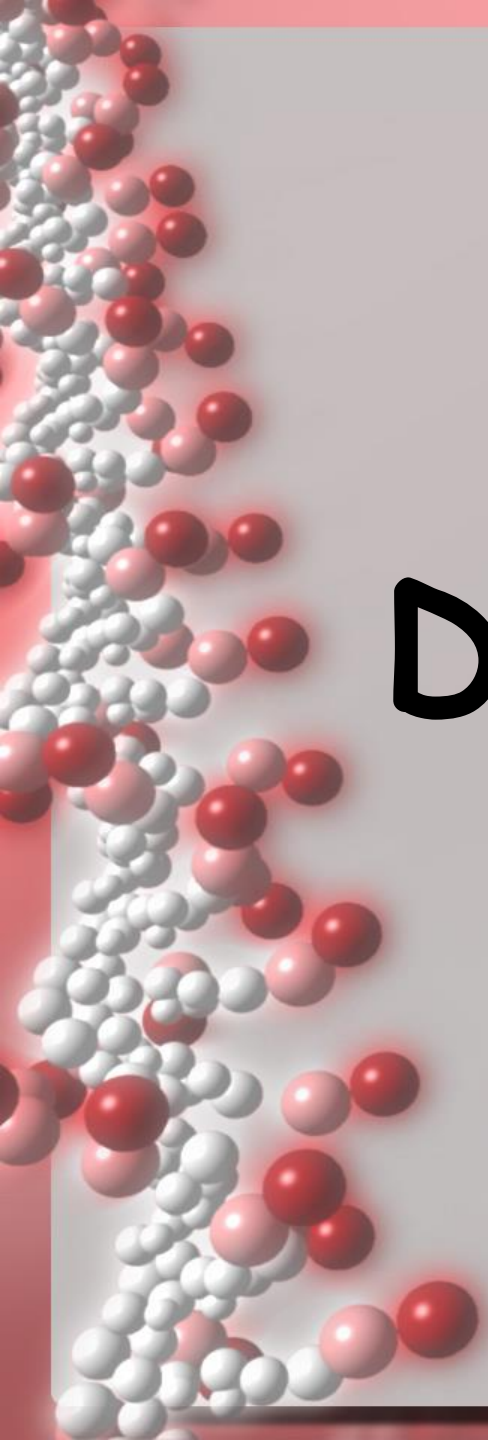
Go to the "Slide Show" shade above

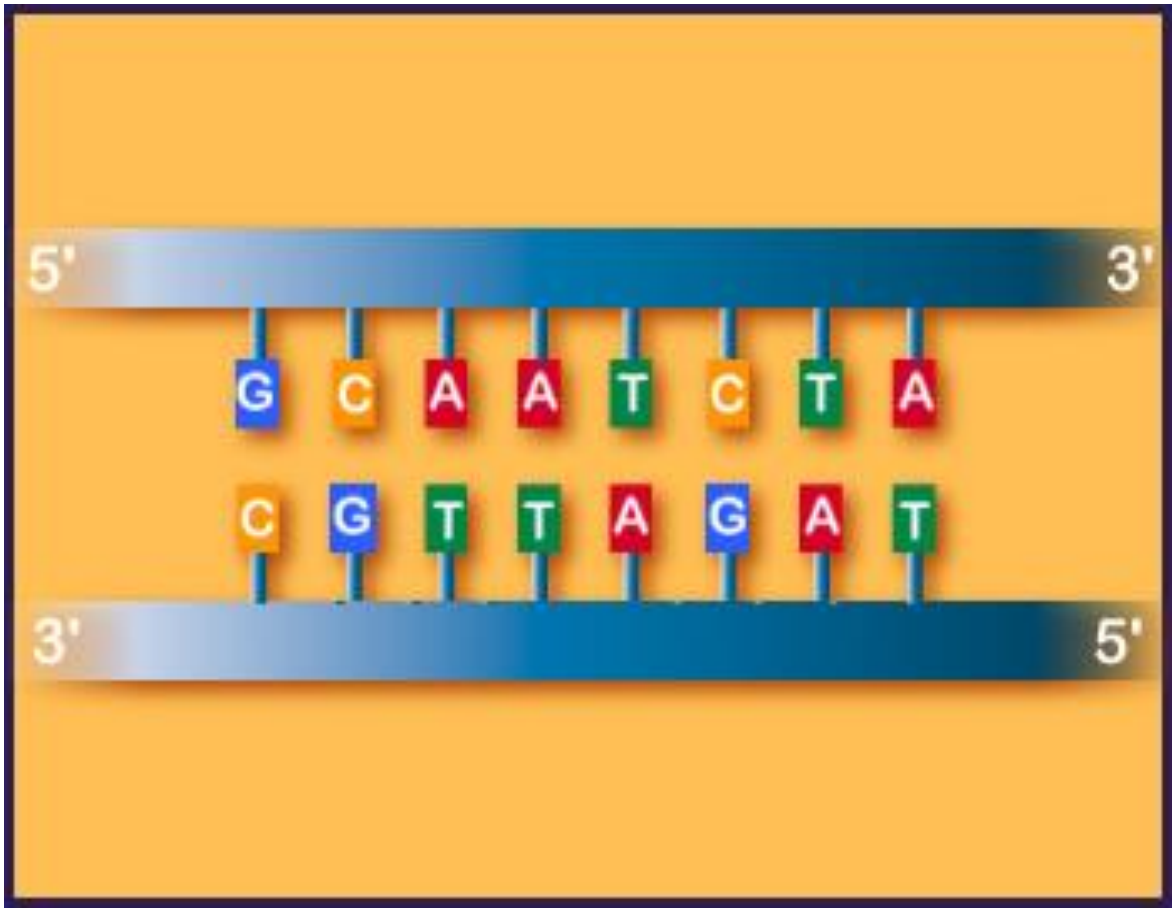
Click on "Play from Beginning"



Chapter 9: DNA, RNA, and Proteins

WARM-UP

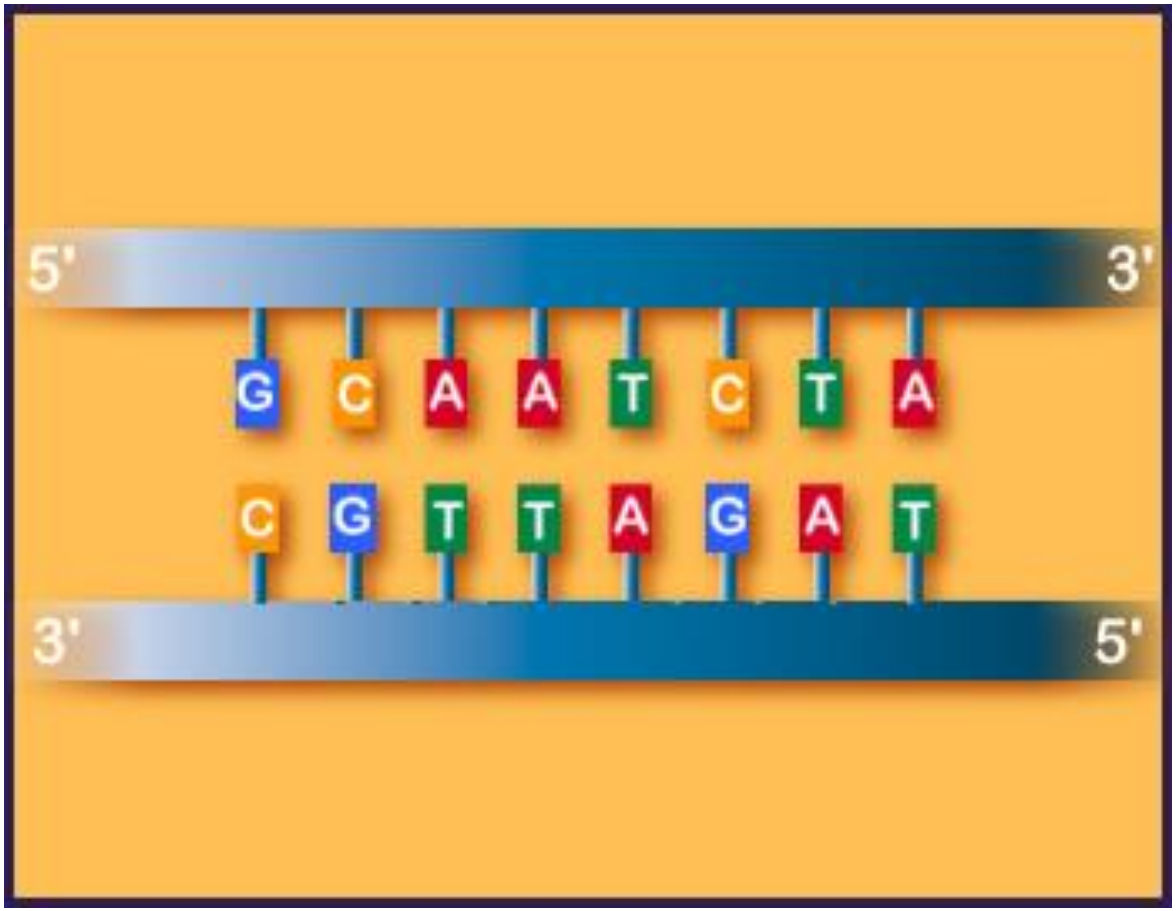
DNA stands for …



What?

WARM-UP

DNA stands for …

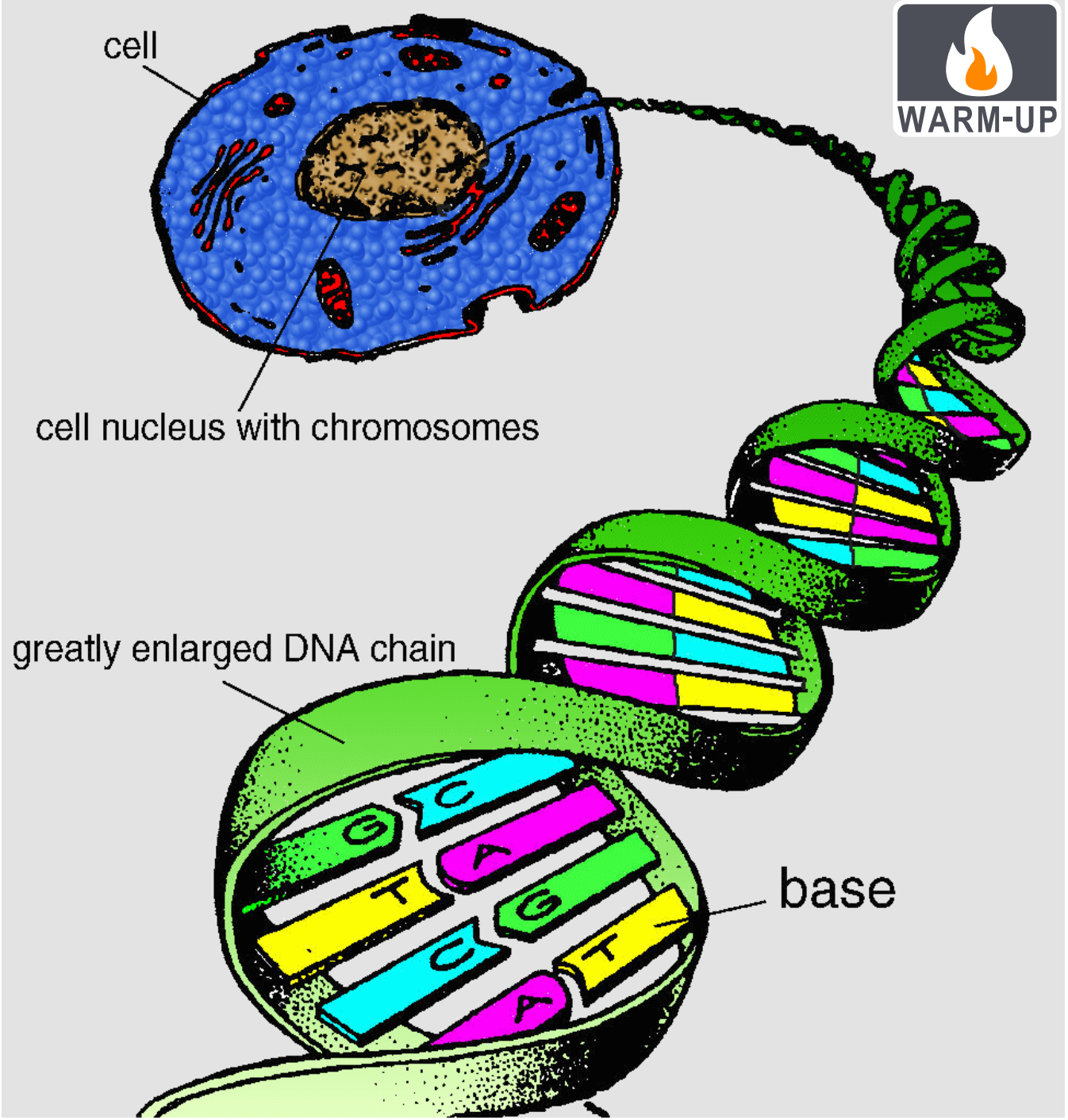


Deoxyribo***N***ucleic ***A***cid

DNA comes from the ____ of the cell.

What comprises DNA?

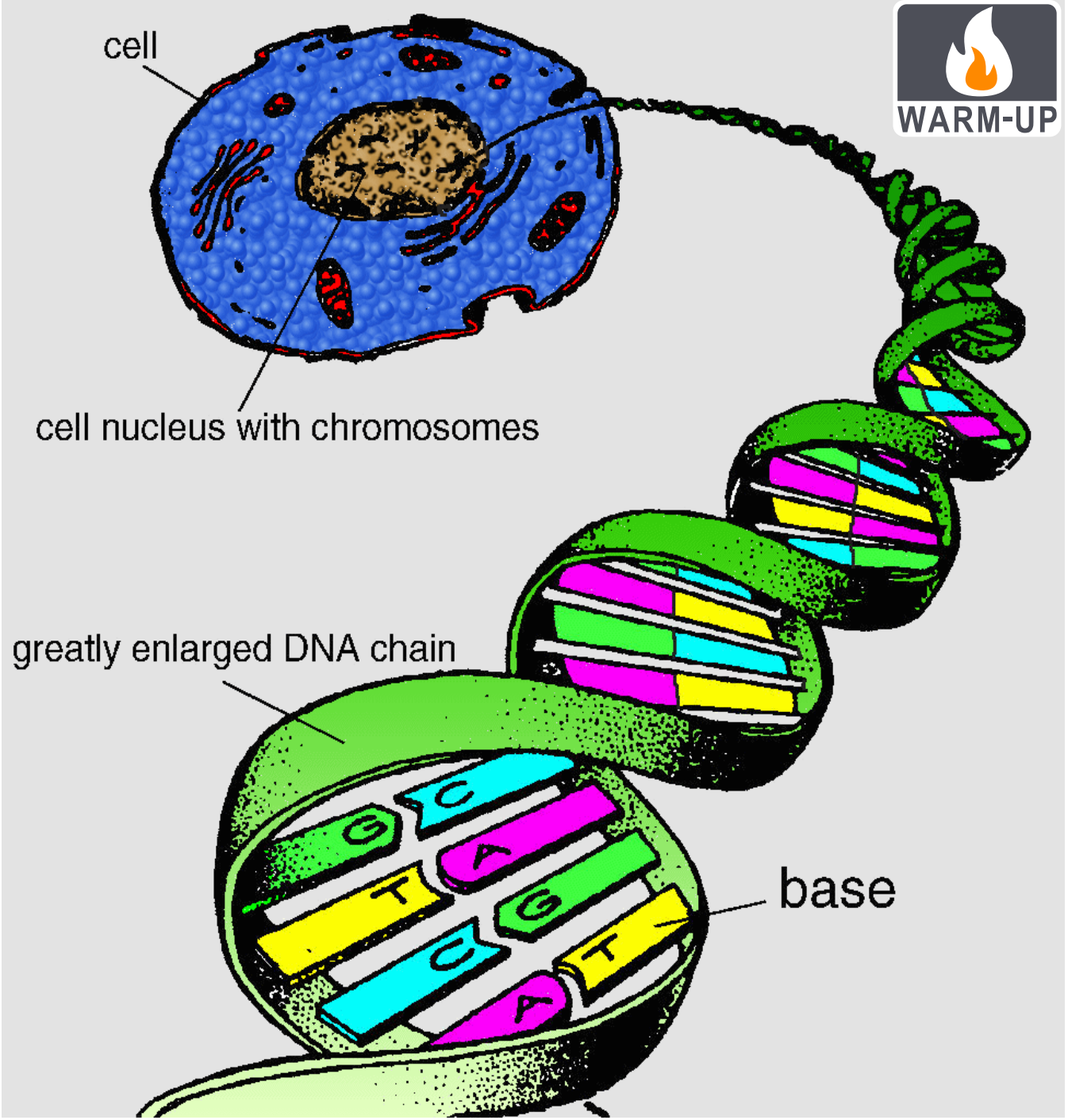
What type of bonds hold the complimentary strands together?



DNA comes from the nucleus of the cell.

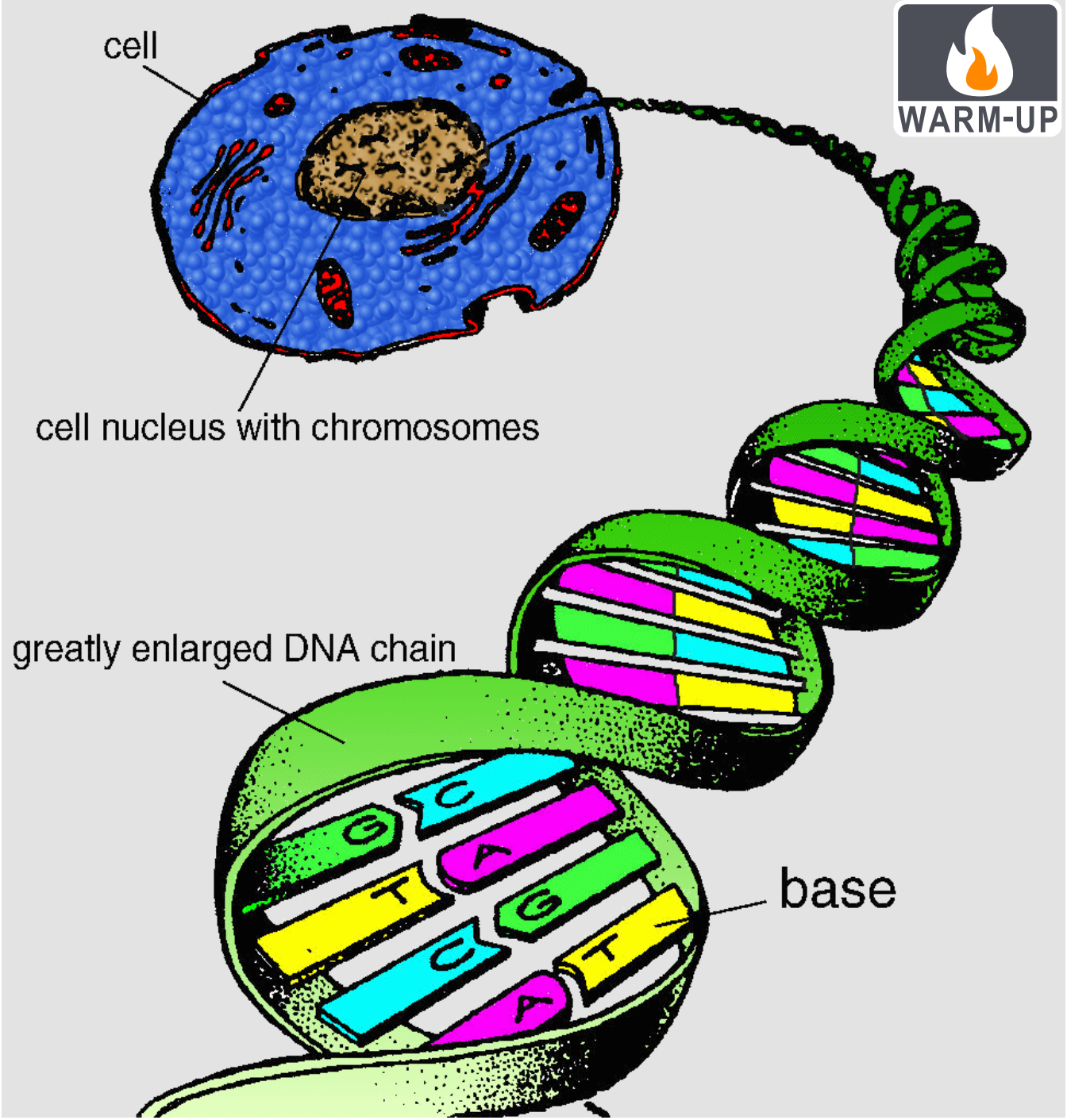
Nucleotides comprise DNA?

Hydrogen bonds hold the complimentary strands together?



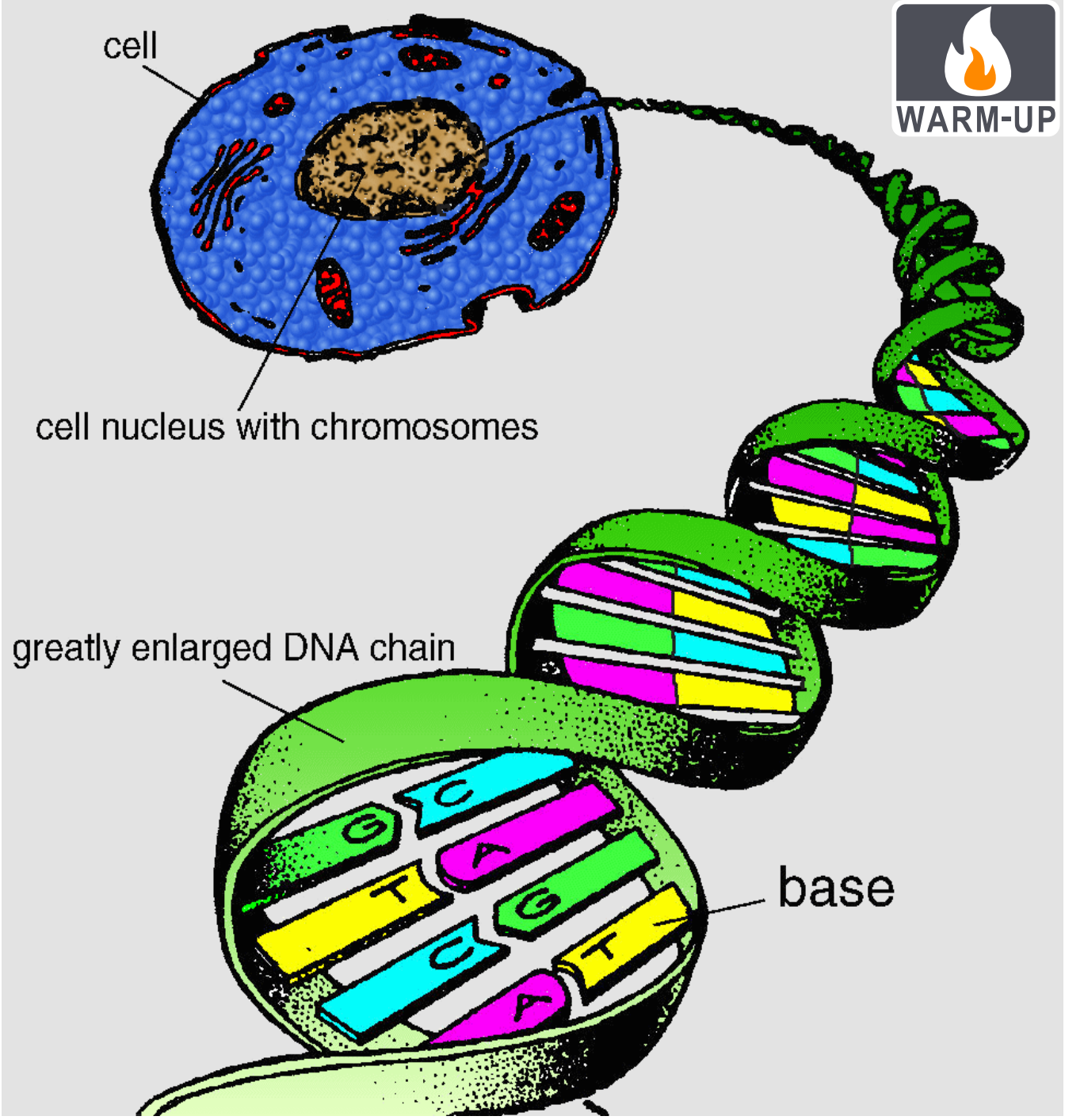
____ bonds with ____ using 2 hydrogen bonds.

____ bonds with ____ using 3 hydrogen bonds.



Adenine bonds with Thymine using 2 hydrogen bonds.

Guanine bonds with Cytosine using 3 hydrogen bonds.



Lesson Objectives

By the end of this lesson, you should be able to:

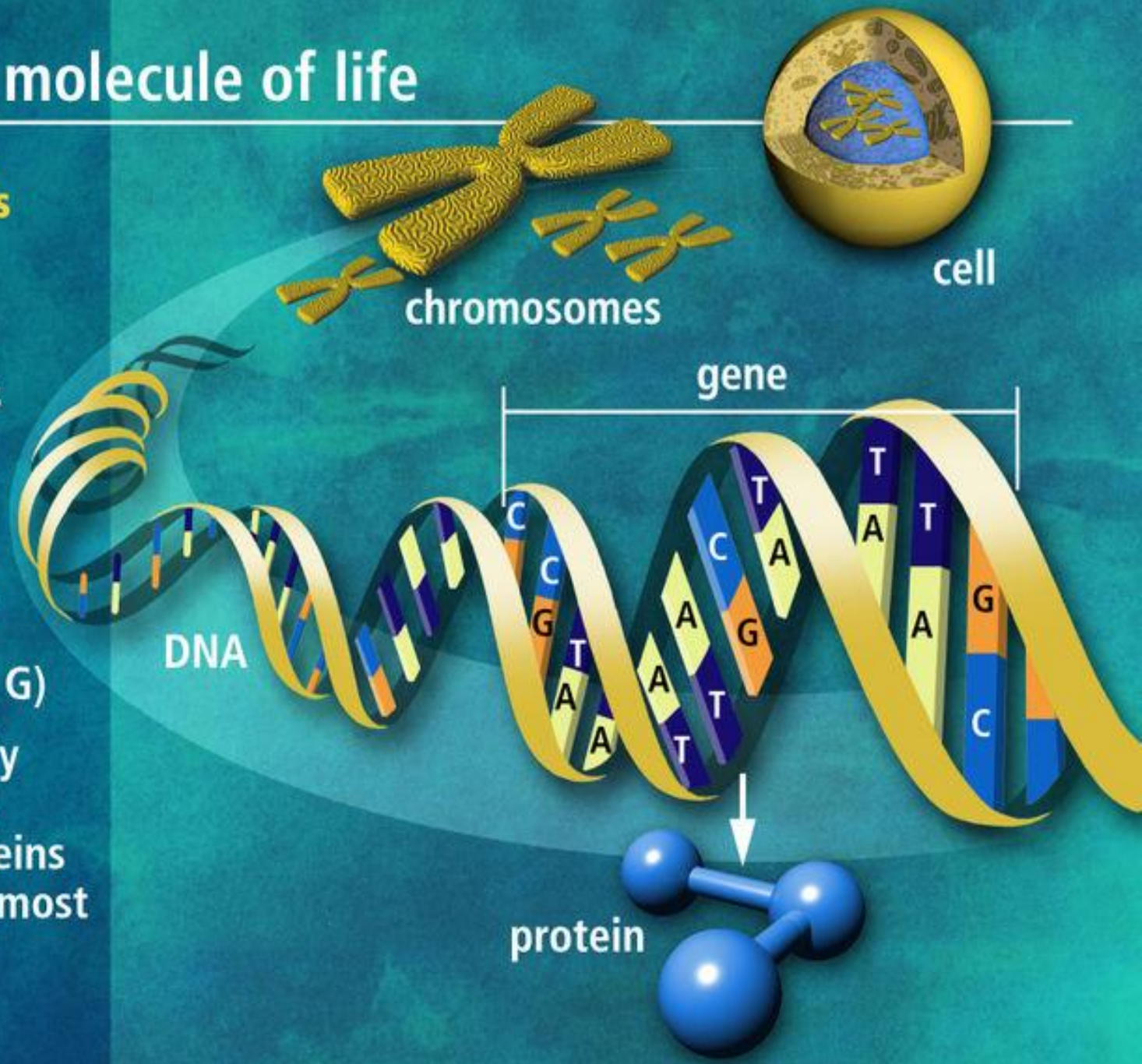
- ❑ Distinguish chromosome, gene, and DNA.
- ❑ Identify and label the anatomy of chromosomes and DNA.
- ❑ Name the scientists who discovered DNA and their contributions.
- ❑ Review the process of DNA replication.
- ❑ Contrast DNA and RNA, introducing protein synthesis.
- ❑ Explain gene expression.
- **Science Practice: DNA Extraction**

DNA the molecule of life

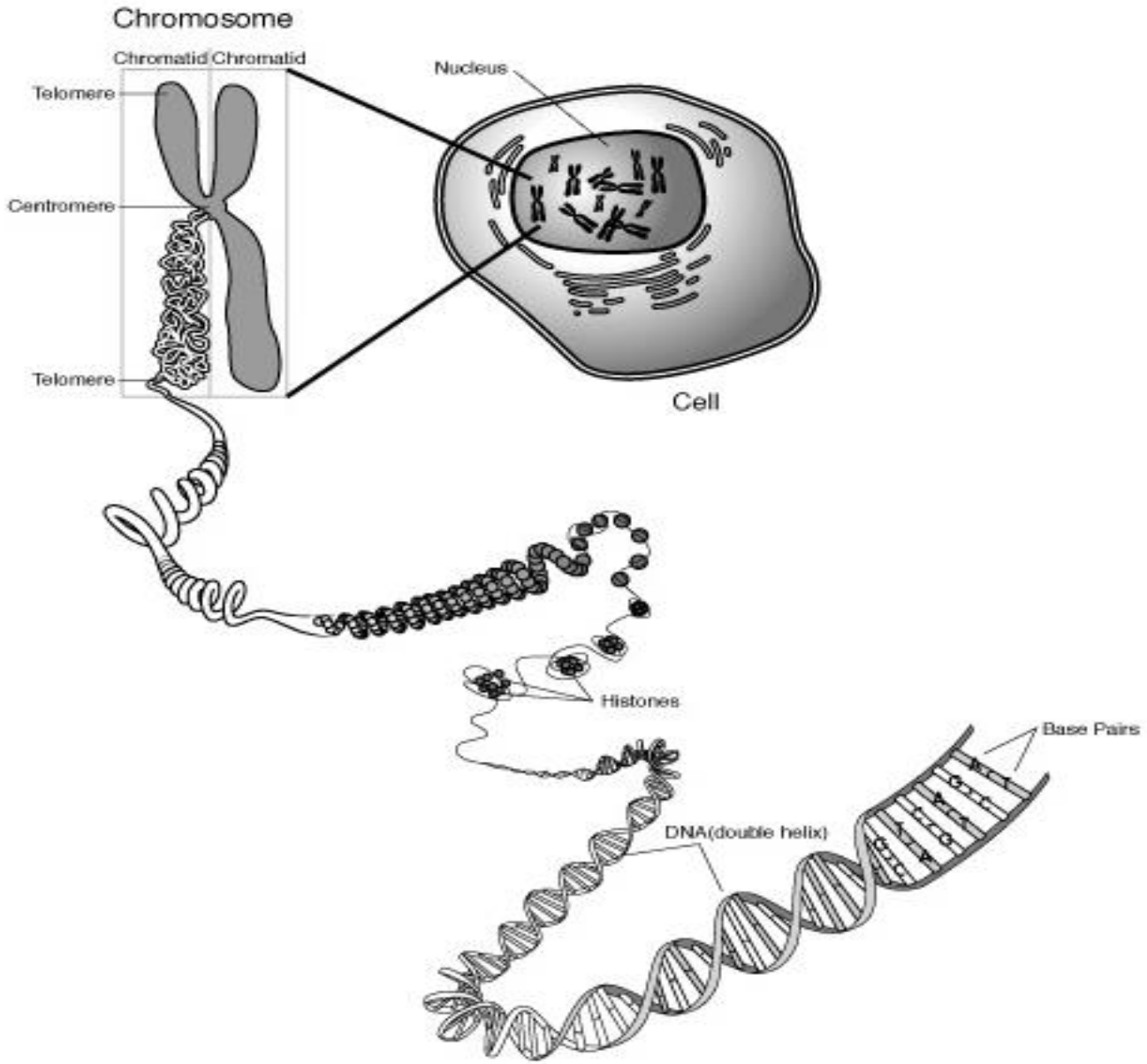
Trillions of cells

Each cell:

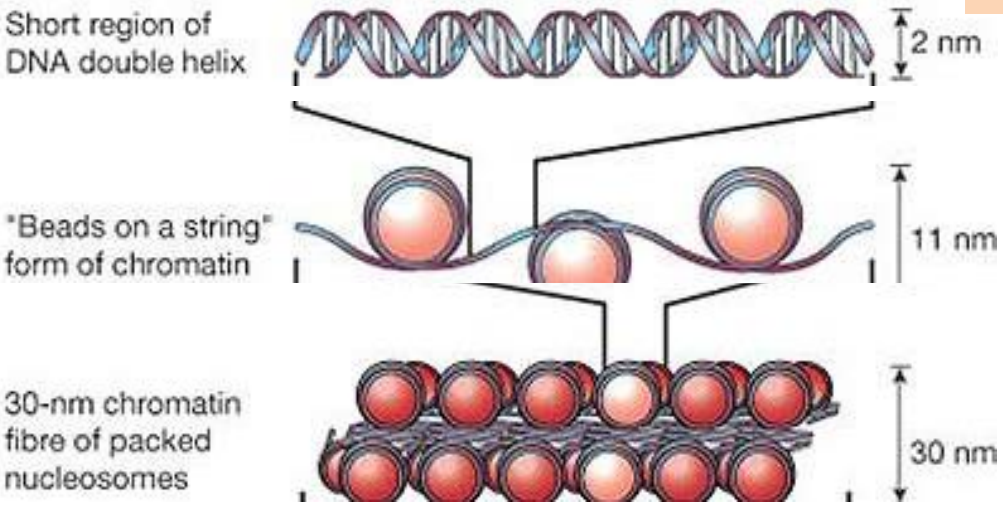
- 46 human chromosomes
- 2 meters of DNA
- 3 billion DNA subunits (the bases: A, T, C, G)
- Approximately 30,000 genes code for proteins that perform most life functions



Chromosomes are made of DNA

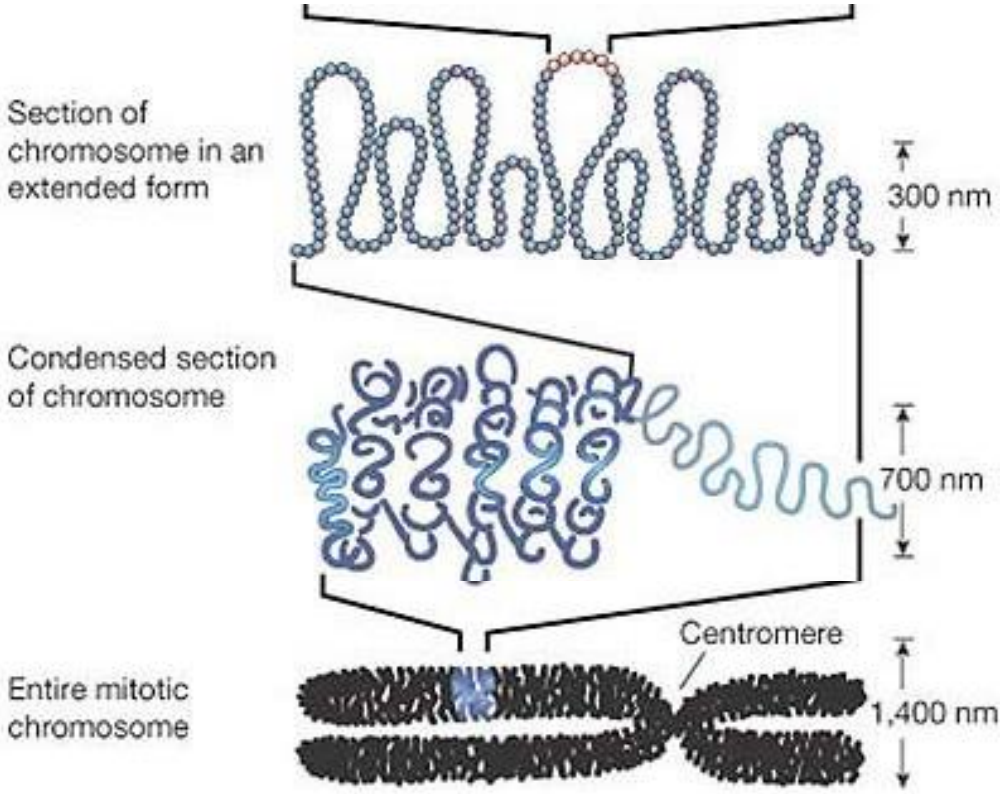


How a chromosome forms.



1. **The DNA wraps around proteins called histones to form beads on a string or chromatin.**
2. **The chromatin fibers further condenses into a fiber.**

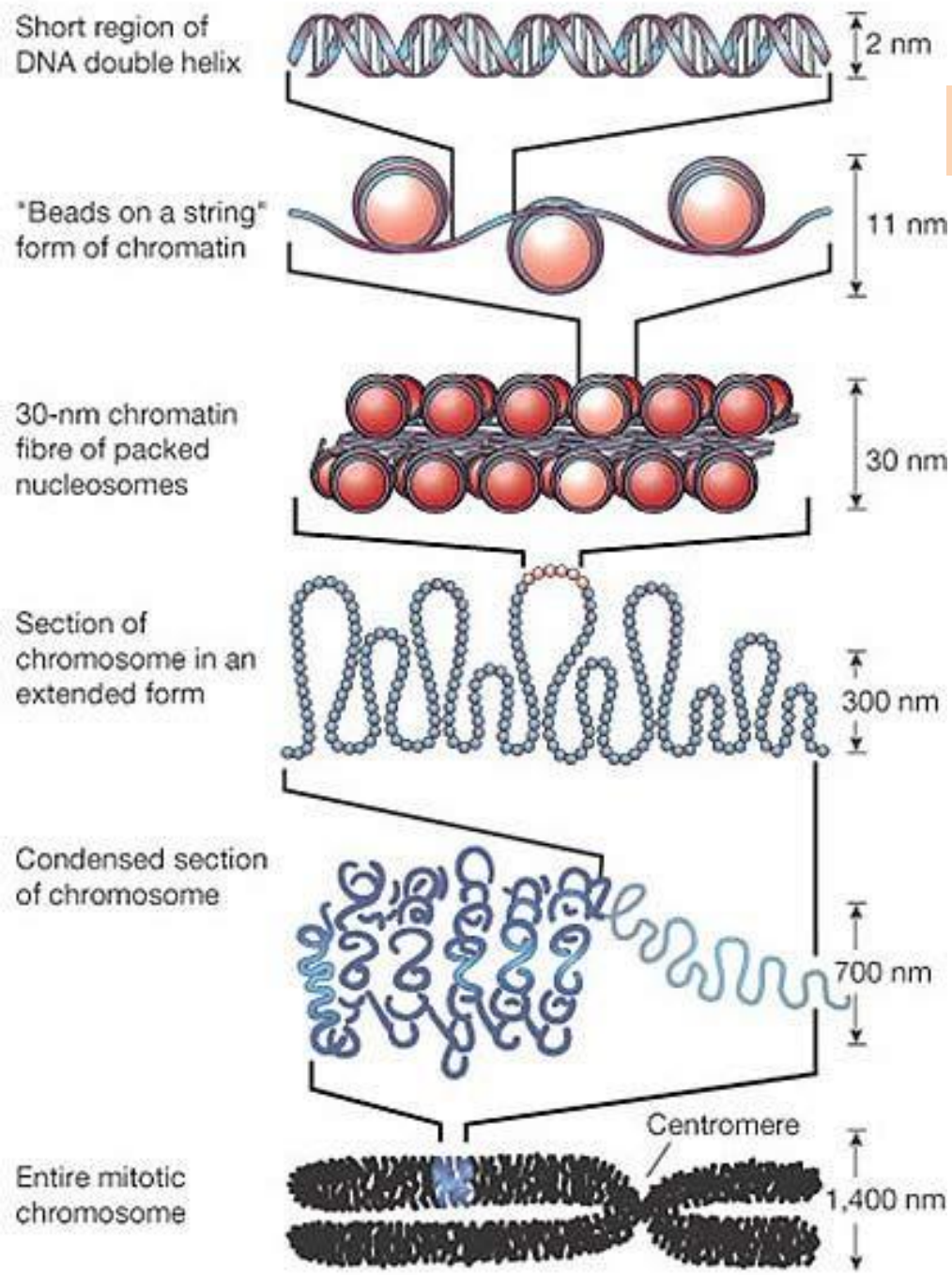
How a chromosome forms.



3. **The condensed chromatin fibers continues to <u>coil</u> around itself.**

4. **The <u>condensed and coiled</u> chromatin fibers become a section of a chromosome.**

This is one entire chromosome coiled and condensed.



How a chromosome forms.

1. **The DNA wraps around proteins called histones to form beads on a string or chromatin.**
2. **The chromatin fibers further condenses into a fiber.**
3. **The condensed chromatin fibers continues to coil around itself.**
4. **The condensed and coiled chromatin fibers become a section of a chromosome.**

This is one entire chromosome coiled and condensed.

DNA, Genes and Chromosomes

1. What is DNA?

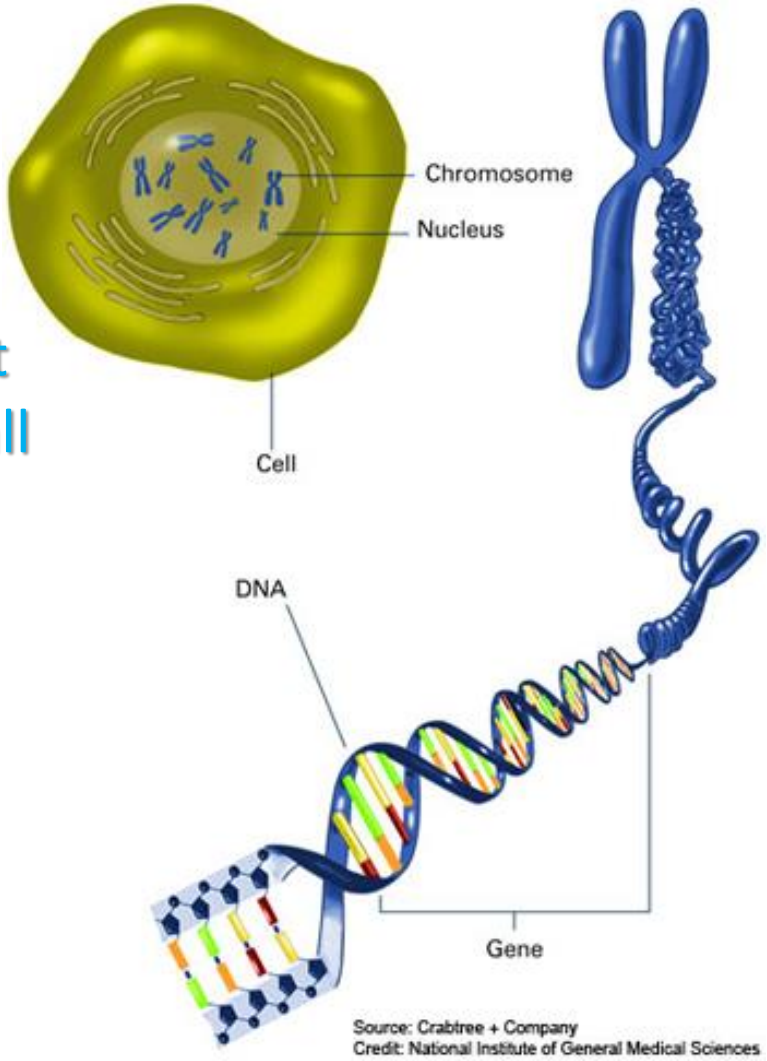
   - Double stranded molecule that contains genetic information about the function and development of all living things.

2. What is a gene?

   - A segment of DNA that codes for a protein (polypeptide).

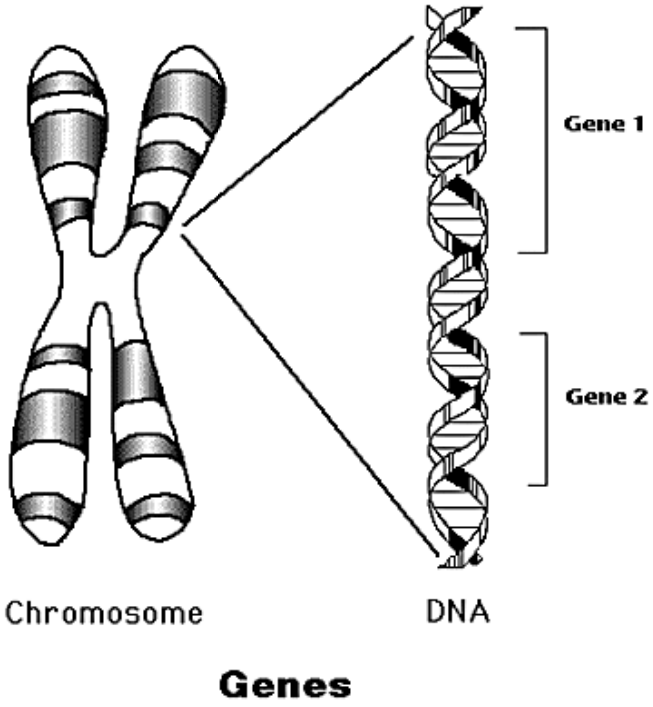
3. What is a chromosome?

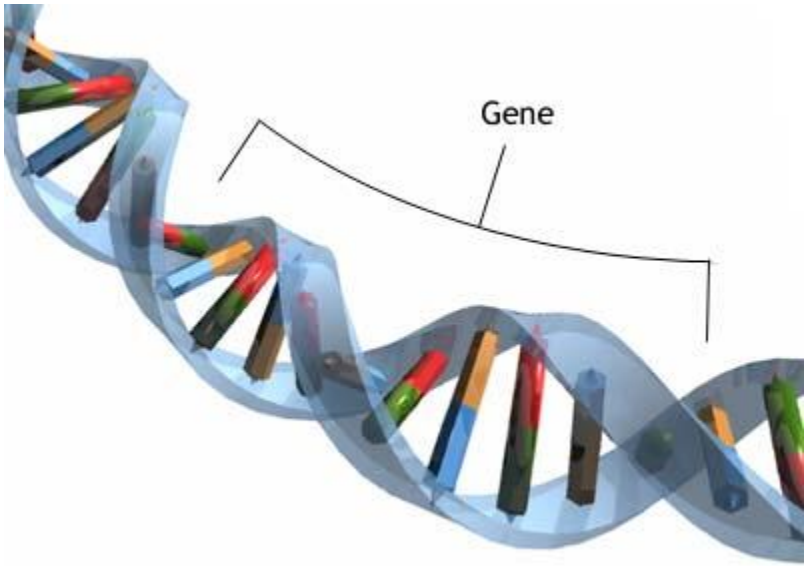
   - A molecule of DNA that contains many genes.



DNA, Genes & Chromosomes

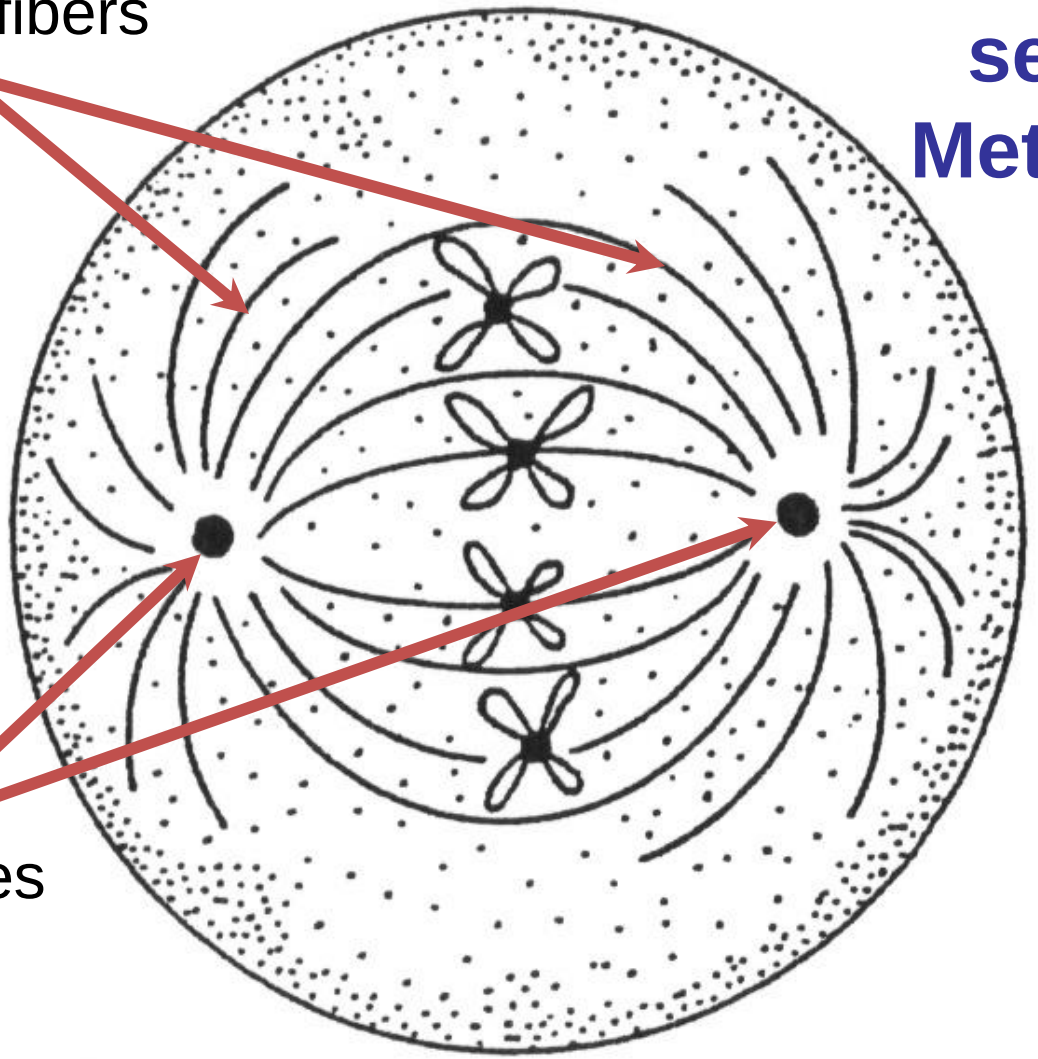
- Genes are segments of DNA that code for proteins
- Chromosomes consist of segments of coding DNA (string of genes that code for various proteins in between non-coding DNA).





METAPHASE

spindle fibers



centrioles

The chromosomes can be most easily seen during the Metaphase portion of Mitosis.

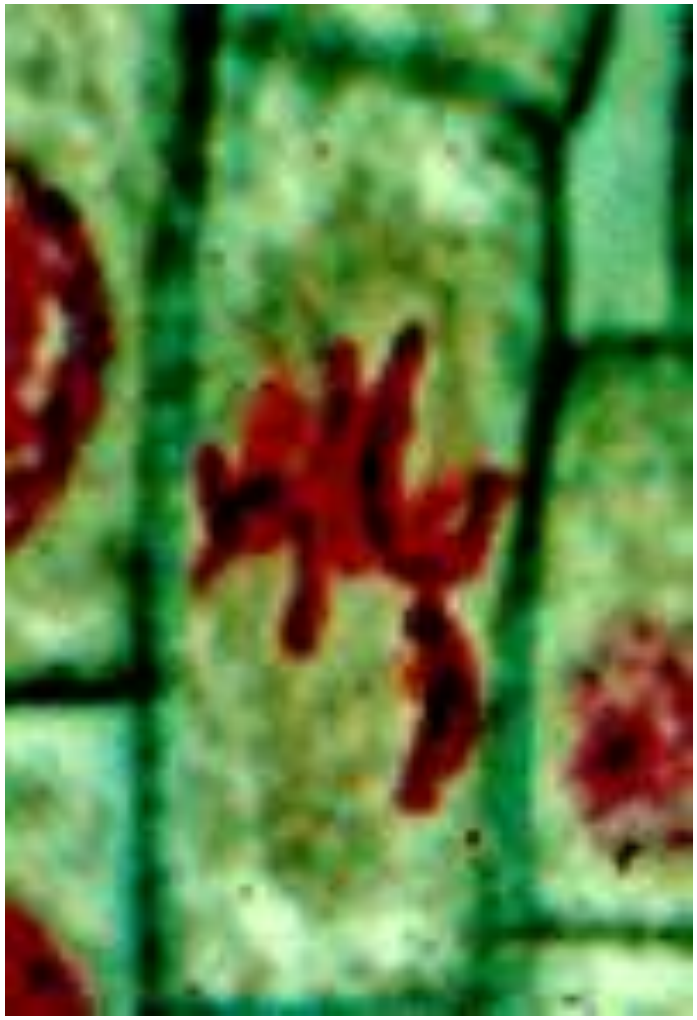
What are the phases of Mitosis in order?

Prophase Metaphase Anaphase Telophase

Chromosomes of an onion root cell

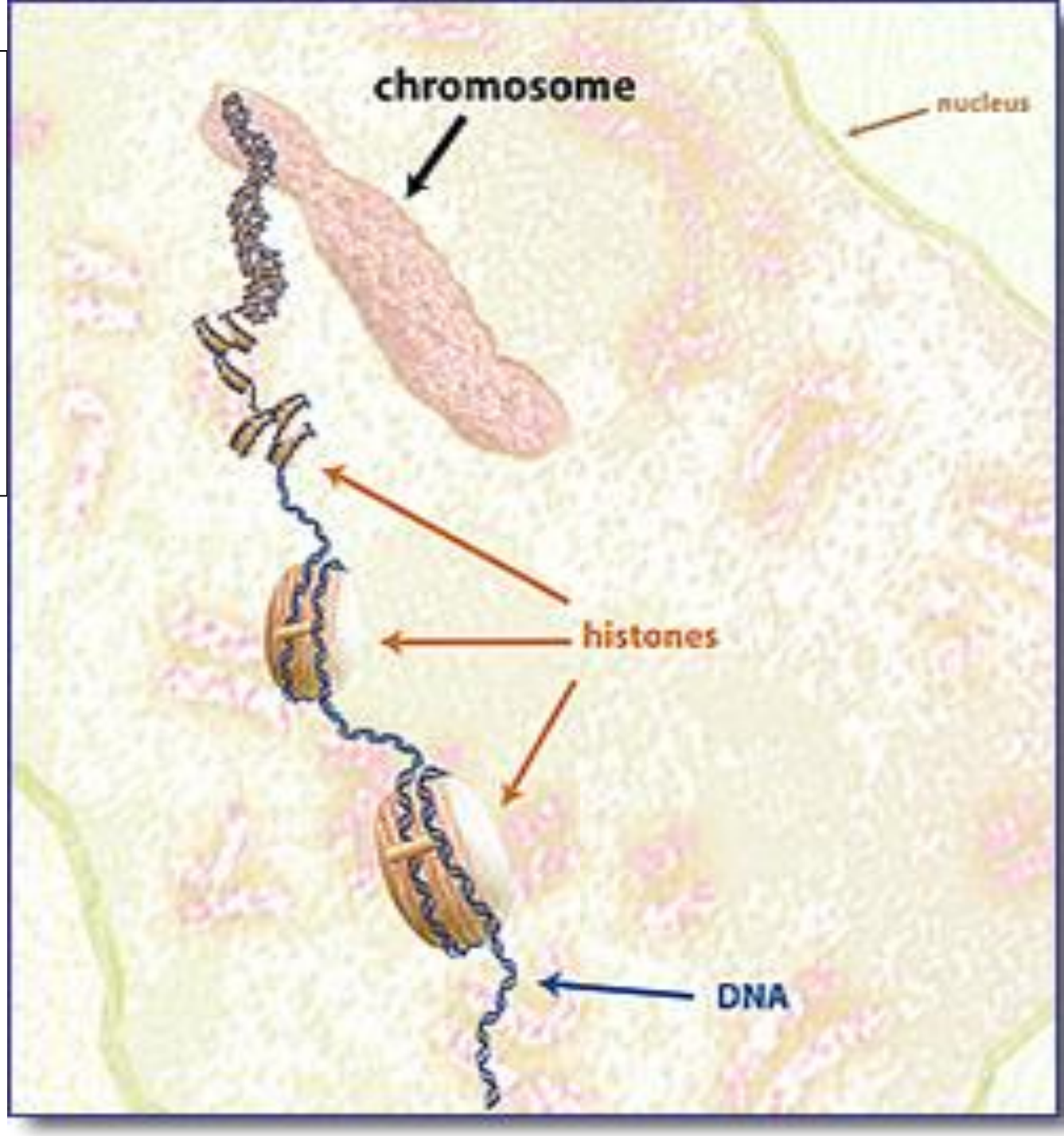
Metaphase

The chromosomes have been dyed red and the cell walls have been dyed green.



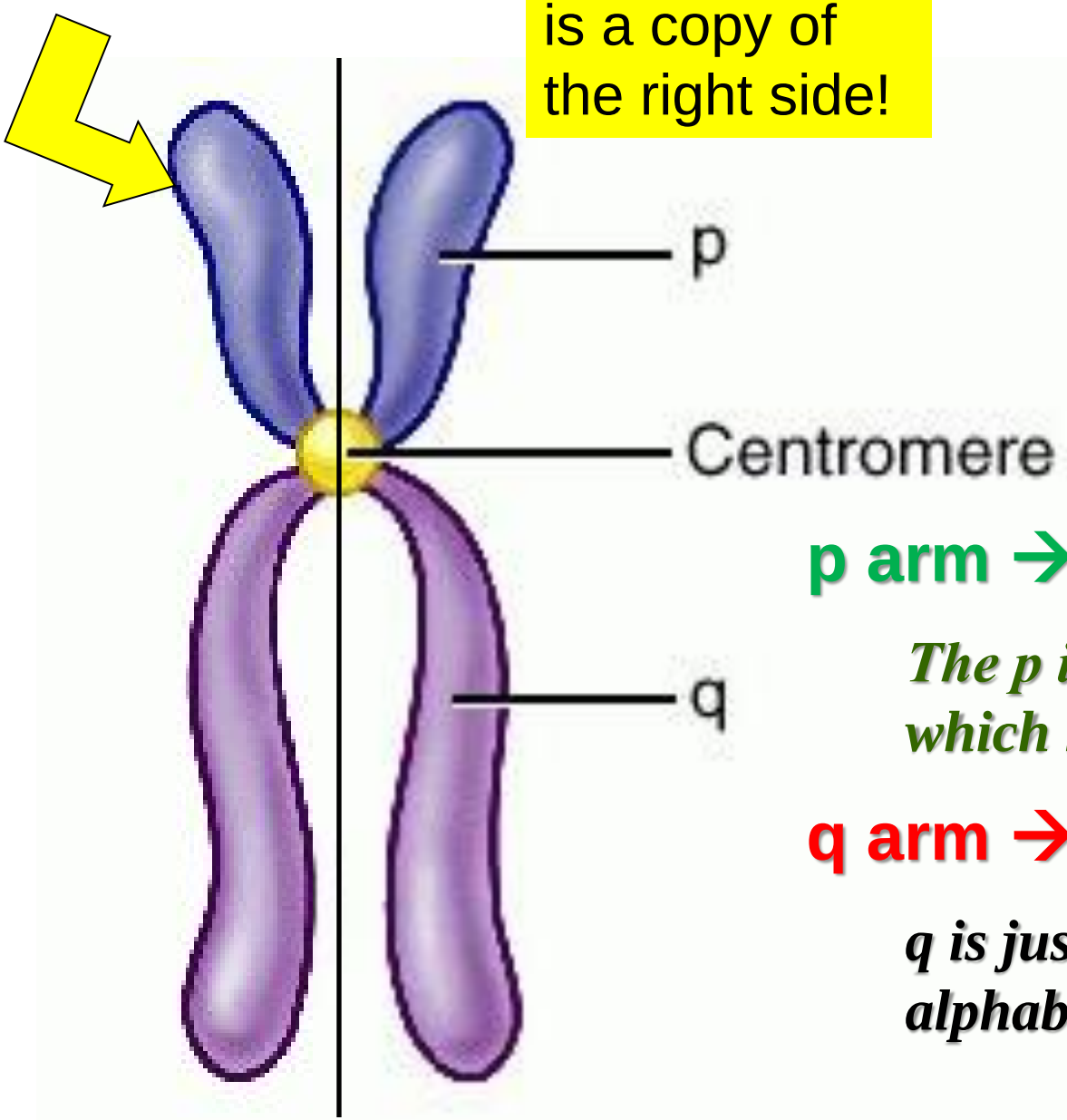
To form chromosomes, the DNA compacts itself into very tight coils.

Initially, the DNA coils itself around proteins called histones.



The left side

is a copy of the right side!



The general shape of an eukaryotic chromosome.

p arm → short side

The p is French for "petit" which means short.

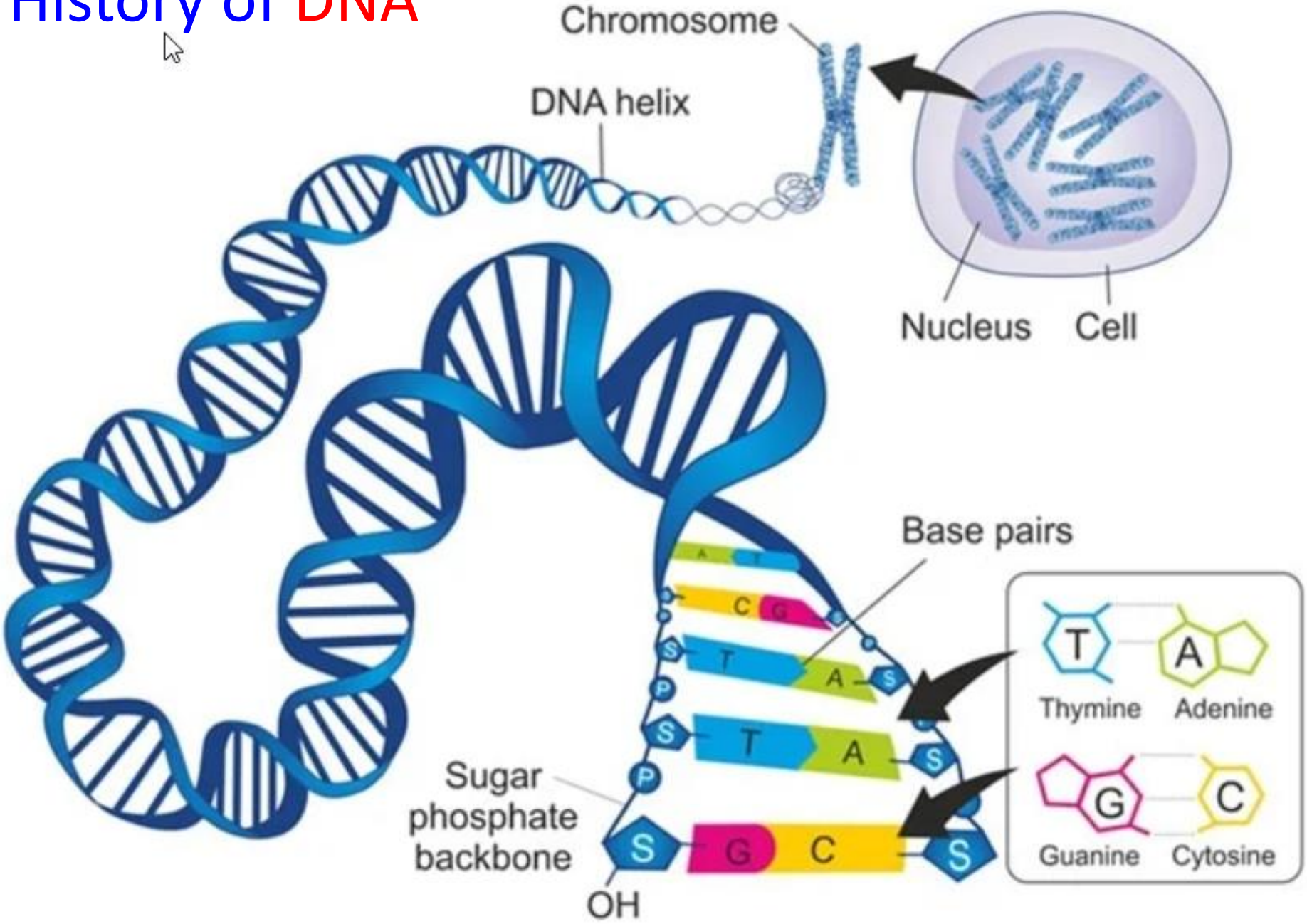
q arm → longer side

q is just the next letter of the alphabet.

Not-so-Random Fact Time

- One nm (or nanometer) is one billionth of a meter.
- A human hair is 80,000 nm thick.
- The DNA from one chromosome when stretched out can be anywhere from 1 to 3 meter long…(yes! meters).

History of DNA



Discovery of DNA

Friedrich Miescher (Swiss, 1869) experimented and isolated a new molecule - nuclein - from the cell nucleus.

He determined that nuclein was made up of hydrogen, oxygen, nitrogen and phosphorus and there was an unique ratio of phosphorus to nitrogen.

Nuclein, found in the nucleus, is now known as DNA.

He extracted and observed DNA from white blood cells.

Miescher, himself, believed that proteins were the molecules of heredity.

Friedrich Miescher

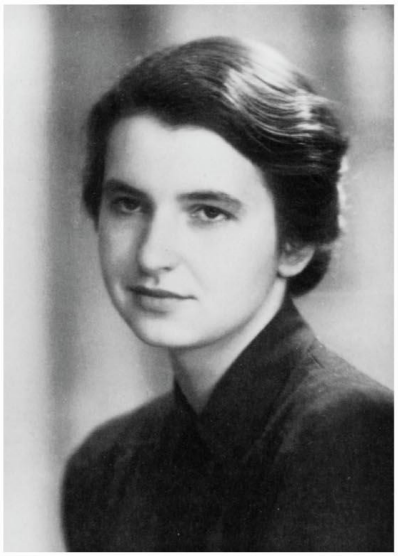
The Race for the Structure of DNA

The Contestants:

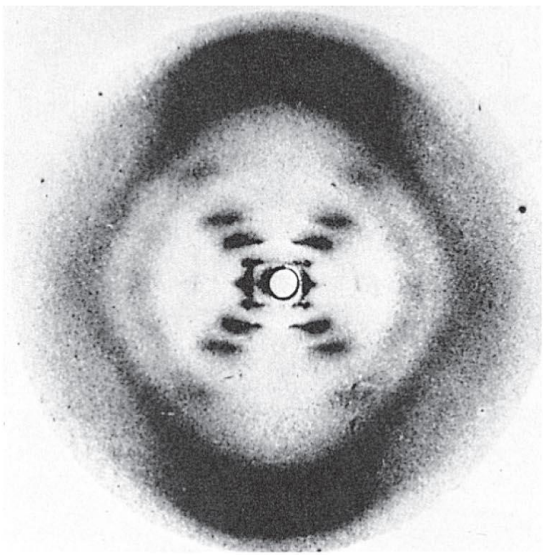
1. Maurice Wilkins and Rosalind Franklin
2. Watson and Crick

Wilkins & Franklin

Rosalind Franklin

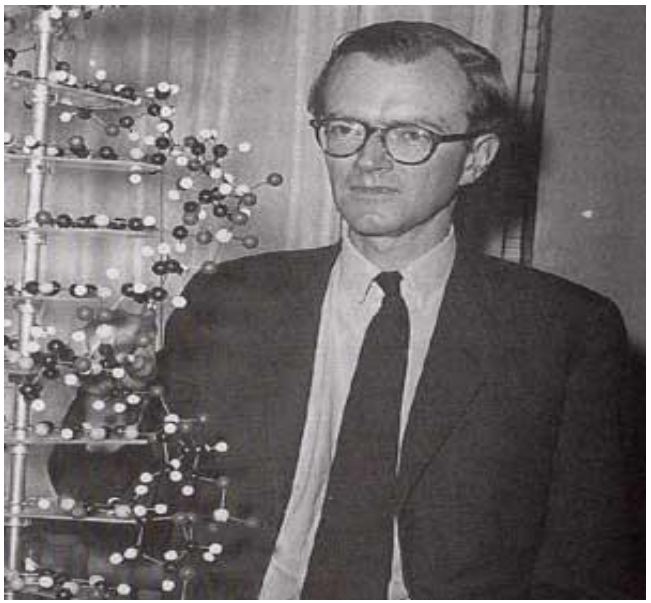


(a) Rosalind Franklin



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

Maurice Wilkins



X-ray crystallography images

DNA is a Double-Stranded Helix

- American James D. Watson journeyed to Cambridge University in England, where the more senior Francis Crick was studying protein structure with a technique called **X-Ray Crystallography**.

Francis Crick

James Watson

Maurice Wilkins

DNA is a Double-Stranded Helix

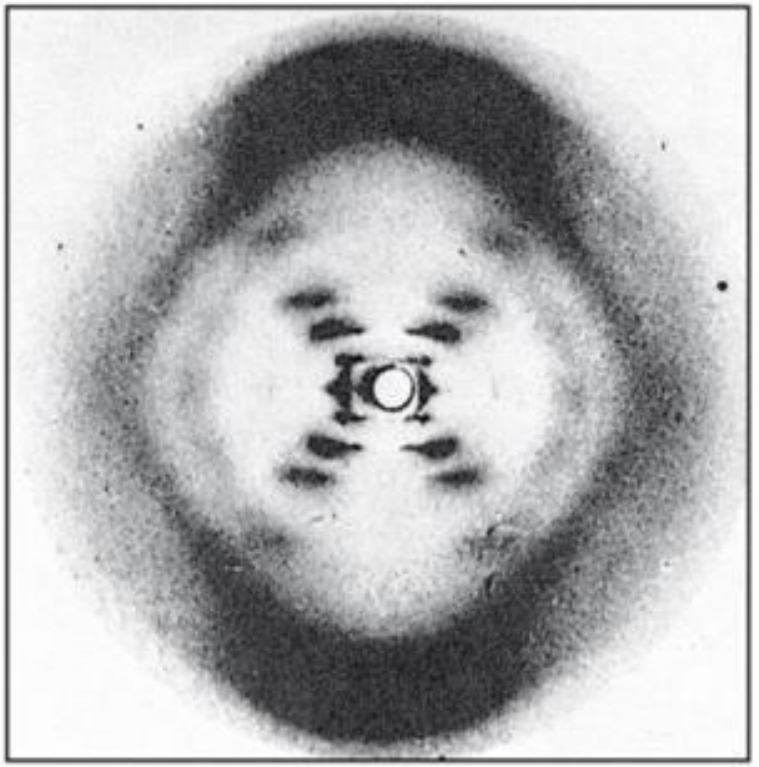
- While visiting the laboratory of Maurice Wilkins at King's College in London, Watson saw an X-ray image of DNA produced by Wilkins's colleague, Rosalind Franklin.

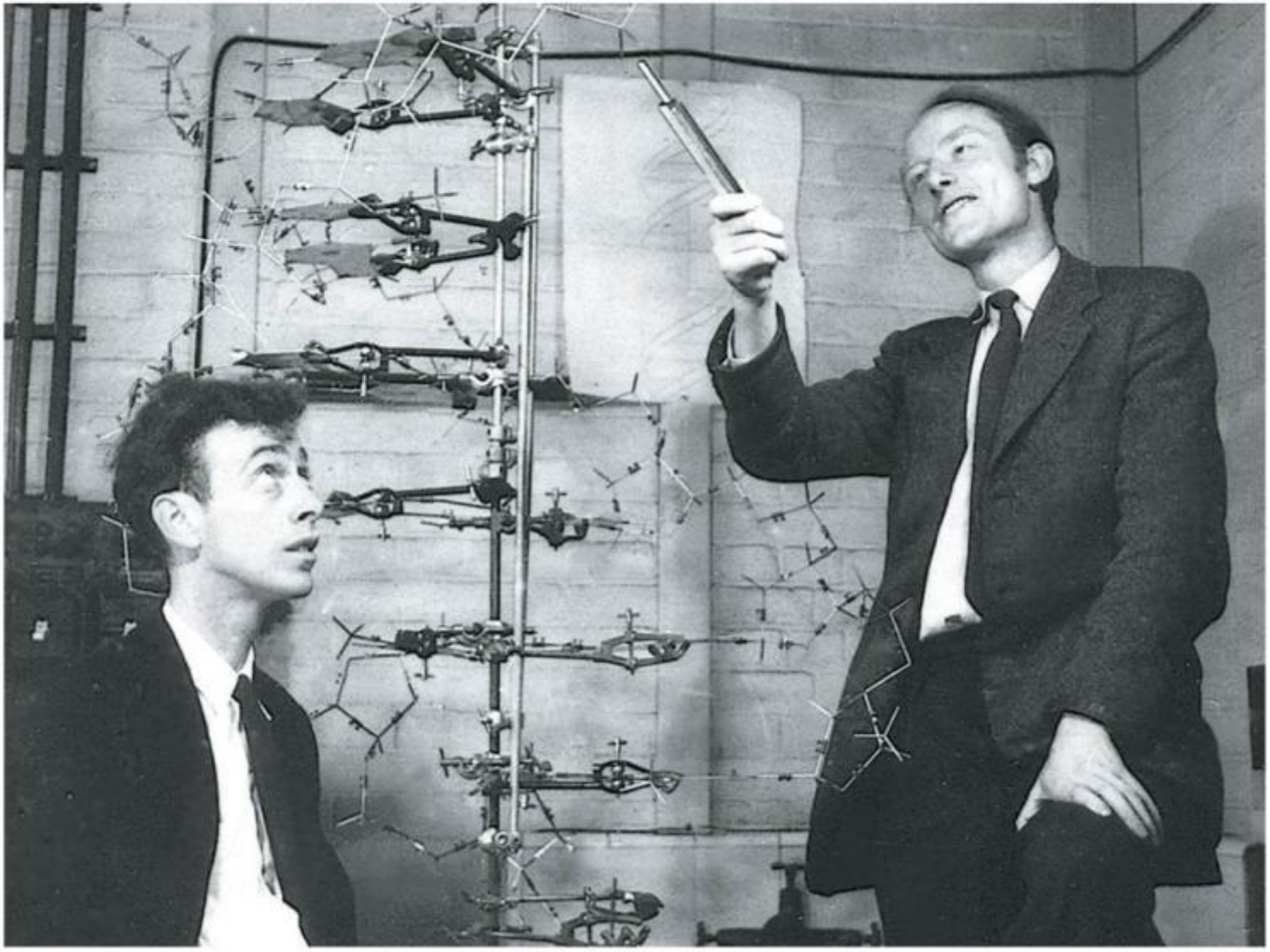
Francis Crick

James Watson

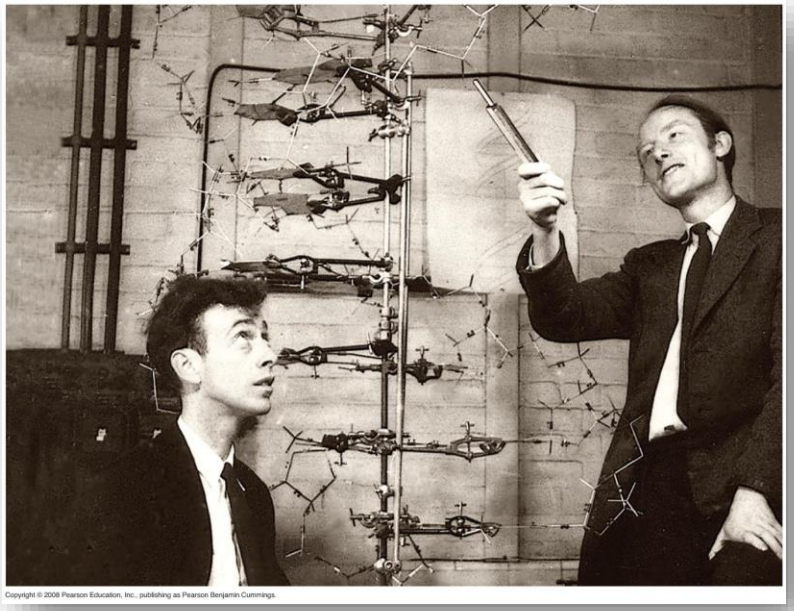
Maurice Wilkins

Rosalind Franklin





Watson and Crick put it all together

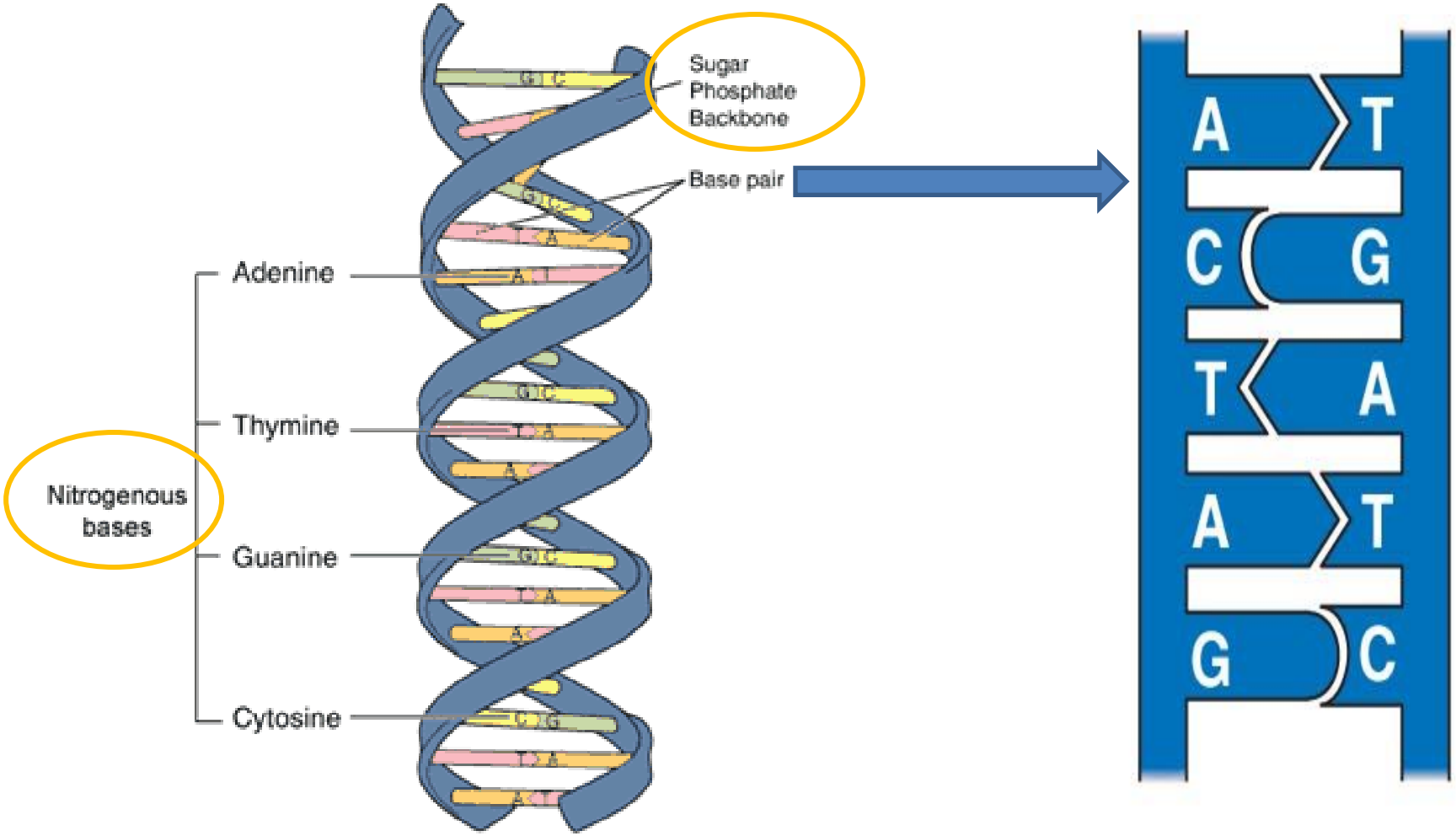


3-D structure of DNA = Double Helix

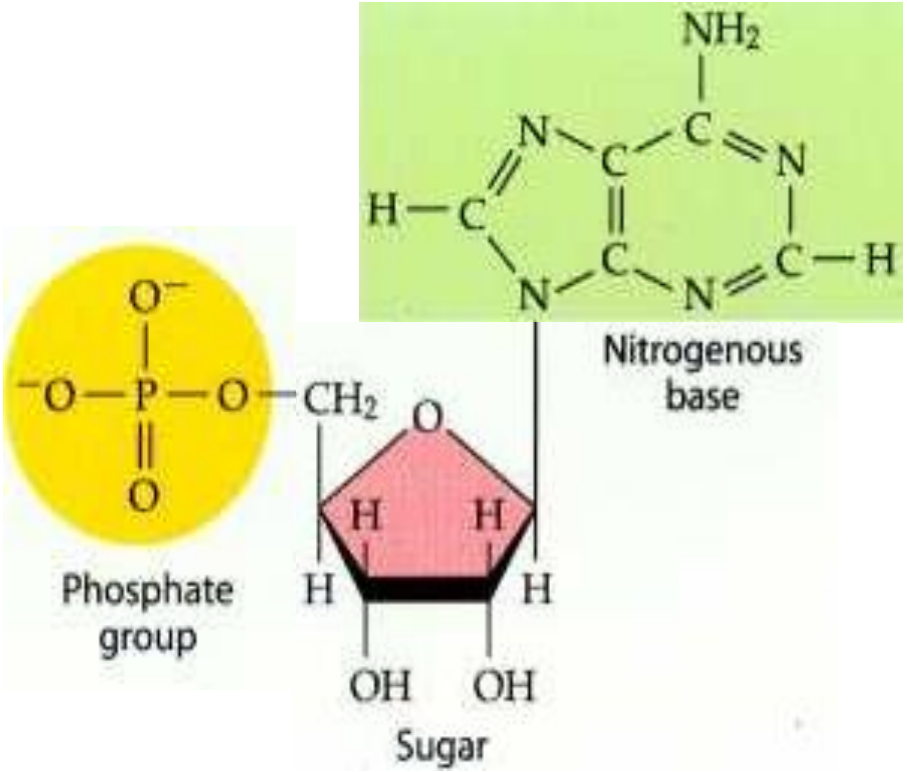
What they used to figure out the structure:

1. Basic components were
   - sugar,
   - phosphates
   - nitrogenous bases
2. Franklin's X-ray crystallography photos
3. Chargaff's Rule (*to be discussed in a few slides*)

Watson and Crick and the *double helix* *(twisted ladder)*

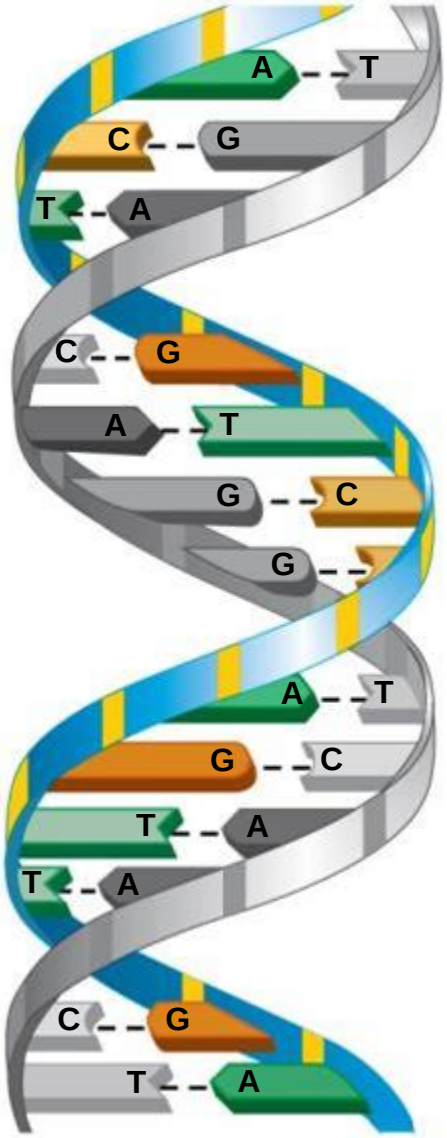


DNA is made up of repeating units called **nucleotides**

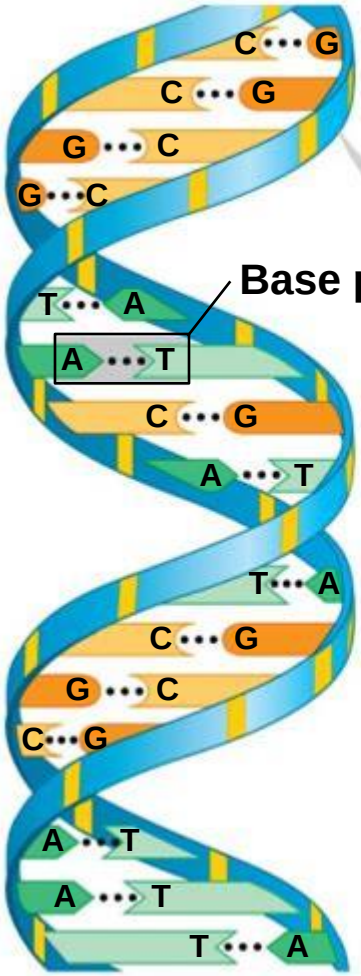


A **nucleotide**:

1. A **nitrogenous base**
   - organic
2. A sugar = **deoxyribose**
   - organic
3. **Phosphate group**
   - inorganic

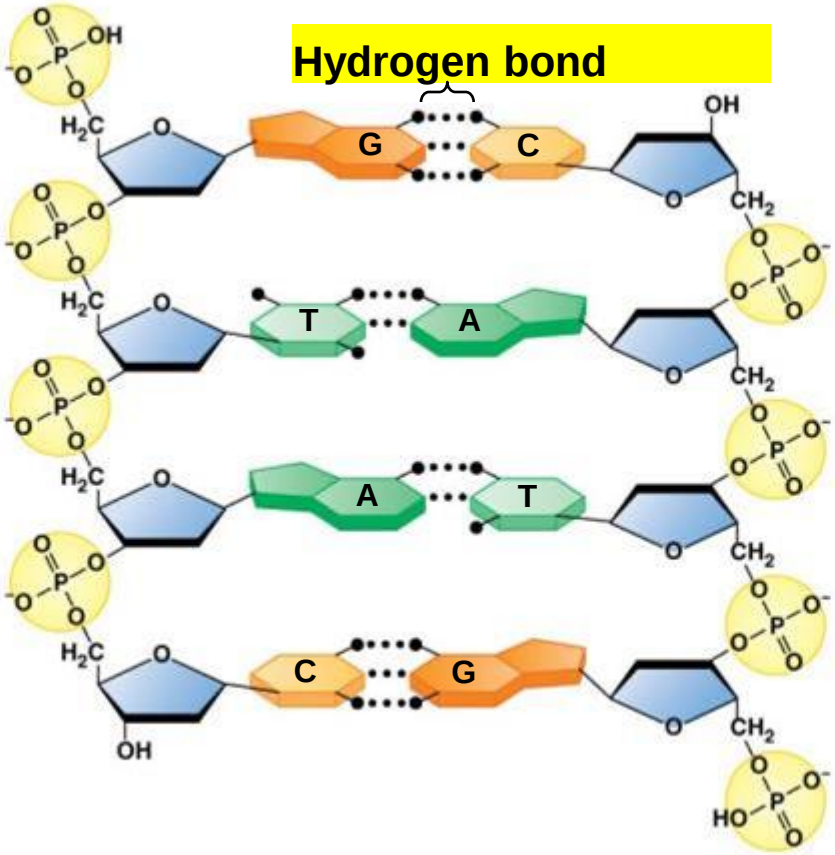


A DNA double helix



Base pair

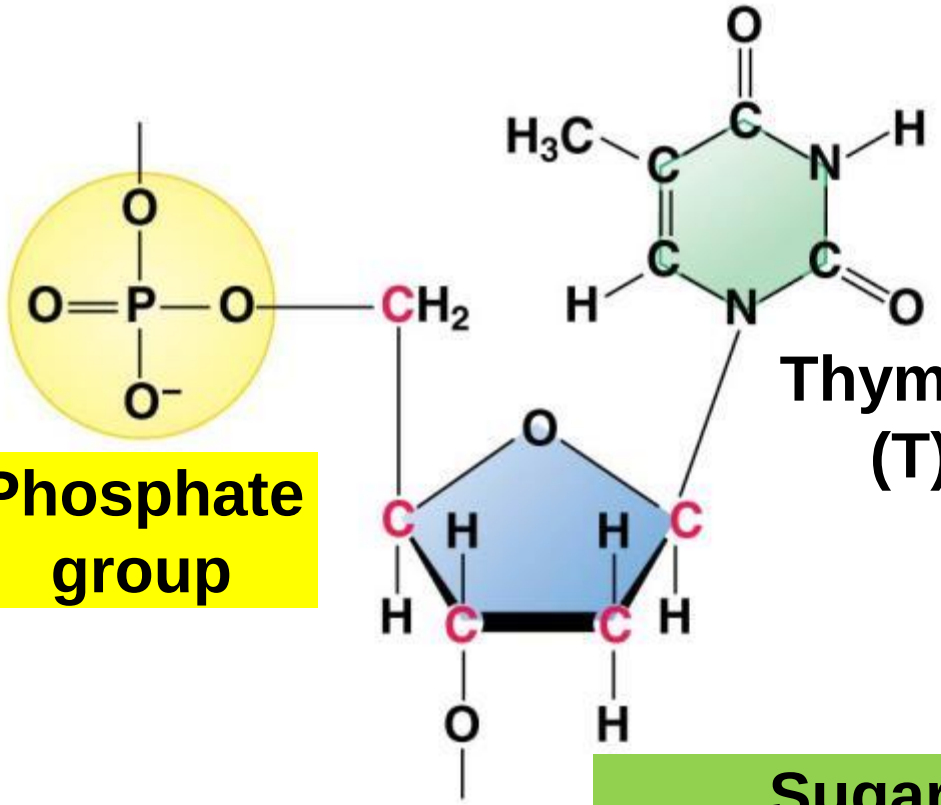
Ribbon model



Partial chemical structure

Computer model

Nitrogenous base (can be A, G, C, or T)



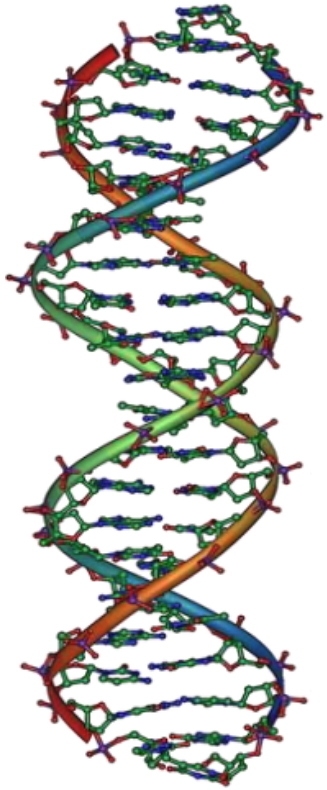
Phosphate group

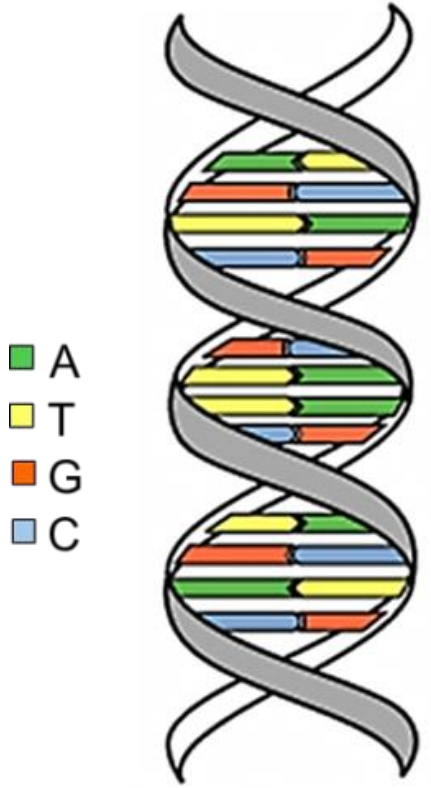
Sugar (deoxyribose)

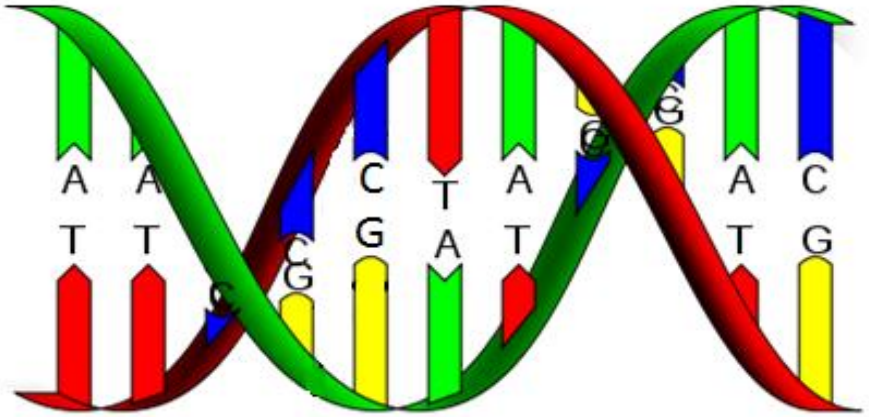
DNA nucleotide

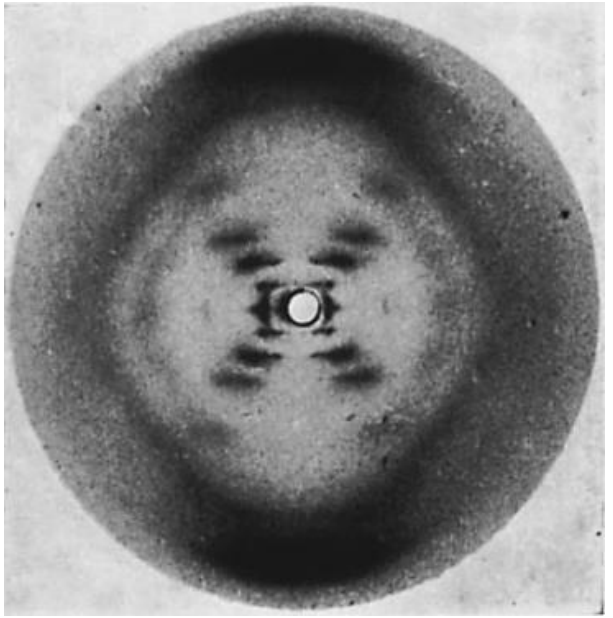
The Discovery of DNA

- 1860s: Friedrich Miescher identified DNA.
- 1940s: Erwin Chargaff created a rule for DNA bases.
- 1952: Rosalind Franklin created a photo of DNA structure.
- 1953: James Watson and Francis Crick created an accurate model of DNA.









The Watson and Crick Model of DNA

A double helix looks like a twisted ladder.

The backbone:

Sugar

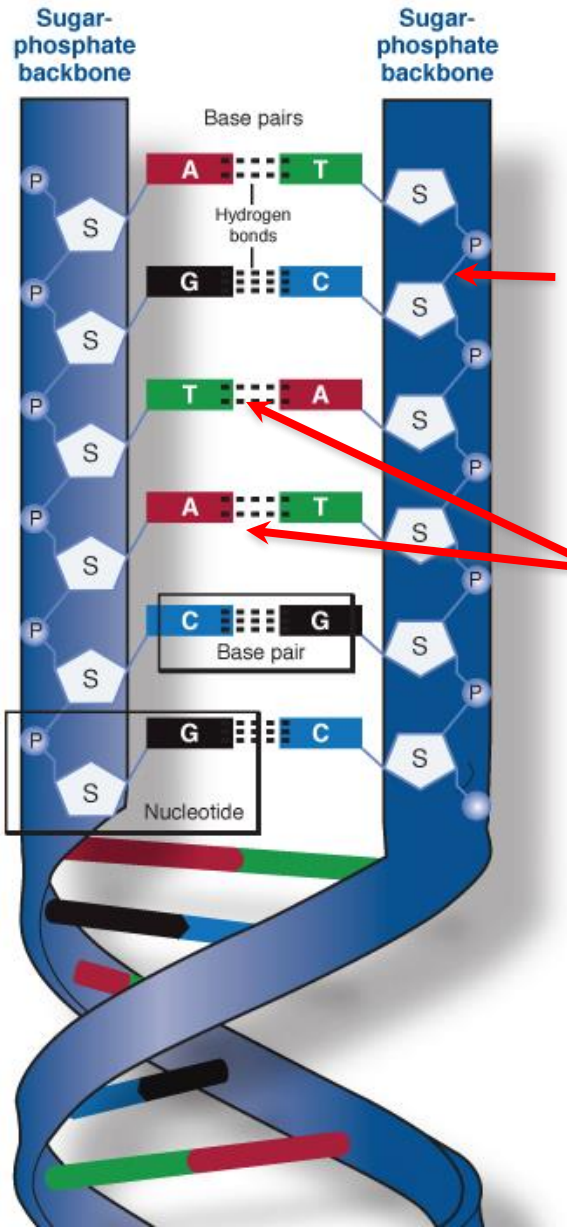
Phosphate groups

(Phosphodiester bonds)

The Rungs:

Two nitrogen bases that pair together across the center of the helix.

Hydrogen Bonds (weak): join the bases together.



Alternating sugar and phosphate groups connected by **phosphodiester bonds.**

Two nitrogen bases connected across the center of the helix by weak **hydrogen bonds.**

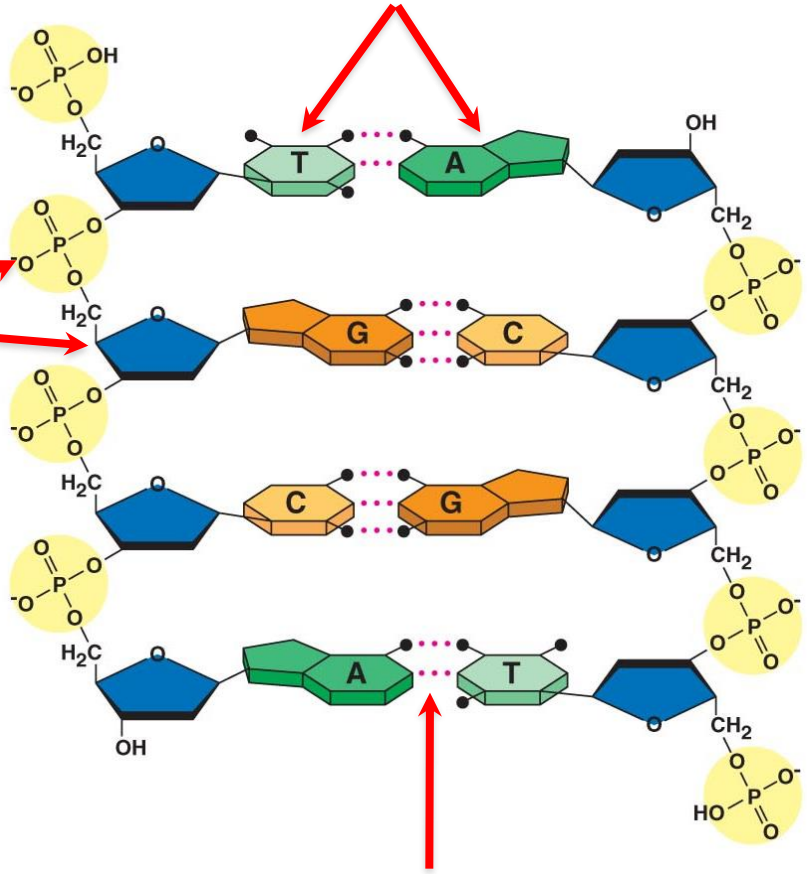
DNA is a Double-Stranded Helix

- Watson and Crick realized that DNA consisted of two polynucleotide strands wrapped into a **Double Helix**.
  - The **sugar-phosphate backbone** is on the **outside**.
  - The **nitrogenous bases** are perpendicular to the backbone in the **interior**.
  - **Specific pairs of bases** give the helix a uniform shape:
    - **A pairs with T**, forming **two hydrogen bonds.**
    - **G pairs with C**, forming **three hydrogen bonds.**

Structure of DNA … A Closer Look

Nitrogen Bases

Sugar
Phosphate
backbone



Hydrogen Bonds

4 Nitrogenous Bases

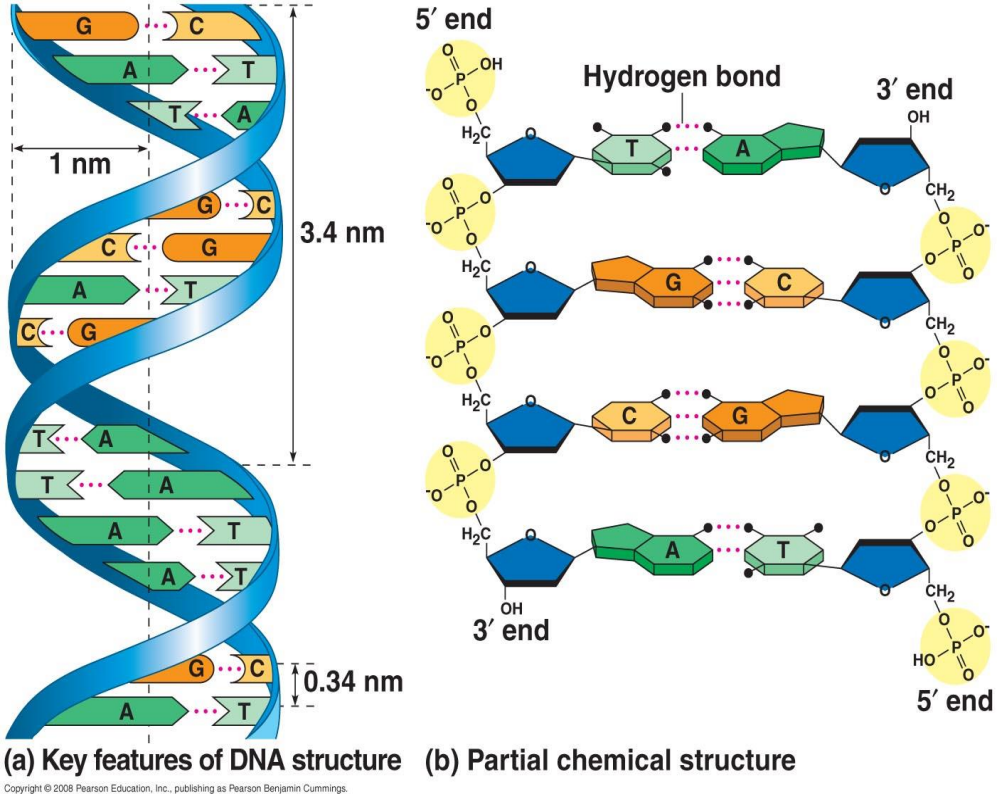
- Adenine
- Guanine
- Cytosine
- Thymine

Two families of bases:

A & G are purines

C & T are pyrimidines

DNA Double Helix



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Sugar-Phosphate 'Backbone'

- Covalently bonded

Chargaff's Rule:

$\# A = \# T$

$\#C \equiv \# G$

Complementary Base Pairs in DNA:

- Adenine always pairs with Thymine
- Cytosine always pairs with Guanine

DNA is a Double-Stranded Helix

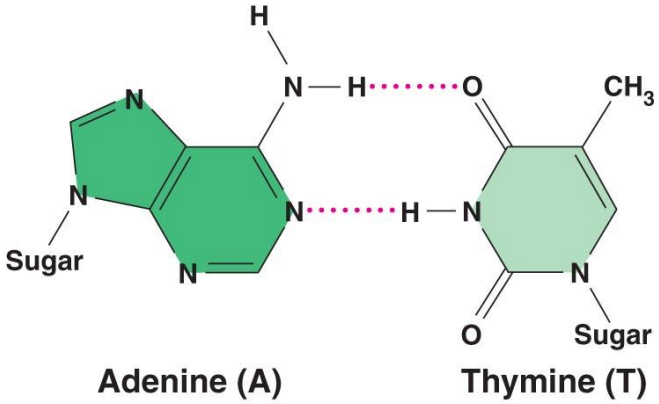
- In 1962, the Nobel Prize in Physiology or Medicine was awarded to James D. Watson, Francis Crick, and Maurice Wilkins.
  - Rosalind Franklin probably would have received the prize as well but for her death from cancer in 1958.
  - Nobel Prizes are never awarded posthumously.

DNA is a Double-Stranded Helix

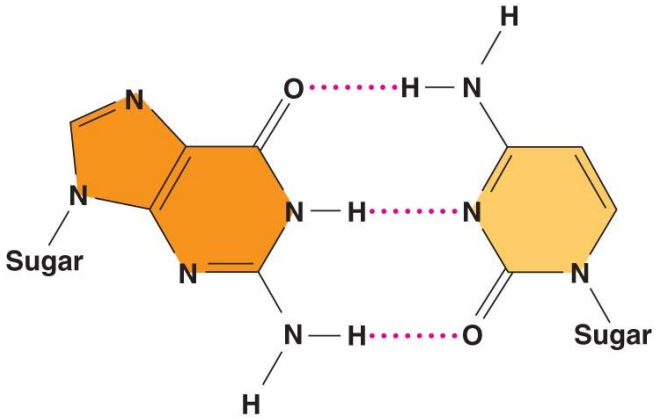
- The **Watson-Crick Model** gave new meaning to the words ***genes*** and ***chromosomes***. It showed:
  1) The **structure of DNA.**
  2) How DNA could **carry genetic information** and **copy it.**
- The genetic information in a chromosome is encoded in the **nucleotide sequence of DNA**.

QUICK CHECK

Complementary Pairs A-T, G-C



Adenine (A) Thymine (T)

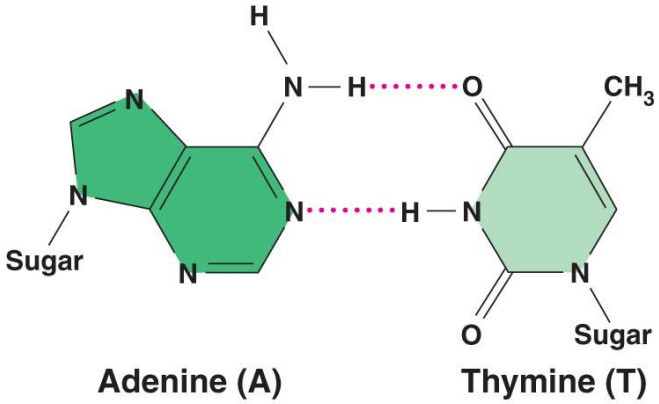


Guanine (G) Cytosine (C)

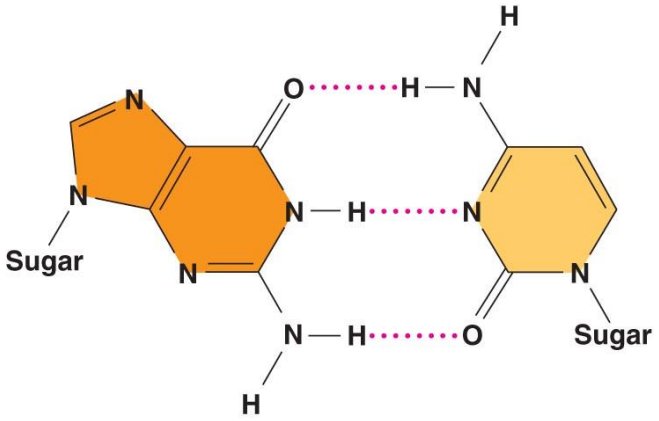
1. What type of bond holds the left side of the ladder to the right side?
2. Why is this important?
3. How many hydrogen bonds between each?

QUICK CHECK

Complementary Pairs A=T, G≡C



Adenine (A) Thymine (T)



Guanine (G) Cytosine (C)

1. What type of bond holds the left side of the ladder to the right side?

   Hydrogen bonds hold the *rungs* together

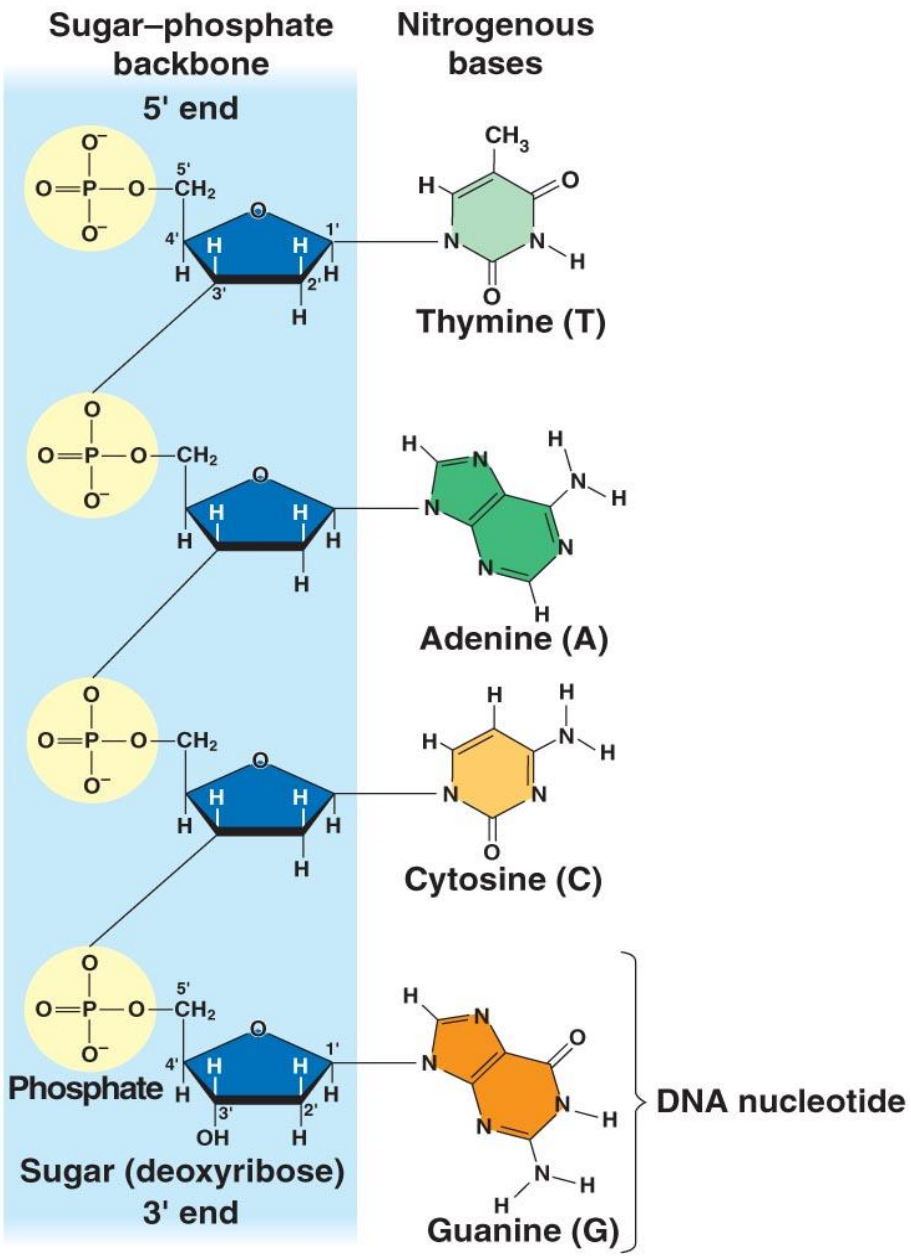
2. Why is this important?

   Easier to break than covalent bonds

3. How many hydrogen bonds between each?

   A=T (2), C≡G (3)

Nucleotides are the building blocks of DNA



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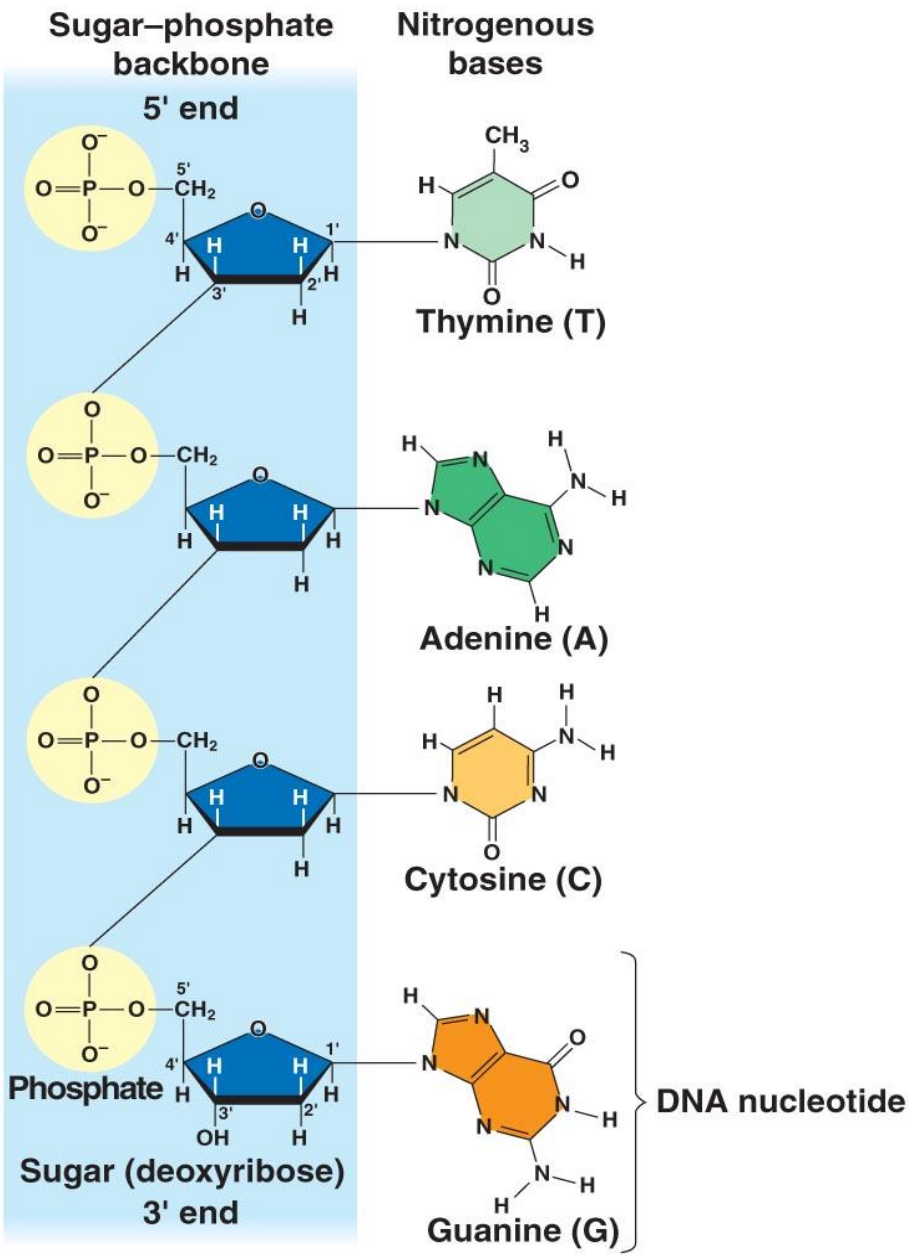
1. How do you make the other side??

P
S - T
P
S - A
P
S - C
P
S - G

left side

Nucleotides are the building blocks of DNA



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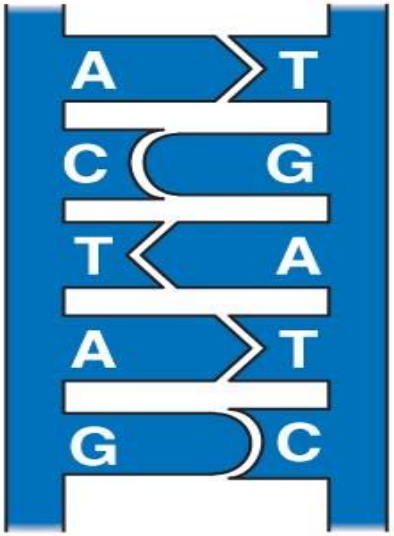
P P
S – T = A - S
P P
S – A = T - S
P P
S – C ≡ G - S
P P
S - G ≡ C – S

left side right side

DNA Replication



1. When does this occur?

   - **End of Interphase (S)**

2. Why does this occur?

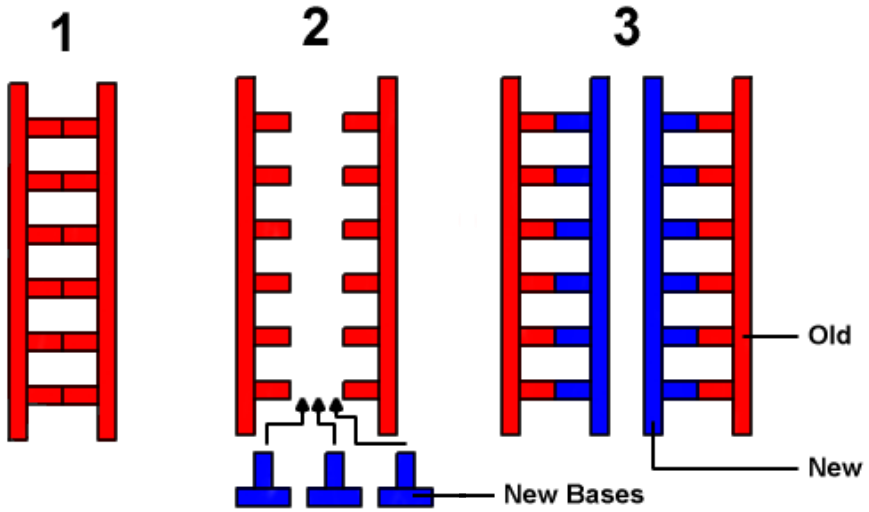
   - **Need to make another copy of DNA for the new cell.**

3. How does this occur?

   - **Semi-Conservative Replication**
   - **Each copy contains one original strand and one newly-synthesized strand.**

Steps Involved in DNA
Semi-Conservative Replication

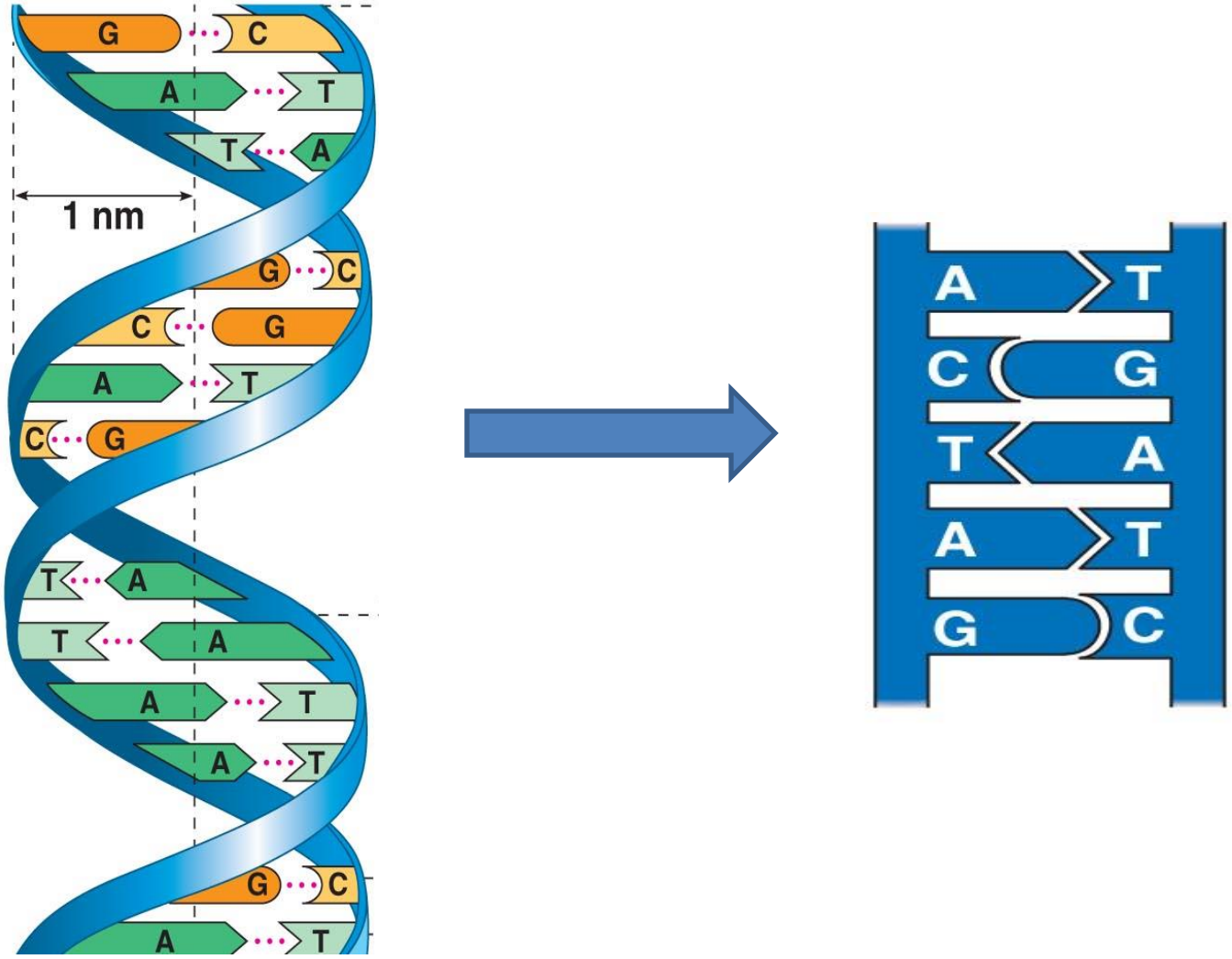
1. Unwind helix
2. Unzip Helix
3. Replicate Helix



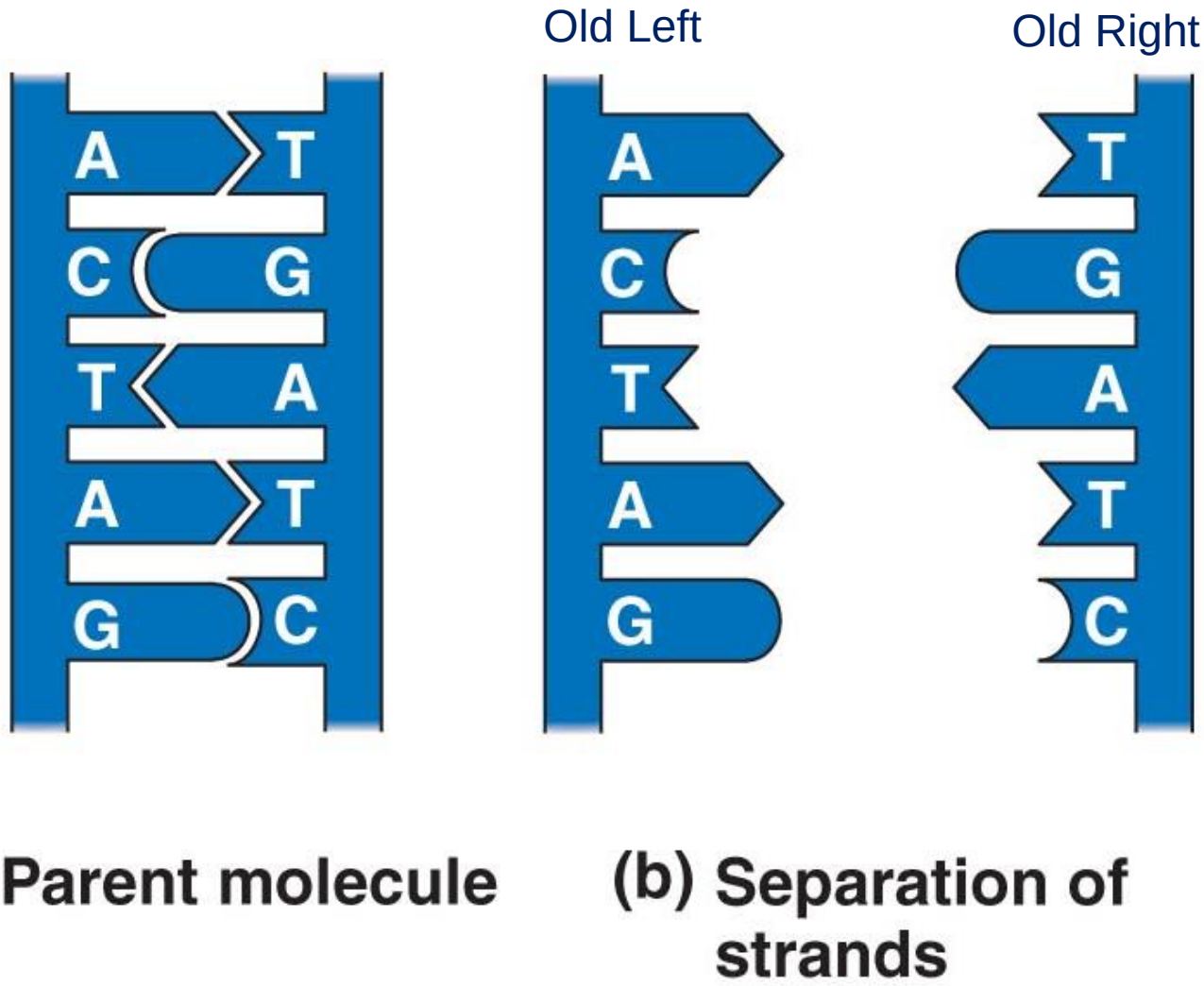
What tells the DNA to do this?

- **Enzymes**

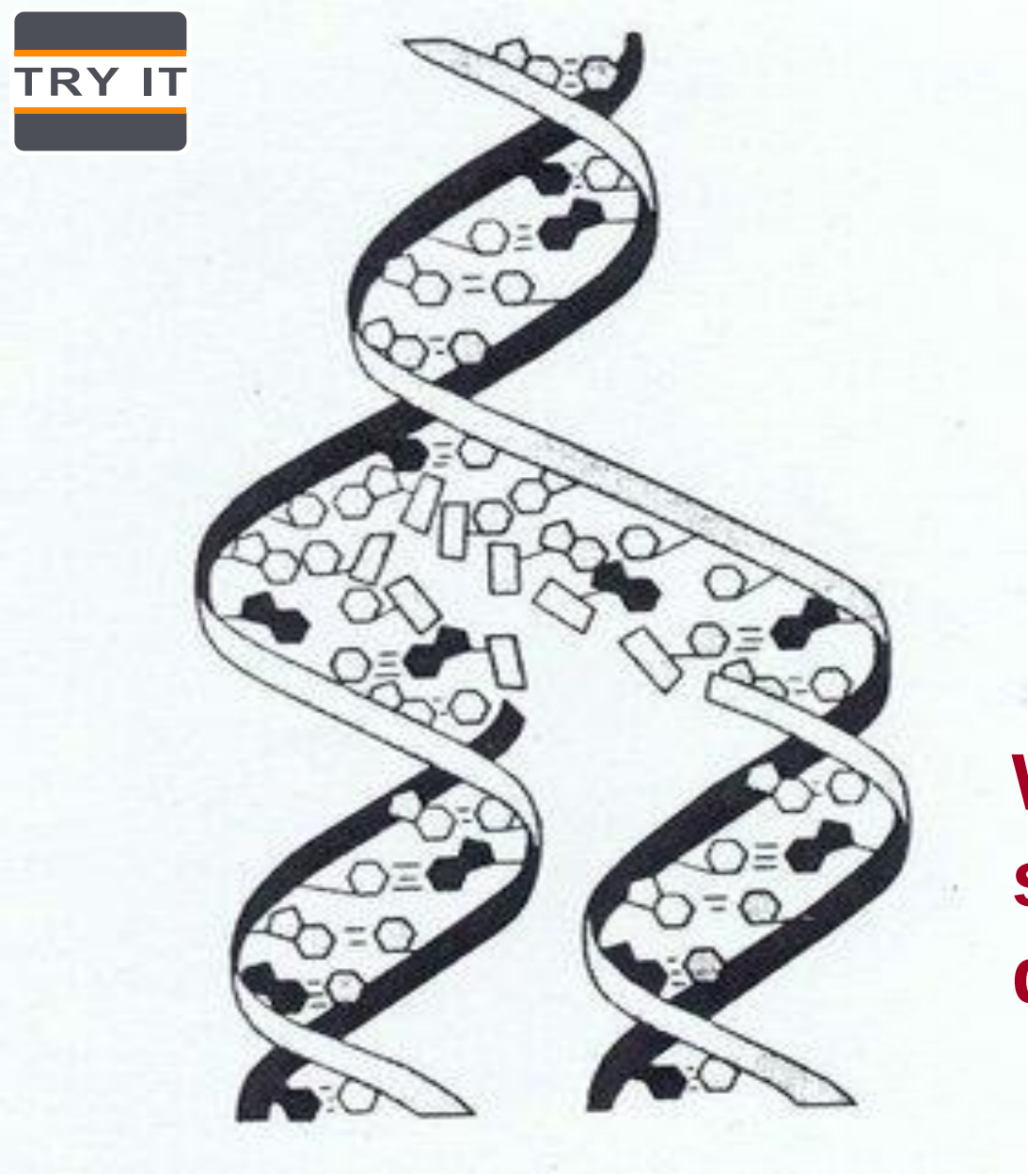
Step 1: Unwind



Step 2: Unzip


Old Left
Old Right
A
T
C
G
T
A
A
T
G
C
A
C
T
A
G
T
G
A
T
C
(a) Parent molecule
(b) Separation of strands

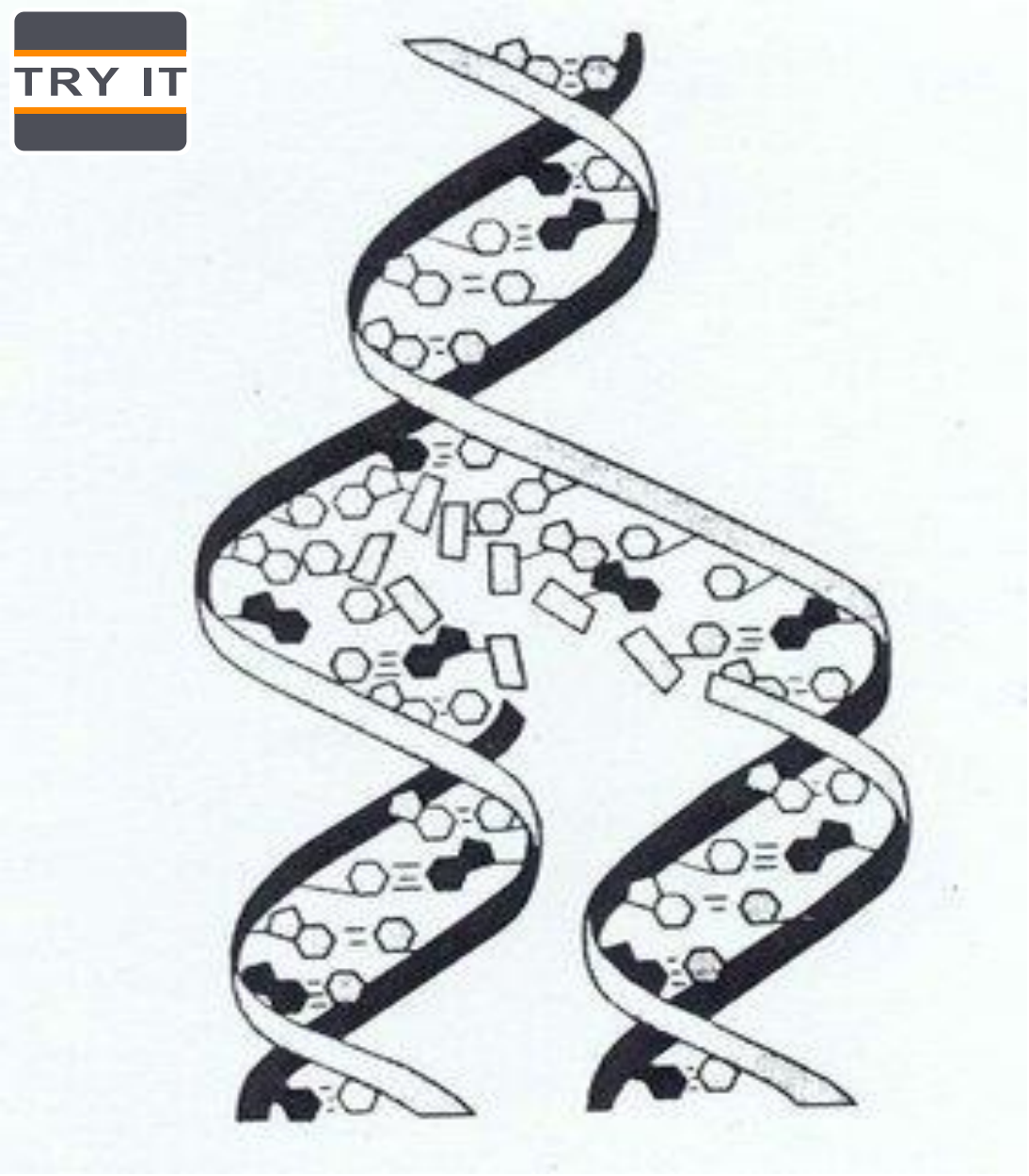
TRY IT



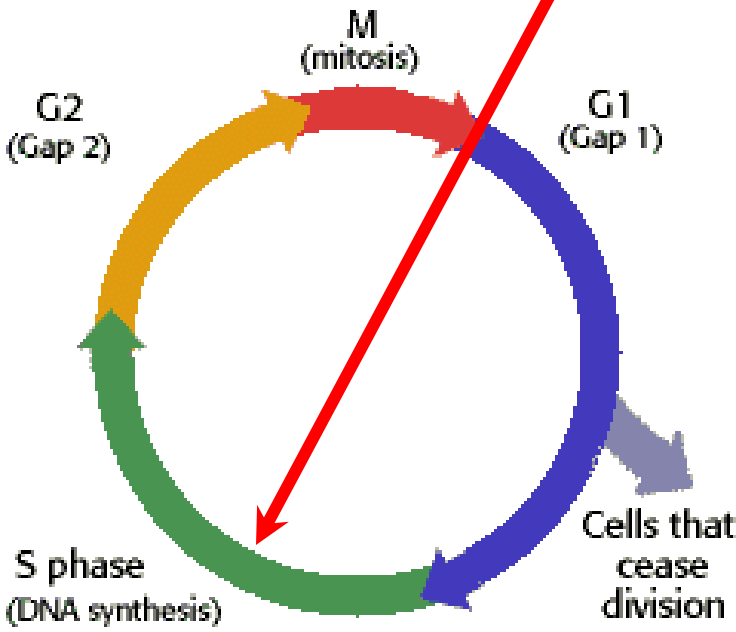
The DNA is unzipped and reconstructed into duplicate strands during the S phase of the cell cycle.

What does the S stand for and when does it occur?

TRY IT



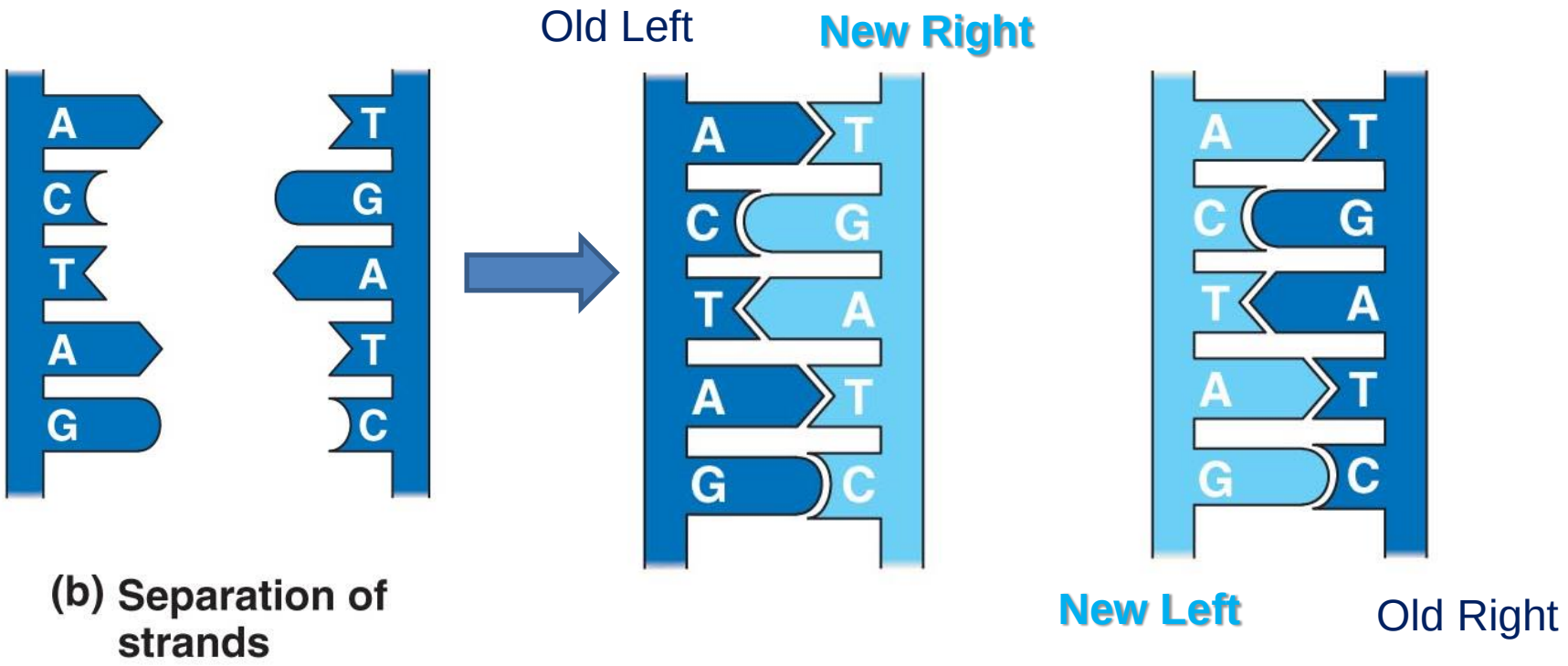
The DNA is unzipped and reconstructed into duplicate strands during the S phase of the cell cycle.



Interphase

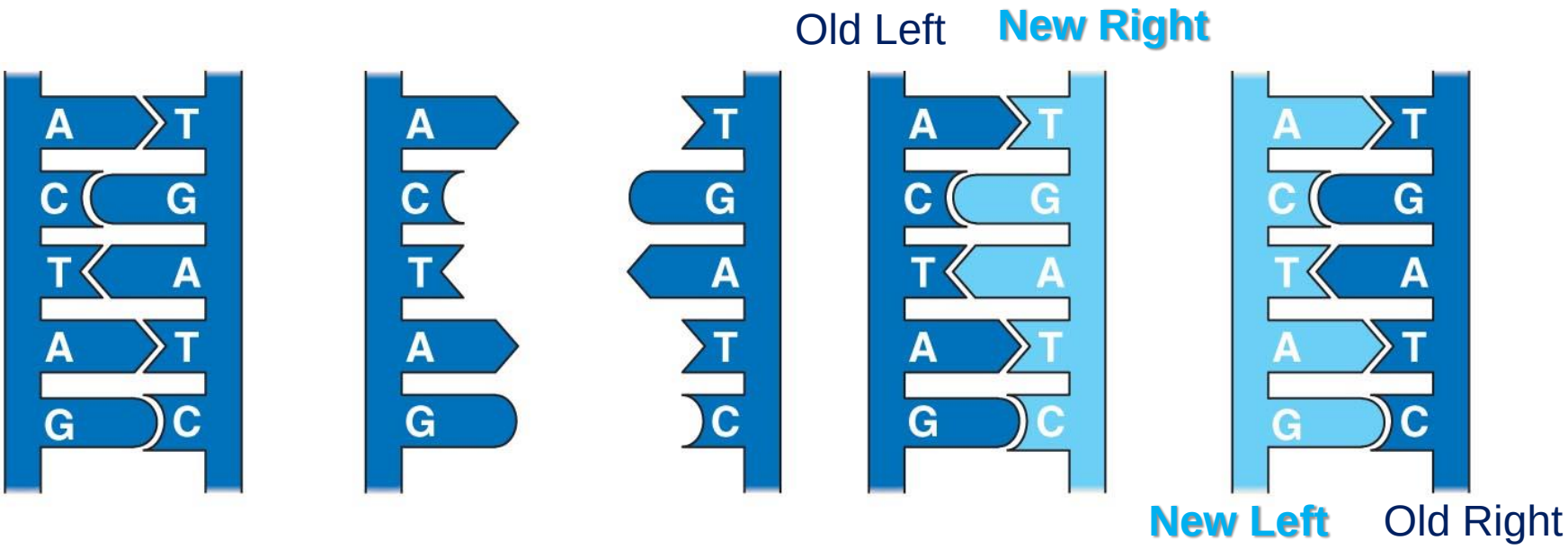
"Synthesis"

Step 3: Replicate



(Semi-conservative)

Step 3: Replicate



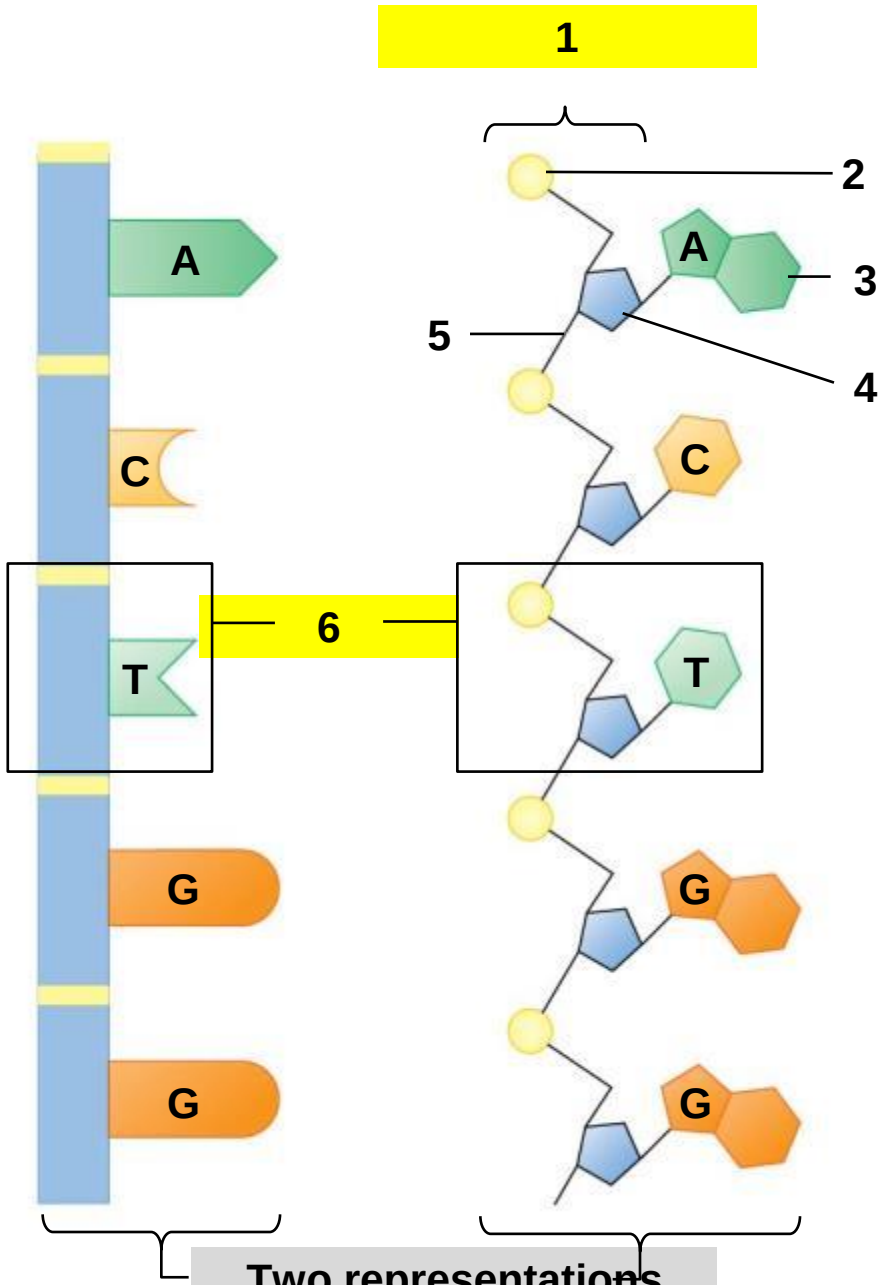
(a) Parent molecule

(b) Separation of strands

(c) "Daughter" DNA molecules, each consisting of one parental strand and one new strand

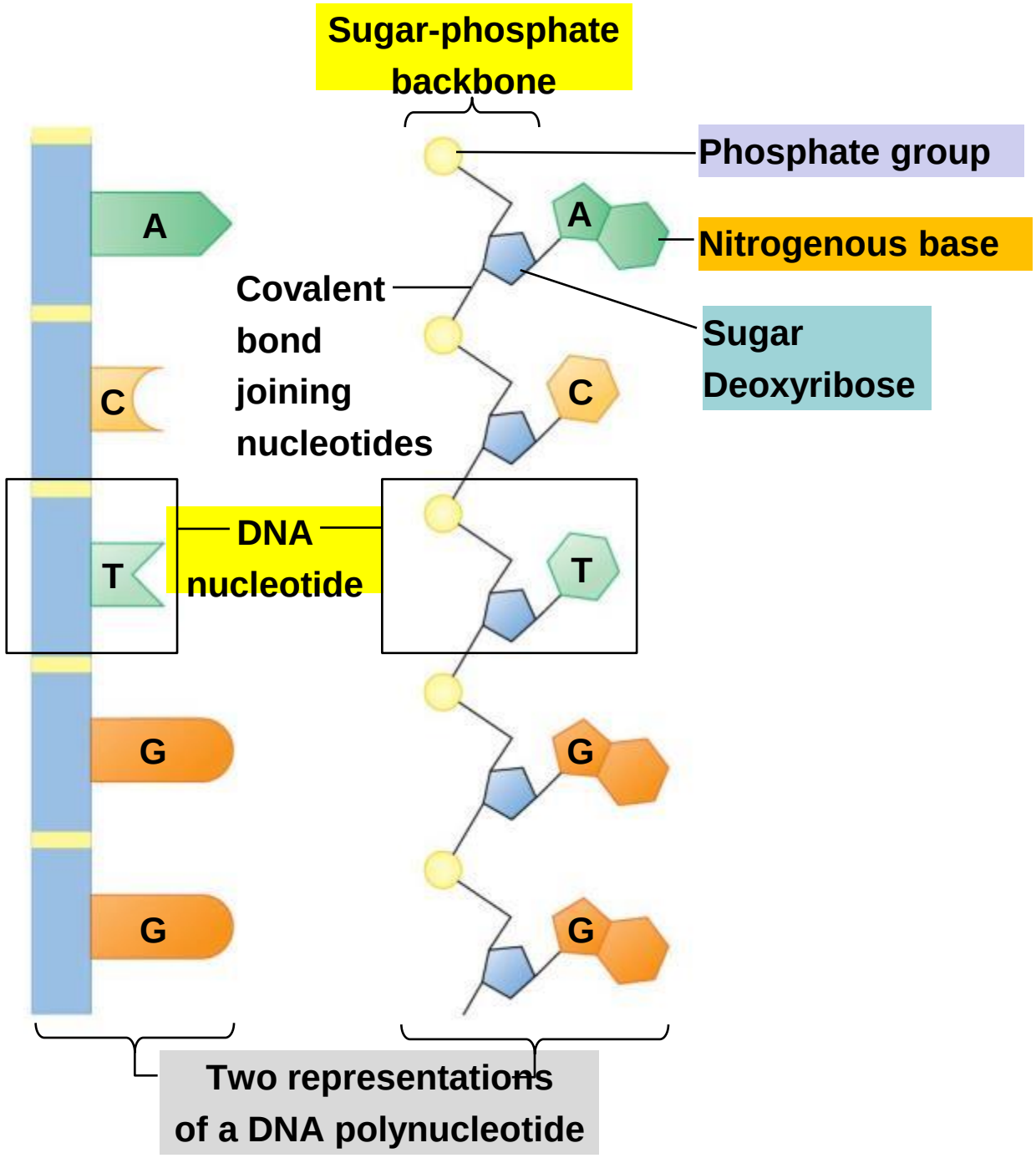
(Semi-conservative)

QUICK CHECK



Two representations of a DNA polynucleotide

QUICK CHECK


Sugar-phosphate backbone
Phosphate group
Nitrogenous base
Sugar Deoxyribose
Covalent bond joining nucleotides
DNA nucleotide
A
C
T
G
G
A
C
T
G
G
Two representations of a DNA polynucleotide

DNA and RNA are Polymers of Nucleotides

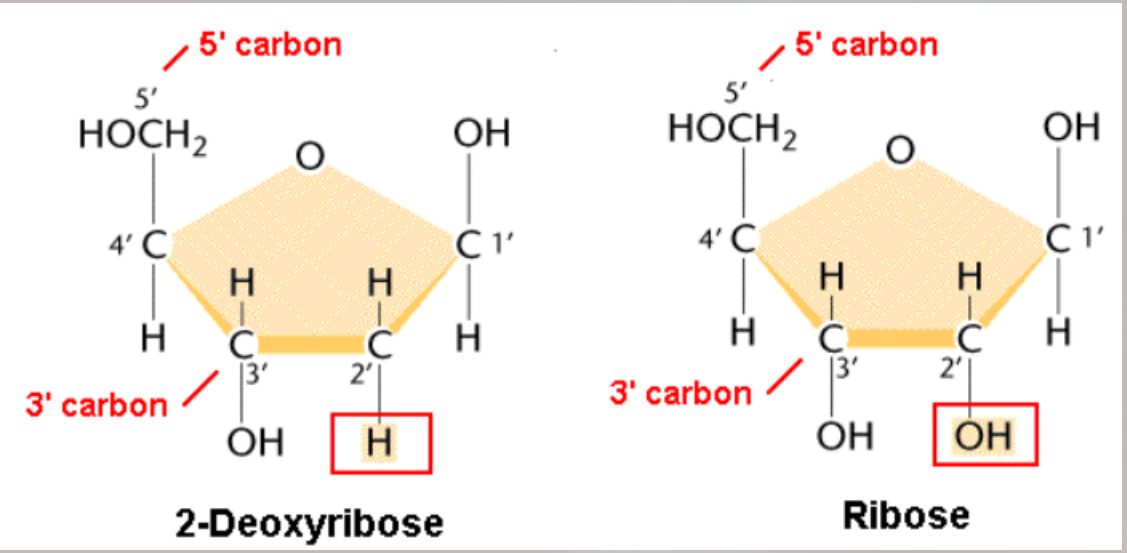
- The full name for **DNA** is **Deoxyribonucleic Acid**, with ***nucleic*** referring to DNA's location in the nuclei of eukaryotic cells.
- **RNA (ribonucleic acid)** is unlike DNA in that it
  - uses the sugar **Ribose** (instead of deoxyribose in DNA).
  - has a nitrogenous base **Uracil (U)** instead of **Thymine (T).**

RNA Differs from DNA

1. Sugar

   RNA's sugar: Ribose

   DNA's sugar: Deoxyribose

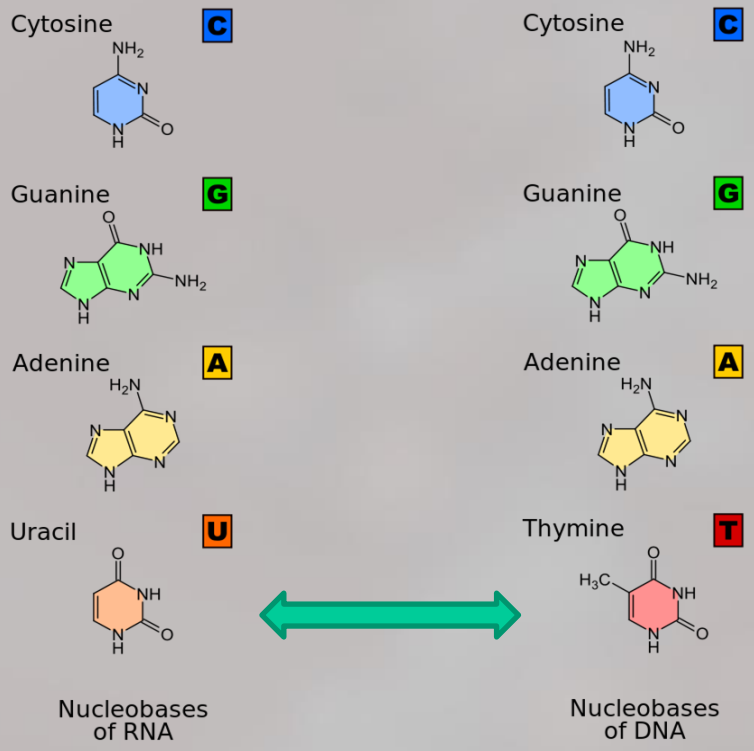


RNA Differs from DNA

2. Bases

RNA has Uracil (U)

DNA has Thymine (T)

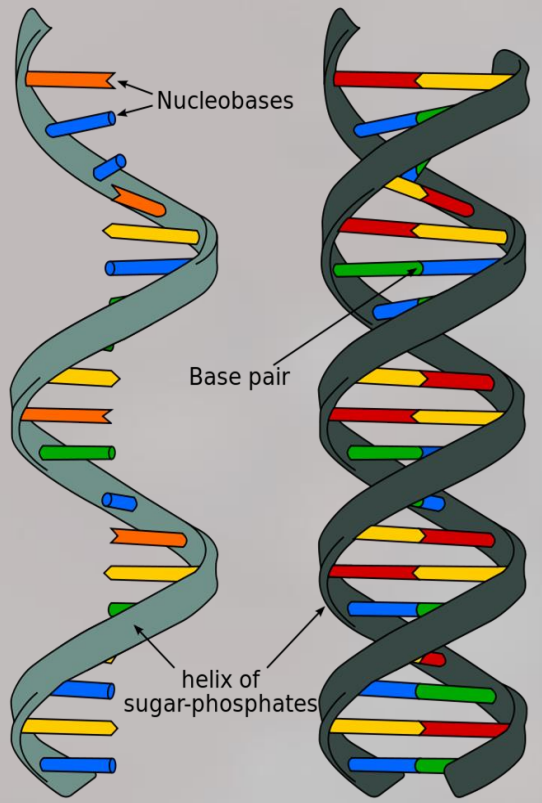


RNA Differs from DNA

3. Structure

RNA is single-stranded

DNA is double-stranded



TRY IT

DNA and RNA are Polymers of ?

- **DNA and RNA** are ? consisting of long chains (?) of monomers called **?**.
- Each of the **#?** strands of DNA is a DNA nucleotide polymer (chain).
- A **Nucleotide** is composed of a
  - **?**
  - **?**
  - **?**
- The nucleotides are joined to one another by a **?** **backbone**

TRY IT

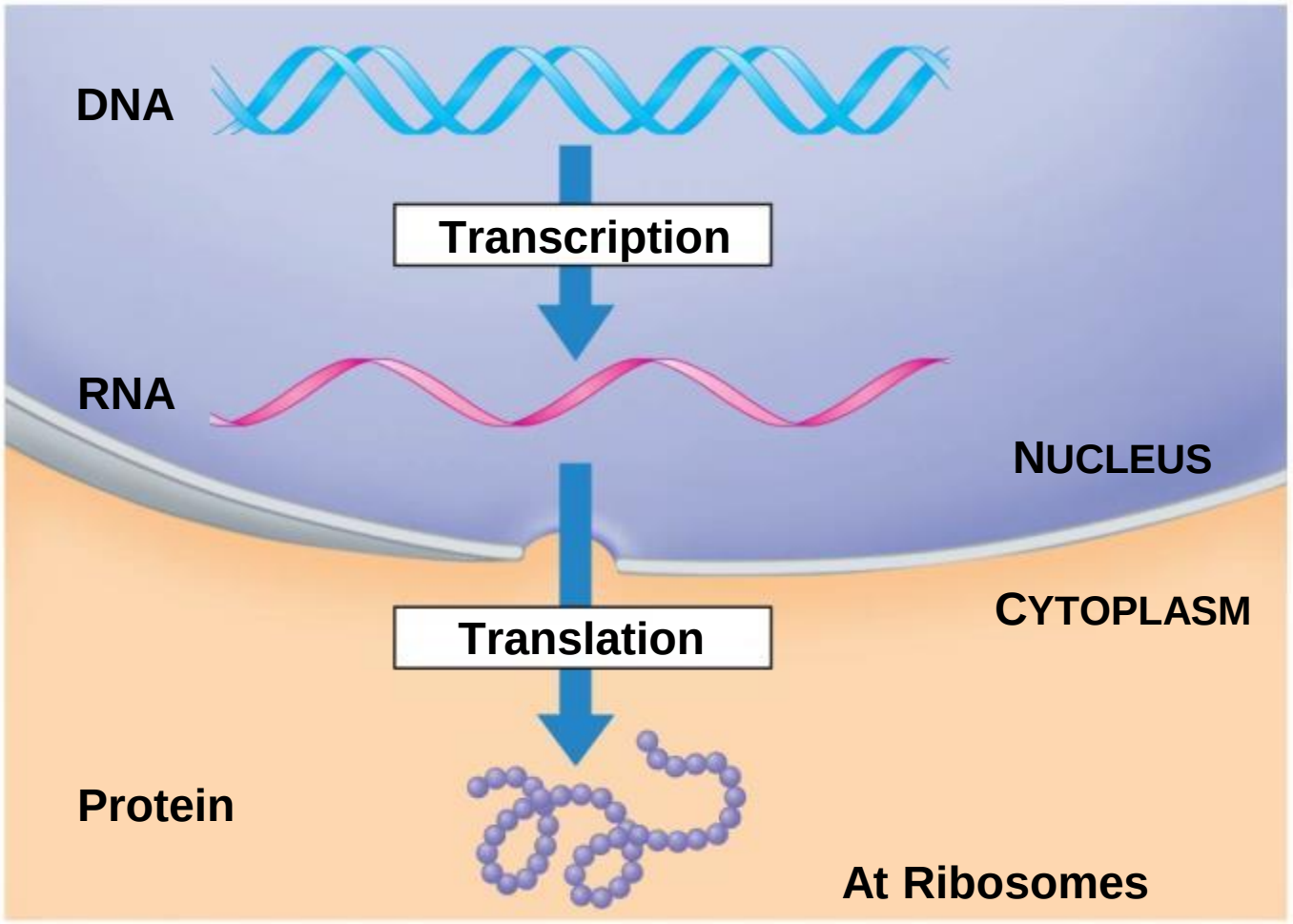
DNA and RNA are Polymers of Nucleotides

- **DNA and RNA** are nucleic acids consisting of long chains (polymers) of monomers called **Nucleotides**.
- Each of the **two strands of DNA** is a DNA nucleotide polymer (chain).
- A **Nucleotide** is composed of a
  - **nitrogenous base**
  - **five-carbon sugar**
  - **phosphate group**
- The nucleotides are joined to one another by a **Sugar-Phosphate backbone.**

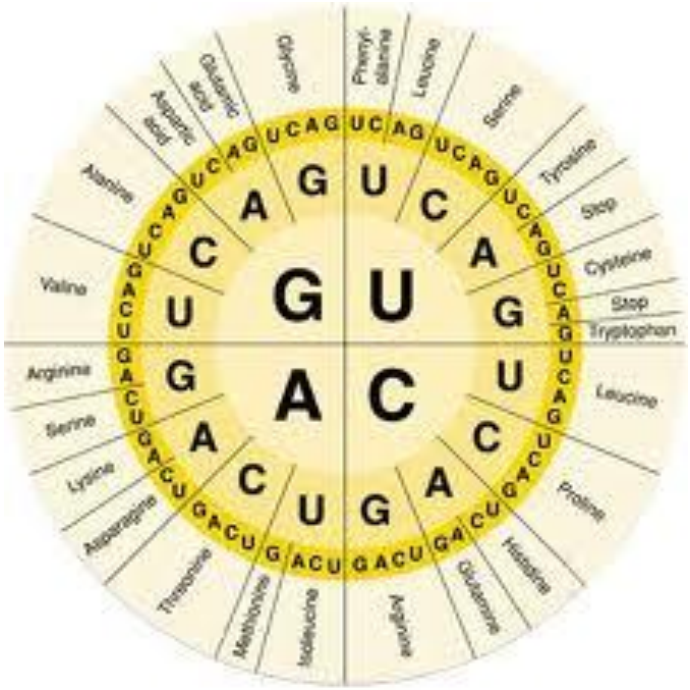
Genes control Phenotypic Traits through the Synthesis of Proteins

DNA specifies Traits by dictating Protein Synthesis.

- **Proteins** are the links between **genotype (genetic make up) and phenotype (appearance).**
- The **molecular chain of command** is from
  - **DNA in the nucleus to RNA.**
  - **RNA in the cytoplasm to protein.**


DNA
Transcription
RNA
NUCLEUS
CYTOPLASM
Translation
Protein
At Ribosomes

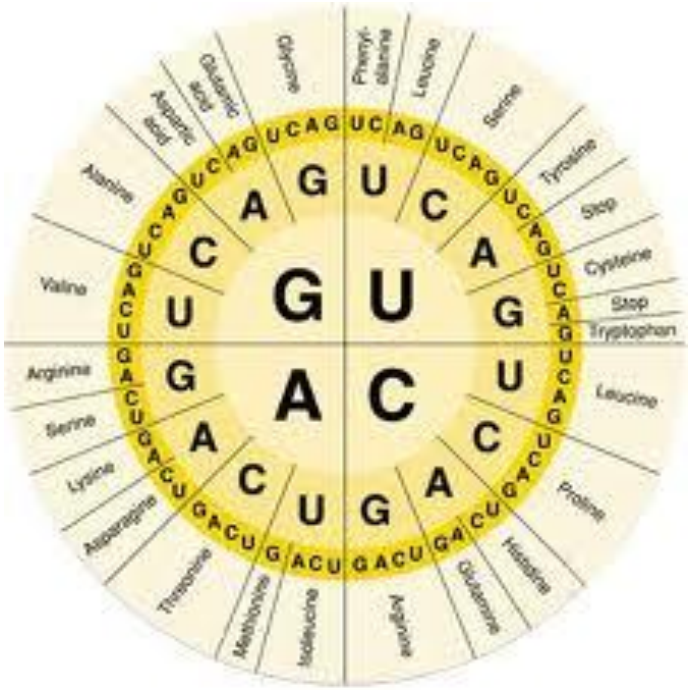
Gene Expression



The DNA molecule, with its four nitrogenous bases, is the code for all proteins that are made in a cell.

Genes make up a portion of the DNA strand. A gene is the coded DNA instructions that controls the production of specific proteins, such as enzymes, structural proteins, etc.

Gene Expression



Proteins are the link between genes and traits of an organism.

The proteins that are made will determine the traits of the offspring.

Gene Expression: The process by which DNA directs the synthesis of proteins.

The expression of genes includes two stages: **Transcription** and **Translation.**