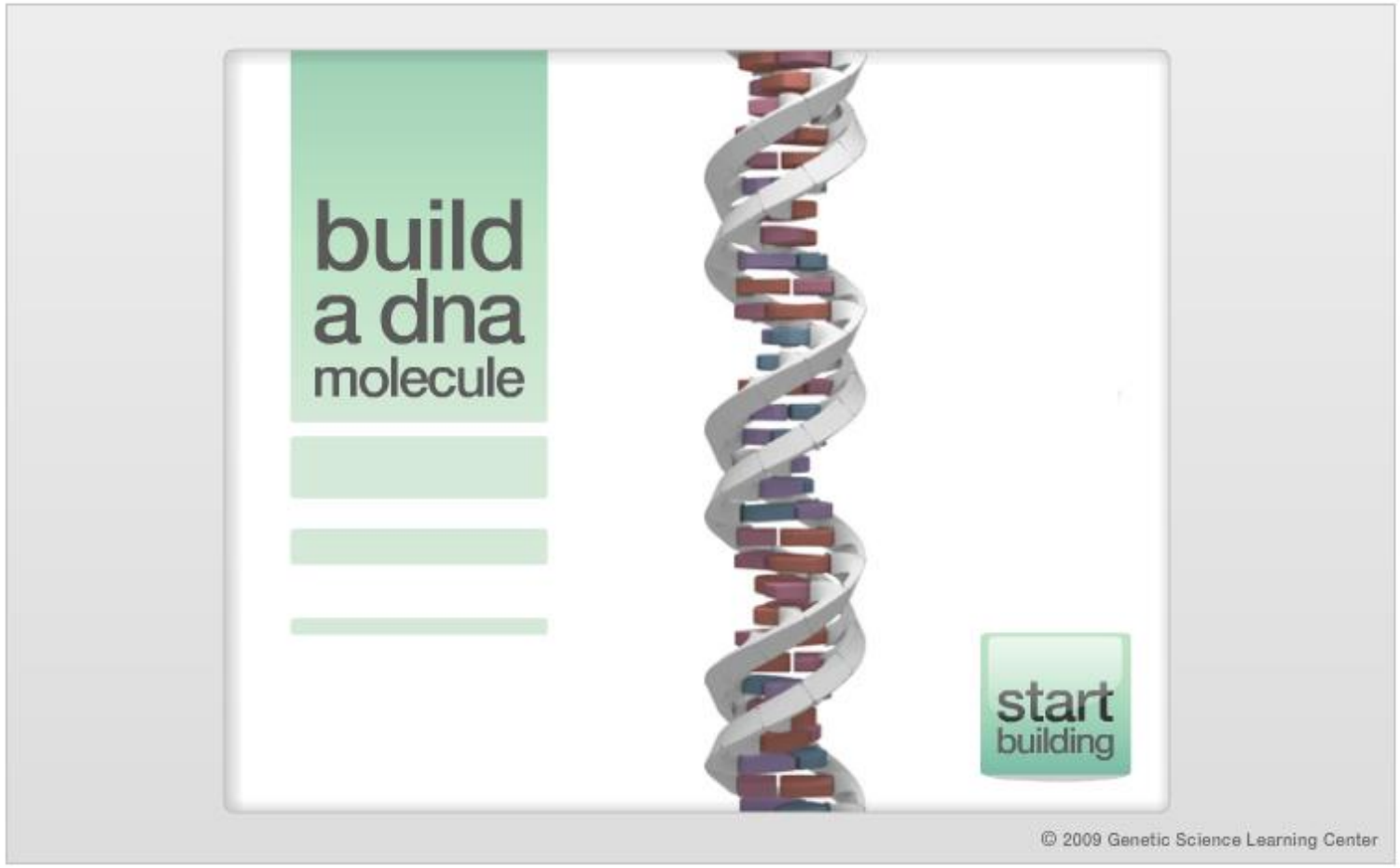
Video - Amoeba Sisters DNA Replication

Complete the worksheet while watching the video

Build a DNA molecule – you try it!

HOME > DNA TO PROTEIN > BUILD A DNA MOLECULE

BUILD A DNA MOLECULE



DNA Webquest Links: Part 1 – History, DNA Structure, DNA Replication

Page 1
DNA History
http://www.dnaftb.org/1/

Page 2
http://www.dnai.org/a/index.html

DNA Replication
http://www.stolaf.edu/people/giannini/flashanimat/molgenetics/dna-rna2.swf

Page 3
http://www.dnai.org/a/index.html

DNA Webquest Links: Part 2 – RNA, Transcription, Translation

Page 4
RNA
http://www.dnaftb.org/21/

Page 5
Transcription (DNA → RNA)
http://www.stolaf.edu/people/giannini/flashanimat/molgenetics/transcription.swf

DNAi website
http://www.dnai.org/a/index.html

Translation (mRNA → protein)
http://www.stolaf.edu/people/giannini/flashanimat/molgenetics/translation.swf

DNAi website
http://www.dnai.org/a/index.html