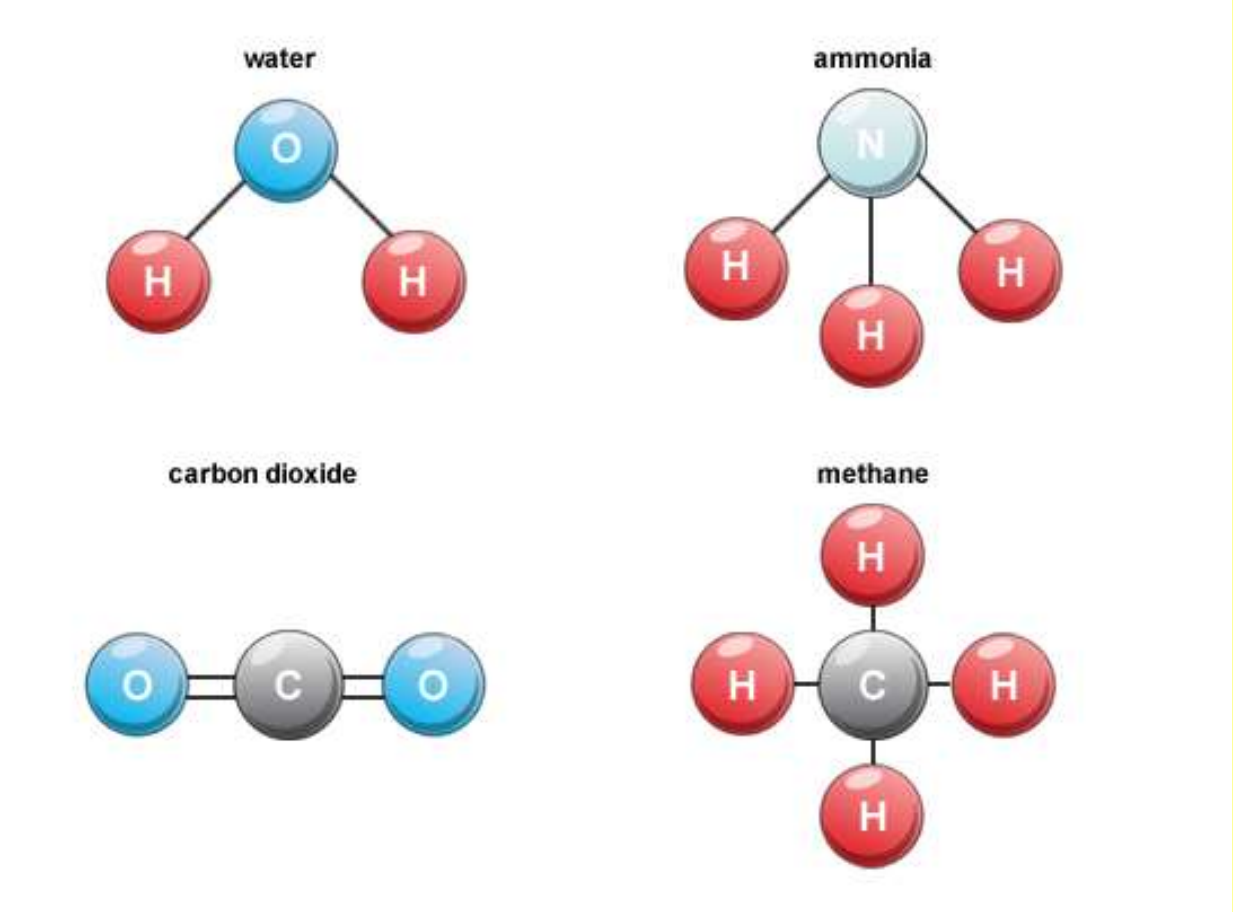
BASIC CHEMISTRY

PURPOSE:
To understand the building blocks of life

ELEMENTS OF THE BUILDING BLOCKS OF LIFE

- **CHNOPS**
  - Carbon
  - Hydrogen
  - Nitrogen
  - Oxygen
  - Phosphorus
  - Sulfur

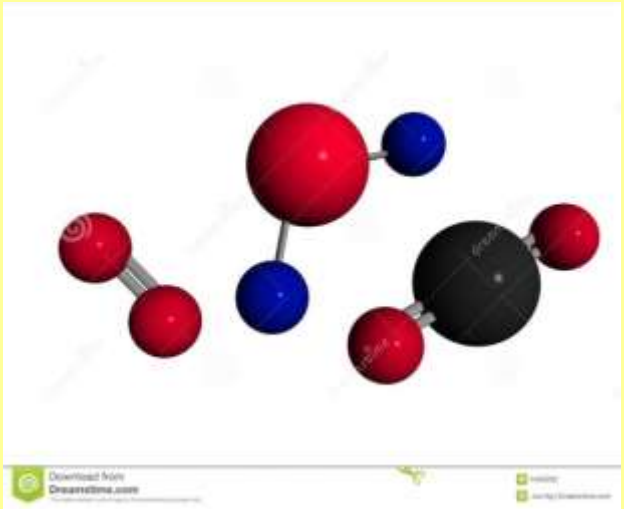
2 or more different atoms chemically bound together = <u>Compounds</u>



2 TYPES OF COMPOUNDS

INORGANIC

- Examples:
  - H_2O
  - O_2
  - CO_2



ORGANIC

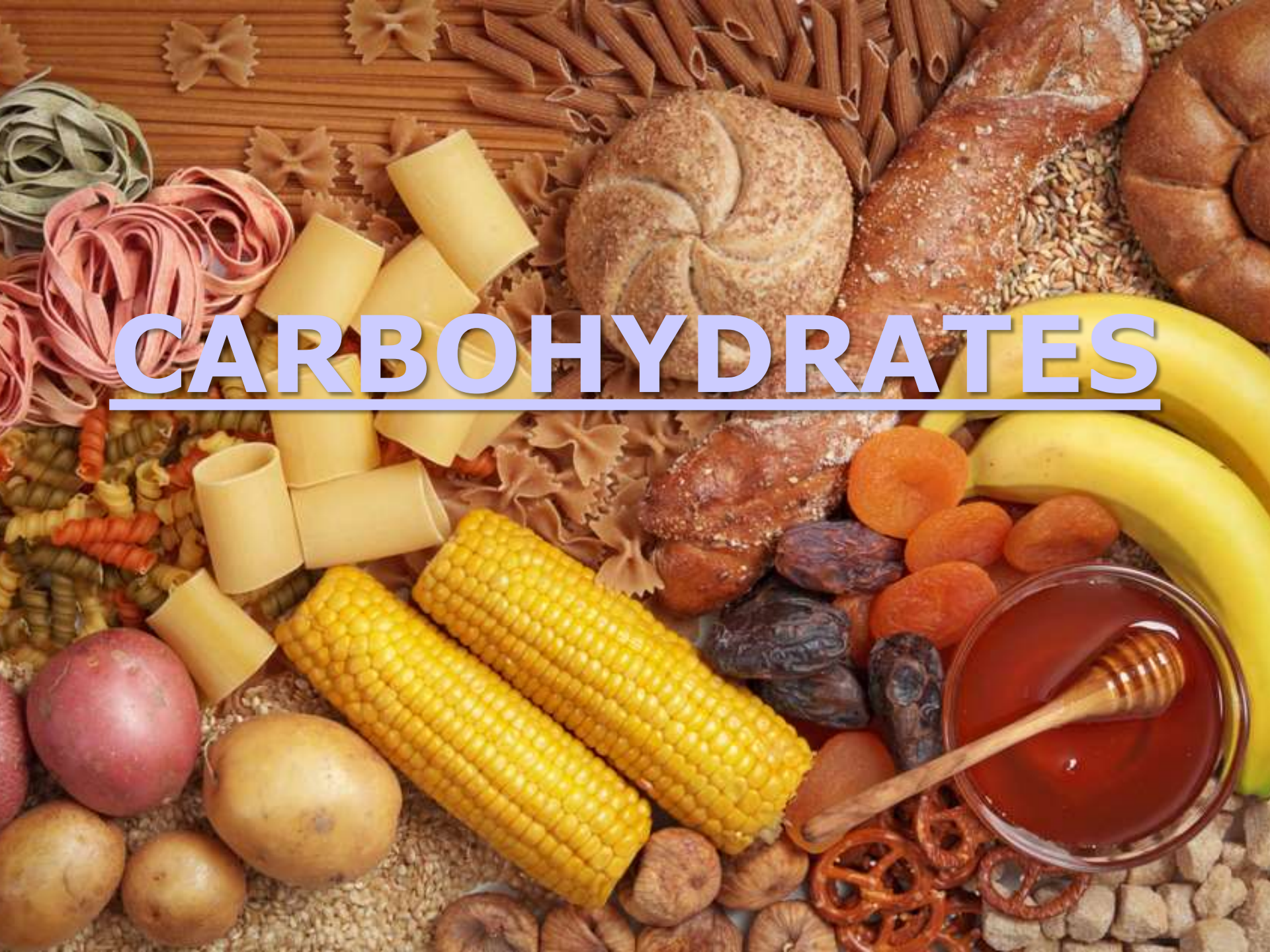
- Has Carbon and Hydrogen
- Examples:
  - $C_6H_{12}O_6$
  - CH_4
  - Starch

What are living things made of?

Organic AND Inorganic compounds

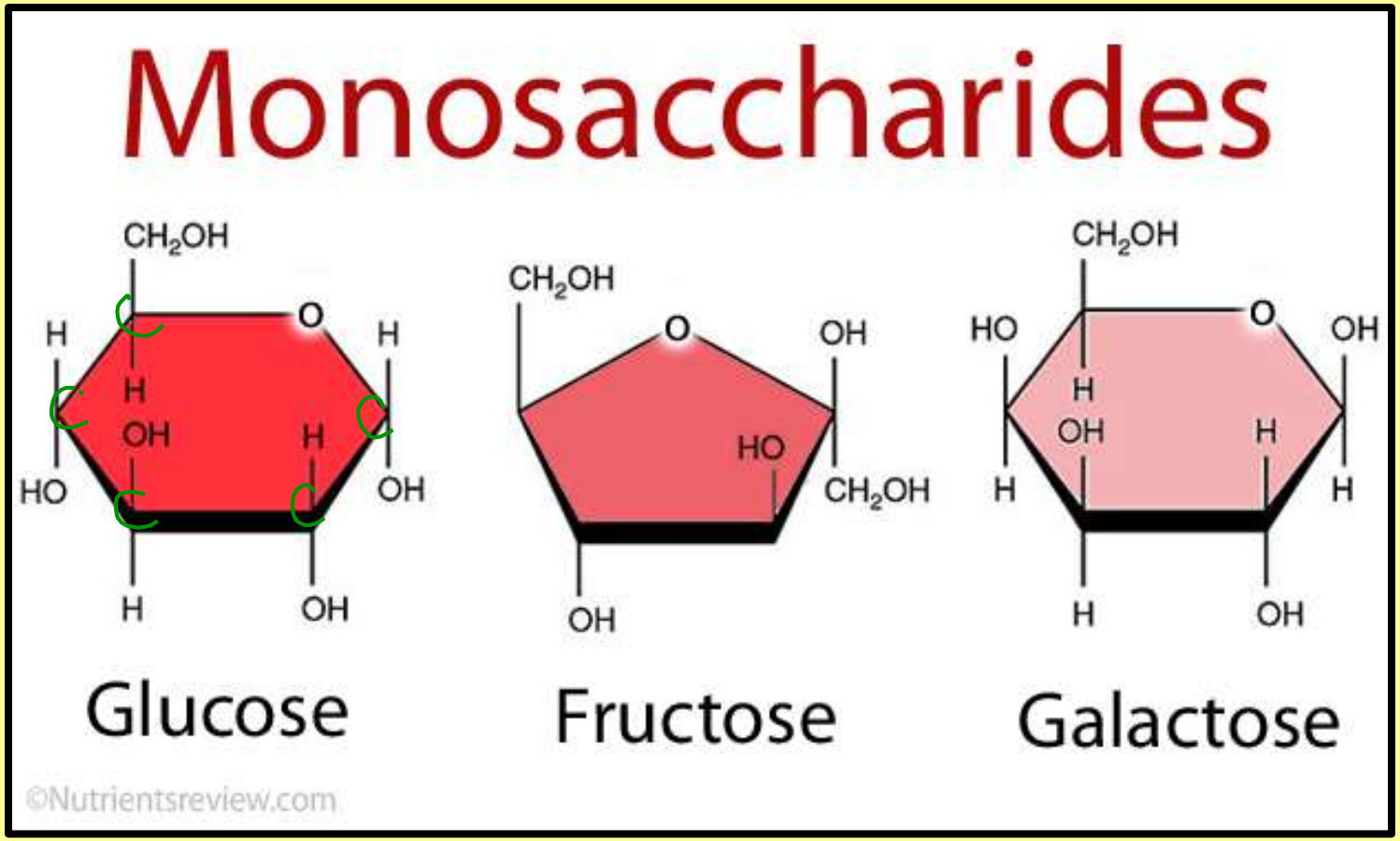
4 types of Organic Compounds

- Carbohydrates (sugars)
- Lipids (fats)
- Proteins
- Nucleic acids (DNA and RNA)


CARBOHYDRATES

CHARACTERISTICS OF CARBOHYDRATES

- Sometimes end in ose
- Made of C, H, O
- 2 Hydrogens for every 1 oxygen (2 to 1, H:O ratio)

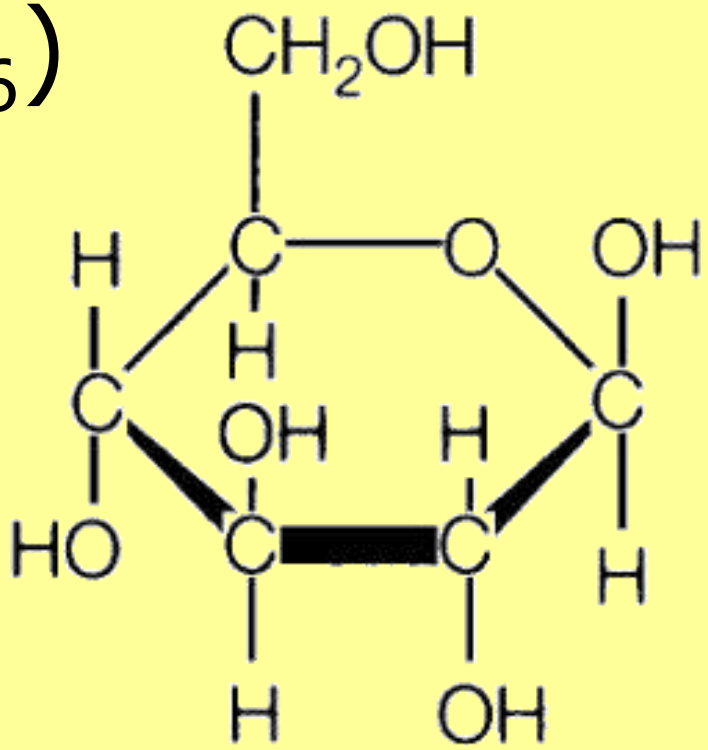


Made of a <u>single ring</u> of carbon

AKA simple sugars

Example of a simple sugar

- Glucose ($C_6H_{12}O_6$)
  - Produced by:
    - Photosynthesis

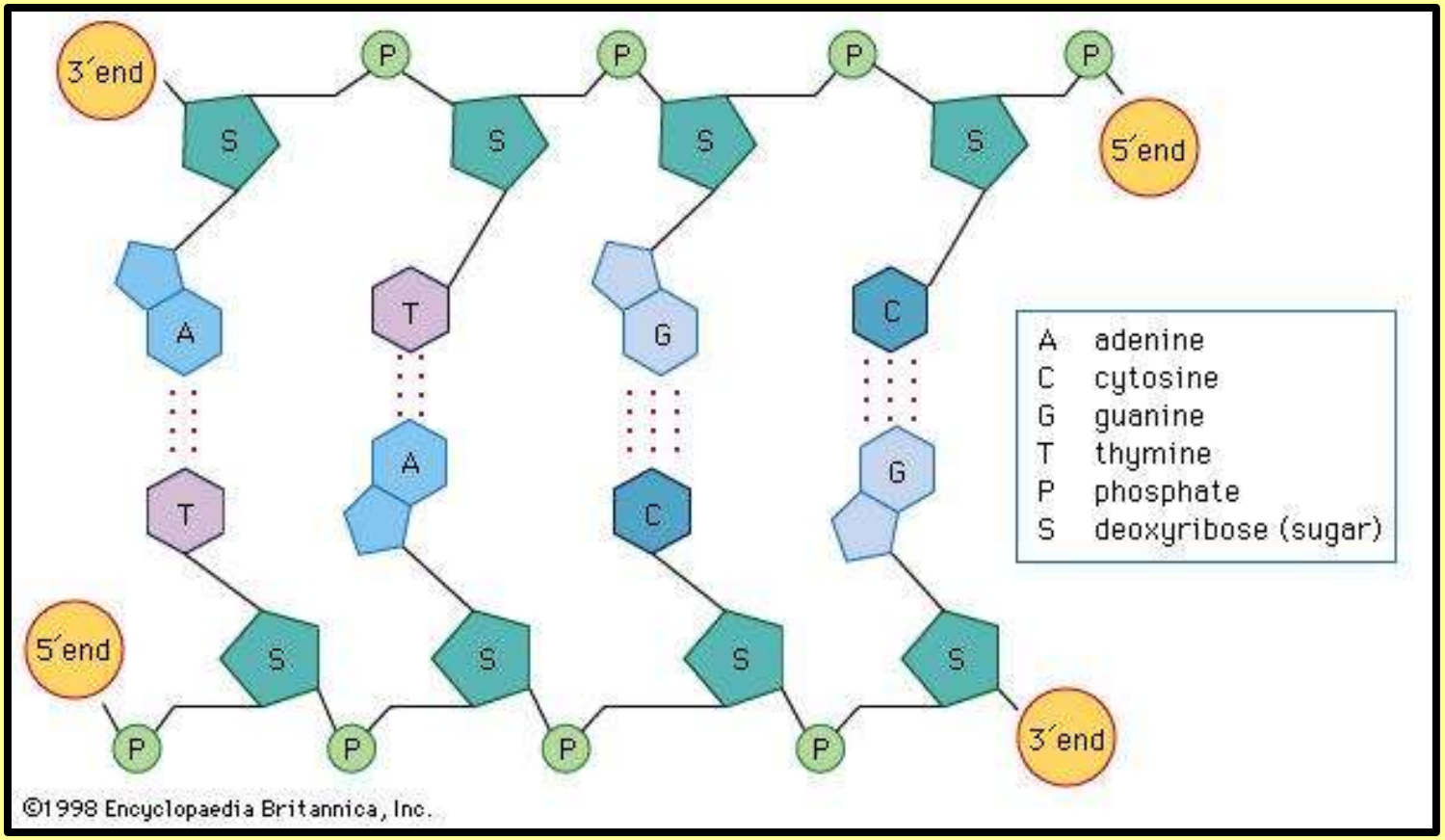


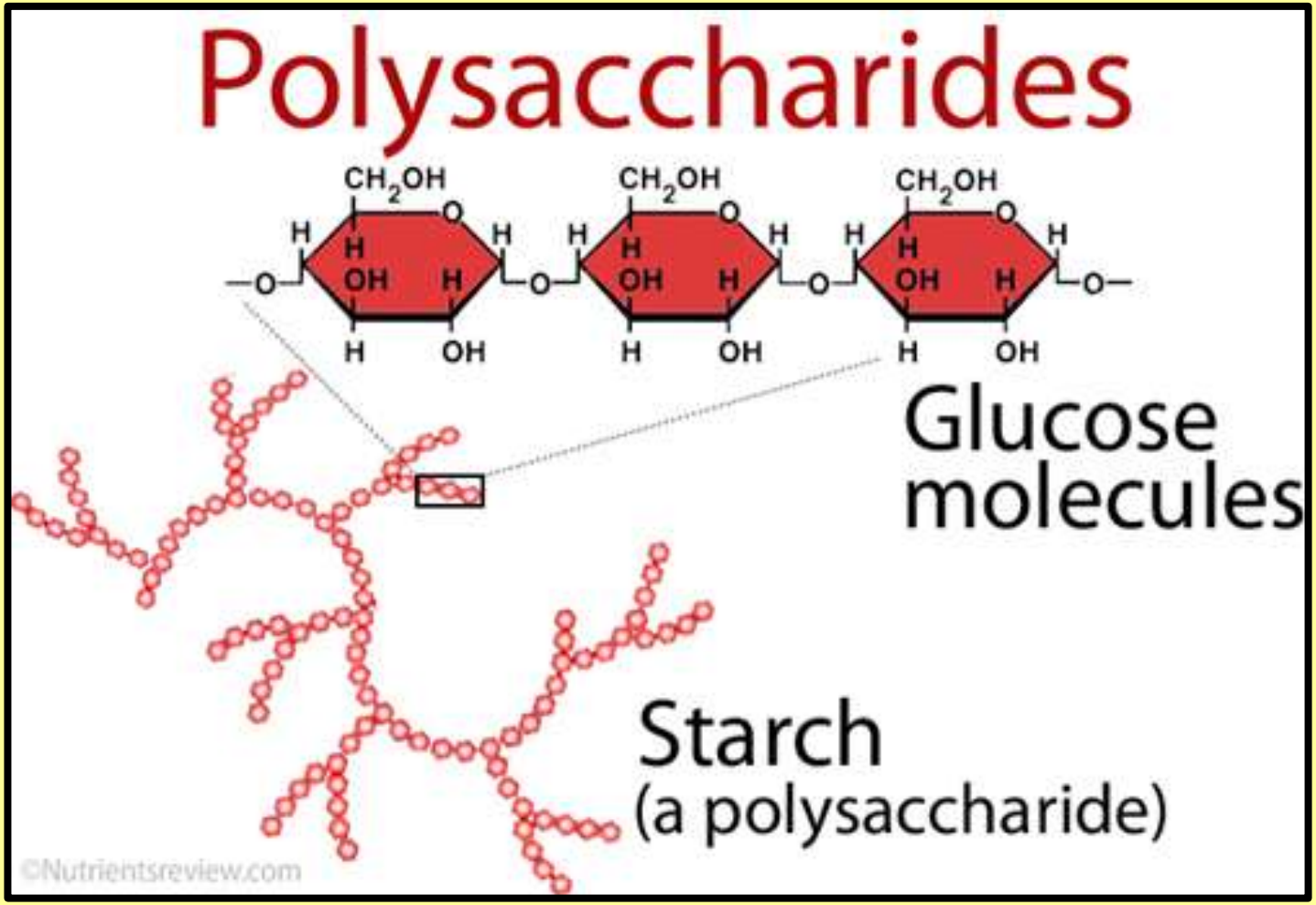
Fructose

- **($C_6H_{12}O_6$) found in:**
  - **<u>Fruit and honey</u>**

Deoxyribose

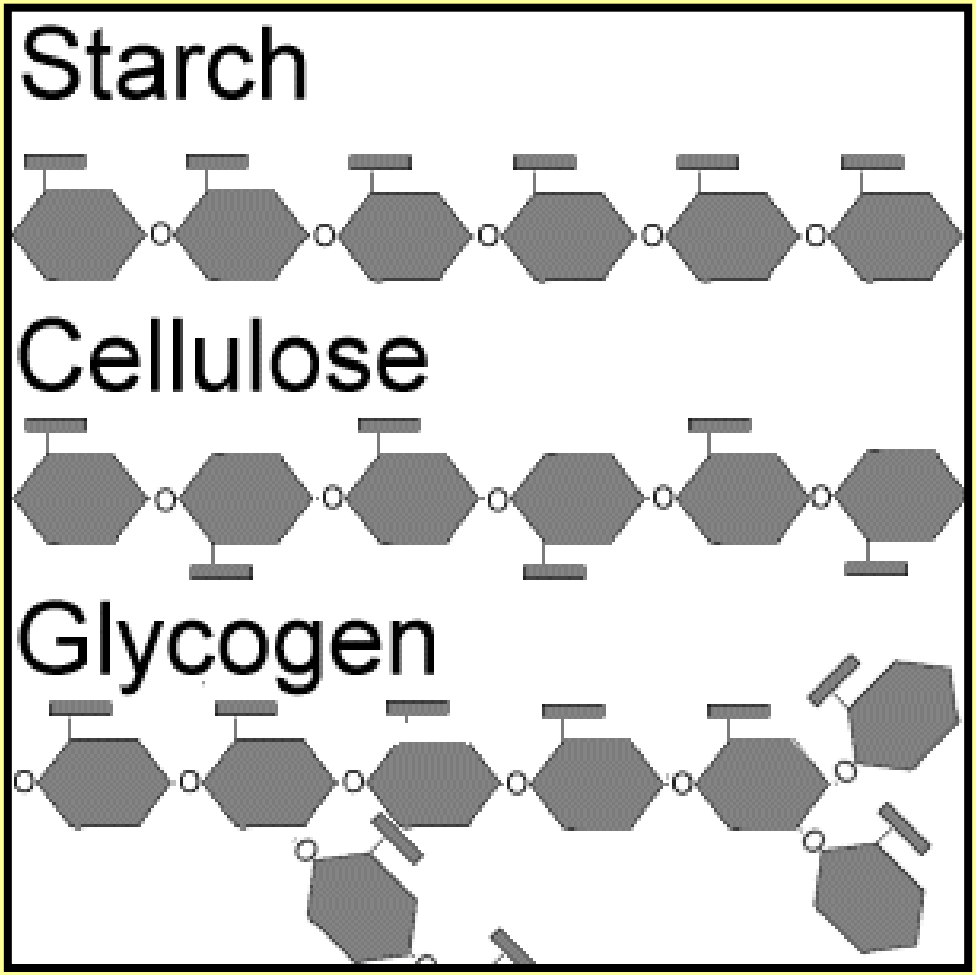
- $C_5H_{10}O_4$, Deoxyribose
- Found in <u>DNA</u>





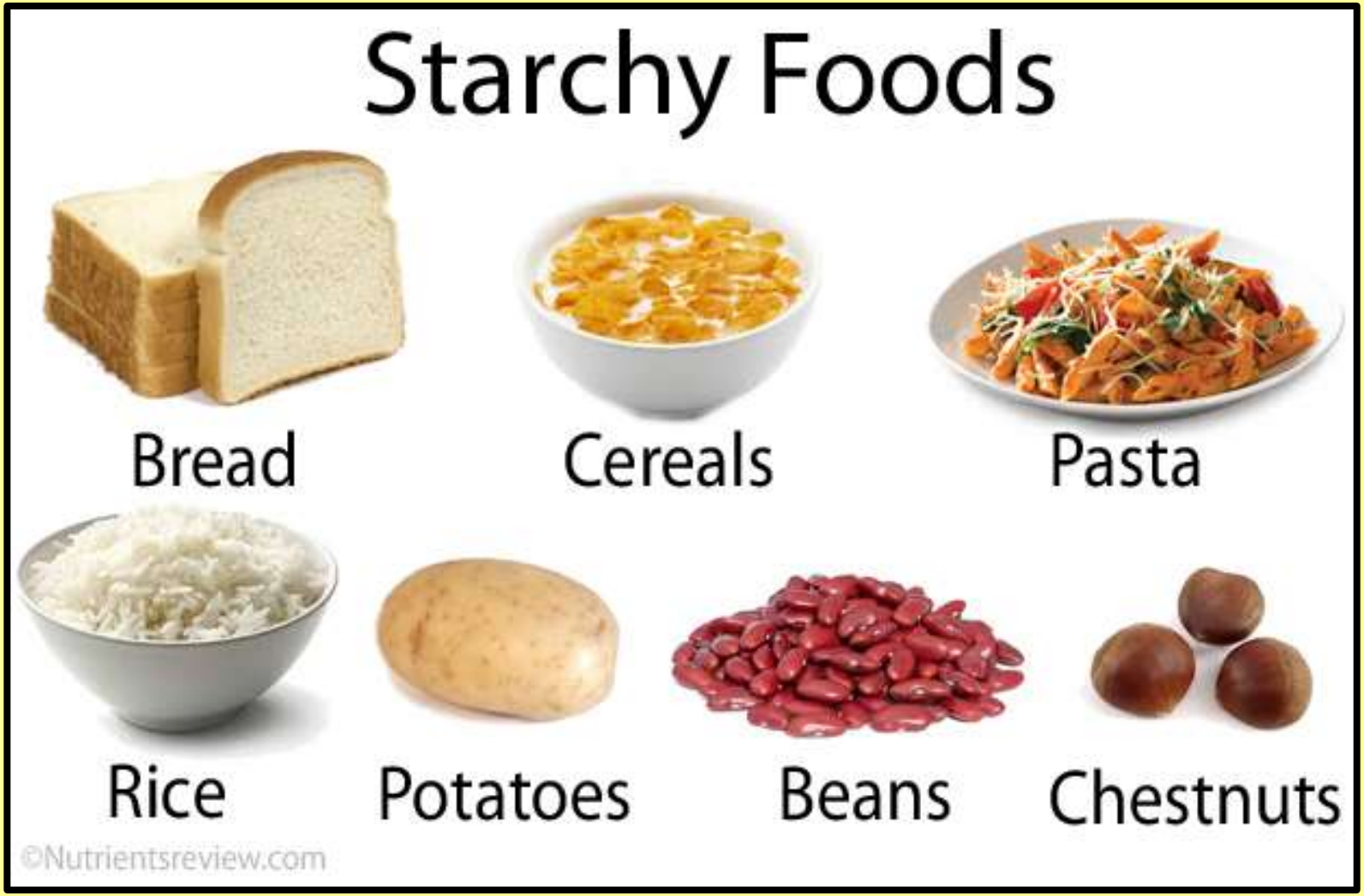
Made of <u>many carbon rings</u>
AKA <u>complex</u> sugars

Examples of complex sugars

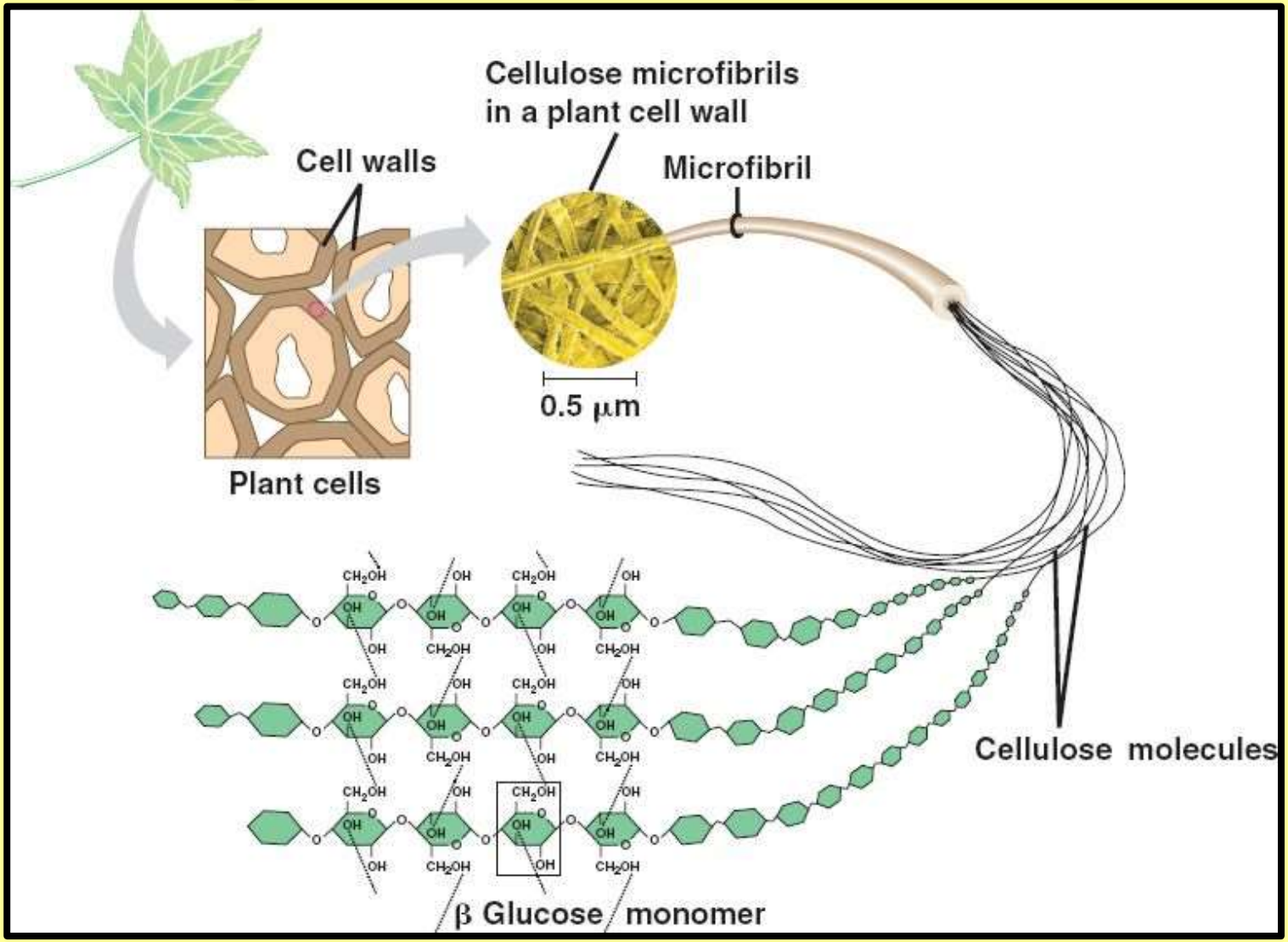


http://bioweb.wku.edu/courses/BIOL115/Wyatt/Biochem/Carbos/Carb_poly.gif

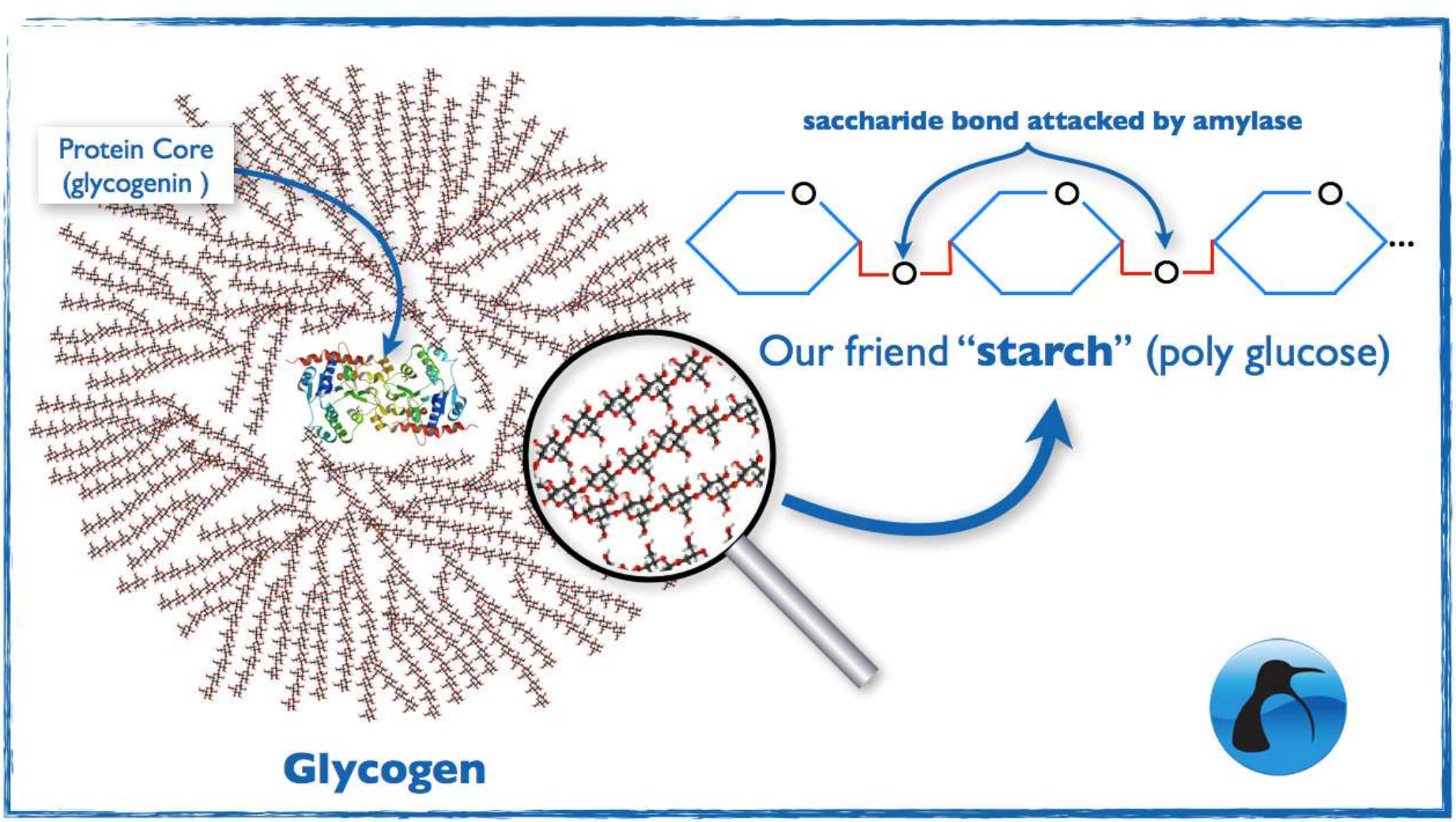
Starch = <u>energy stored in plants</u>



Cellulose = <u>makes up plant cell walls</u>



Glycogen = energy stored in liver and muscles



HOW DO I FIGURE OUT WHAT CARBS ARE PRESENT?

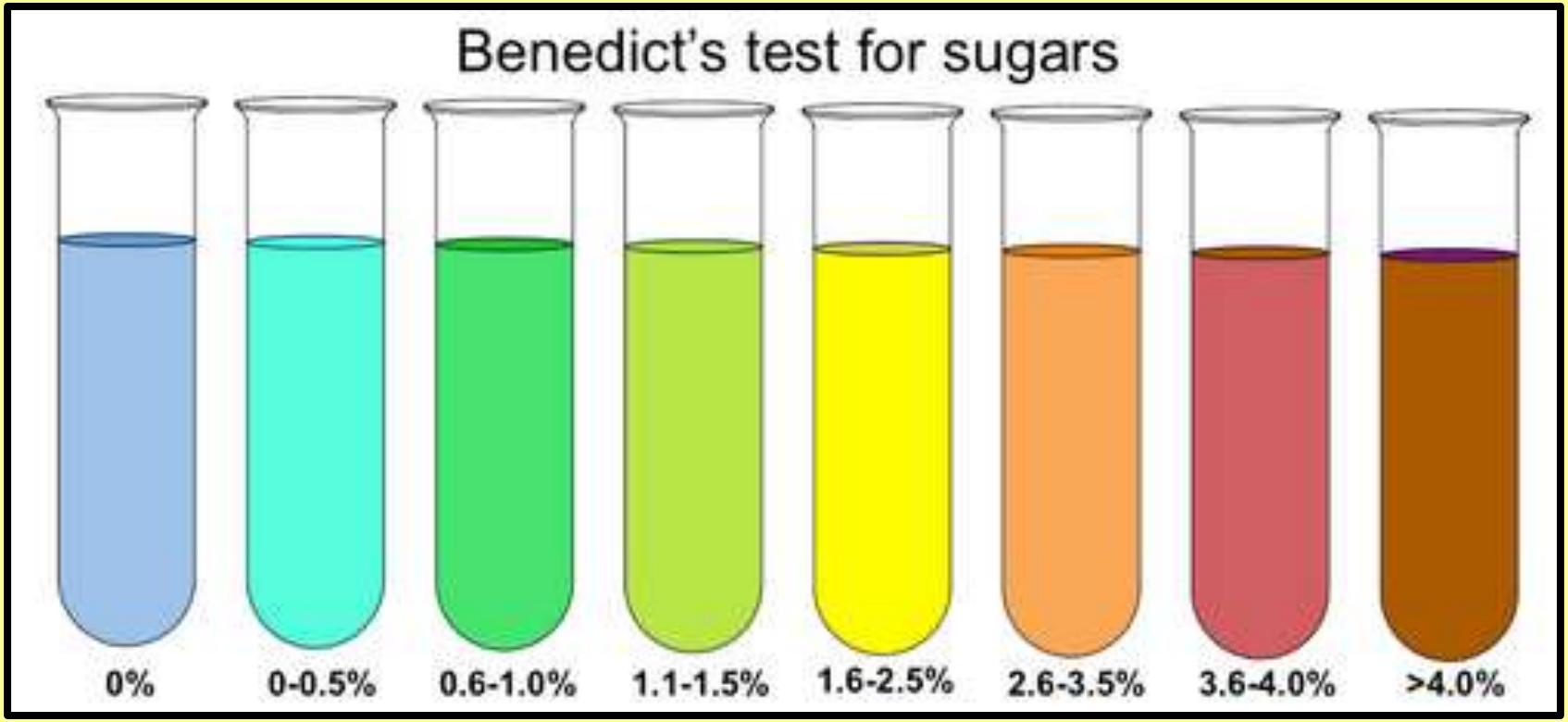
Chemical Indicators

- Iodine = **STARCH** indicator
  - Turns color in the presence of **STARCH**

ORANGE: Iodine
WHITE: Starch solution
BLACK: Starch solution + Iodine

Chemical Indicators

- Benedicts = **<u>GLUCOSE</u>** indicator
  - Turns color in the presence of **<u>GLUCOSE</u>** when heated

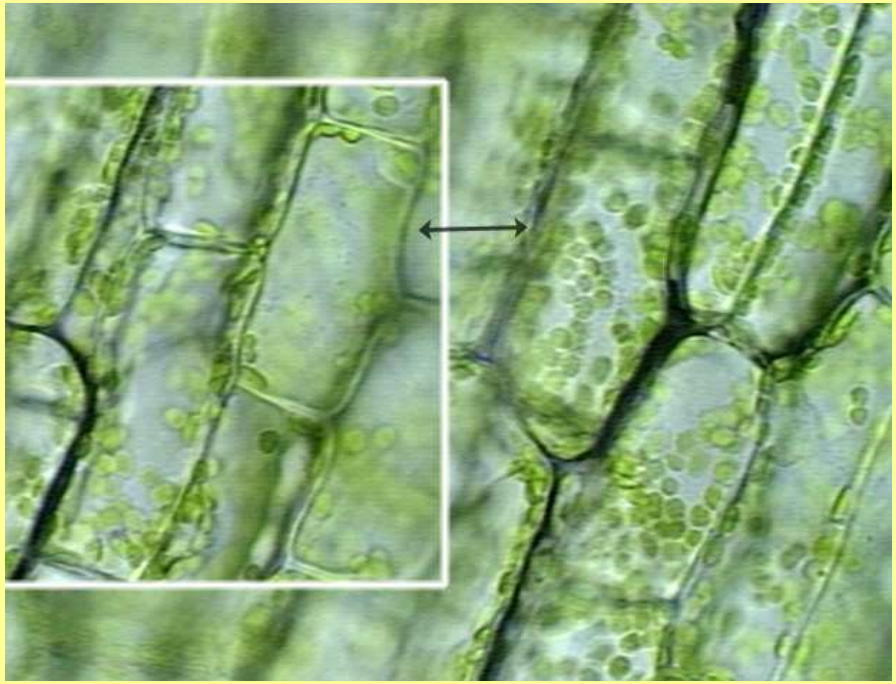


ENERGY PROCESSES INVOLVING CARBS

- Photosynthesis
- Respiration

Photosynthesis

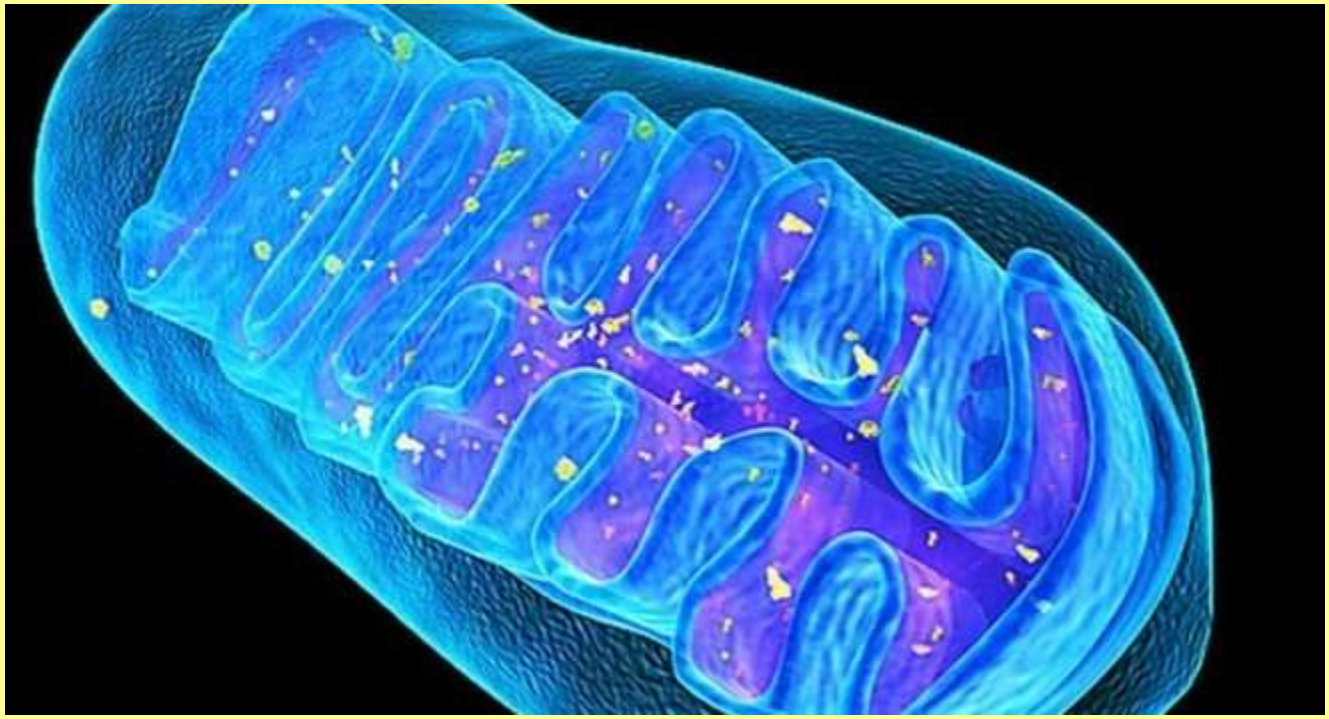
- Occurs in the **<u>chloroplasts</u>** of green plants



http://botit.botany.wisc.edu/images/130/Plant_Cell/Elodea/Chloroplasts_face_side_MC.jpg

AEROBIC Cellular Respiration

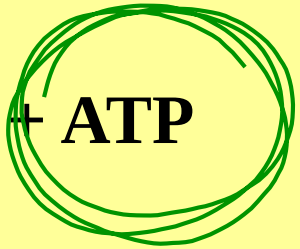
- Occurs in the
  - **<u>Mitochondria</u>**



Aerobic Cellular Respiration

- Both plants and animals respire

$$C_6H_{12}O_6 + 6O_2 \xrightarrow[\text{Enzymes}]{} 6H_2O + 6CO_2 + ATP$$



2 types of respiration

- **Aerobic**
  - With oxygen O_2
  - Produces **more** energy
- **Anaerobic**
  - Without oxygen O_2)
    - Also called **fermentation**
  - Produces **less** energy
  - Produces **lactic acid** → muscle fatigue

QUIZ

1. What are the 6 most important elements for life
2. What is the difference between organic and inorganic molecules
3. Name 4 types of organic compounds
4. Draw a picture of a simple sugar
5. Draw a picture of a complex sugar
6. What are complex sugars made up of

7. Name 2 energy processes
8. Name the organelle where photosynthesis takes place
9. Name the organelle where aerobic respiration takes place
10. What is the difference between aerobic and anaerobic respiration?

4 Types of organic compounds

- Carbohydrates (sugars)
- **Lipids (fats)**
- Proteins (enzymes, hemoglobin, antibodies…)
- Nucleic acids (DNA and RNA)

LIPIDS

LIPIDS

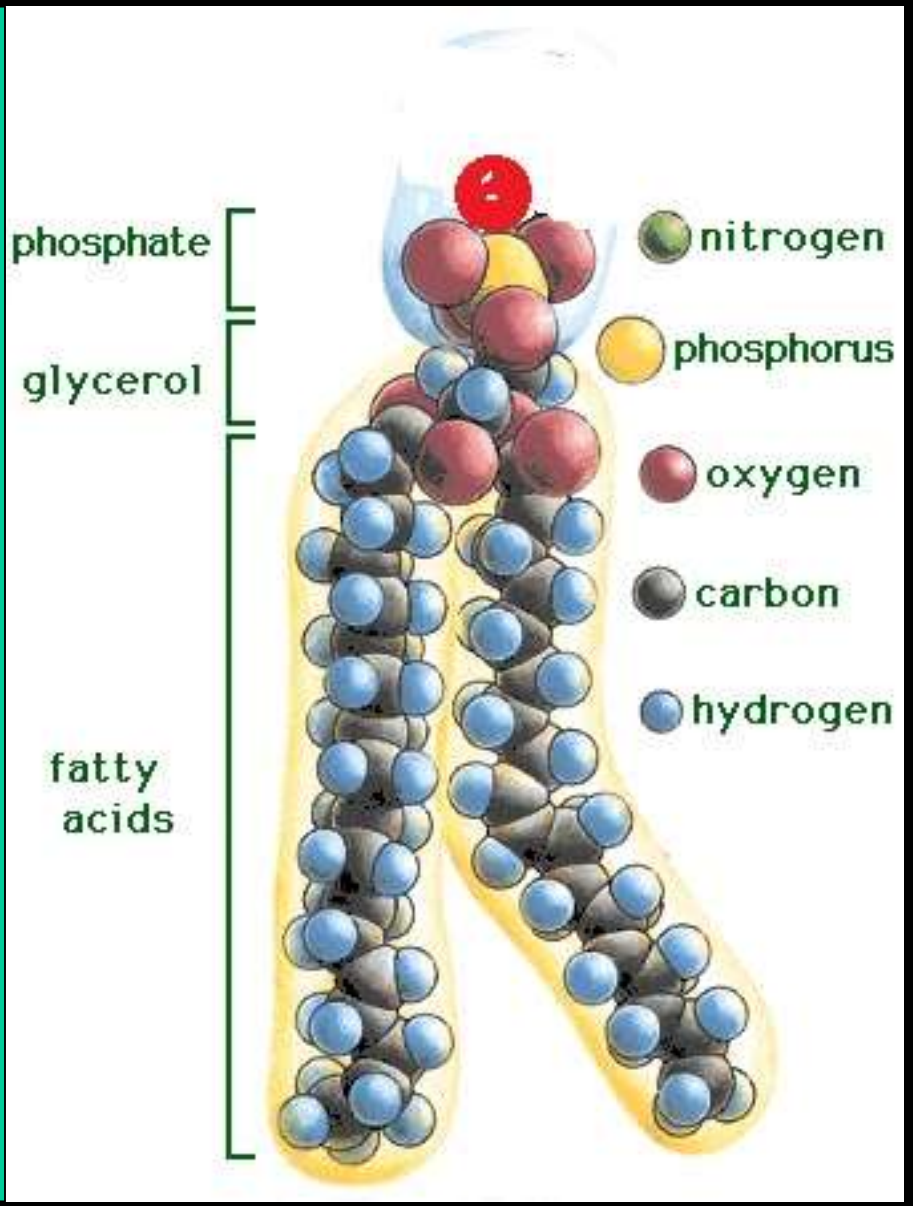
- Lipids = Fats and oils
- Made of C,H, and O
- H:O ratio is greater than 2:1
  - Fats have more H

Characteristics and jobs of lipids

- Building blocks
  - Fatty acid chains
  - Glycerol
- Hydrophobic =
  - **Afraid of water**

Example

- Phospholipids = make up cell membranes (hydrophobic end and hydrophilic end)


phosphate
glycerol
fatty acids
nitrogen
phosphorus
oxygen
carbon
hydrogen

JOBS OF FAT

- **Store energy**
- Make up **cell membranes**
- Act as **hormones**
  - –Chemical messengers

Fats → energy

- 1g of fat [redacted] 1g of carbohydrates
- Women have [redacted] % body fat → [redacted]

ENERGY HIERARCHY




GOOD FATS

VS.

BAD FATS




FATS

THE GOOD
THE BAD
& THE UGLY

American Heart Association | American Stroke Association.
life is why

✓ GOOD

Monounsaturated & Polyunsaturated Fats

- Can lower bad cholesterol levels
- Can lower risk of heart disease & stroke
- Can provide essential fats that your body needs but can't produce itself

SOURCE

Plant-based liquid oils, nuts, seeds and fatty fish

EXAMPLES

Oils (such as canola, olive, peanut, safflower and sesame)

Avocados

Fatty Fish (such as tuna, herring, lake trout, mackerel, salmon and sardines)

Nuts & Seeds (such as flaxseed, sunflower seeds and walnuts)

✗ BAD

Saturated Fats

- Can raise bad cholesterol levels
- Can lower good cholesterol levels
- Can increase risk of heart disease & stroke

SOURCE

Most saturated fats come from animal sources, including meat and dairy, and from tropical oils

EXAMPLES

Beef, Pork & Chicken Fat

Butter

Cheese (such as whole milk cheeses)

Tropical Oils (such as coconut, palm kernel and palm oils)

✗ UGLY

Hydrogenated Oils & *Trans* Fats

- Can raise bad cholesterol levels
- Can lower good cholesterol levels
- Can increase risk of heart disease & stroke
- Can increase risk of type 2 diabetes

SOURCE

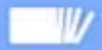
Processed foods made with partially hydrogenated oils

EXAMPLES

Partially Hydrogenated Oils

Some Baked Goods

Fried Foods



Stick of Margarine

American Heart Association **Recommendation**

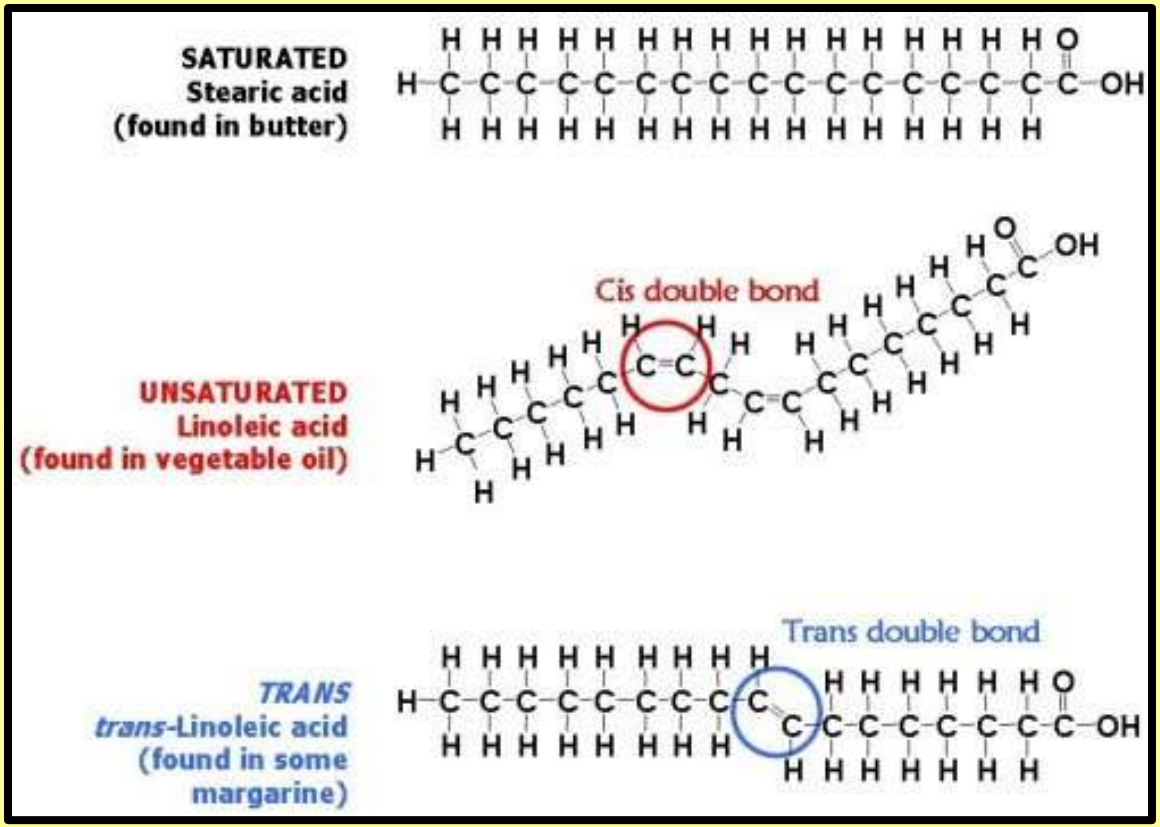
Eat a healthy dietary pattern that:

Includes **good fats** | *Limits* **saturated fats** | *Keeps trans fats* **as LOW as possible**

For more information, go to **heart.org/fats**

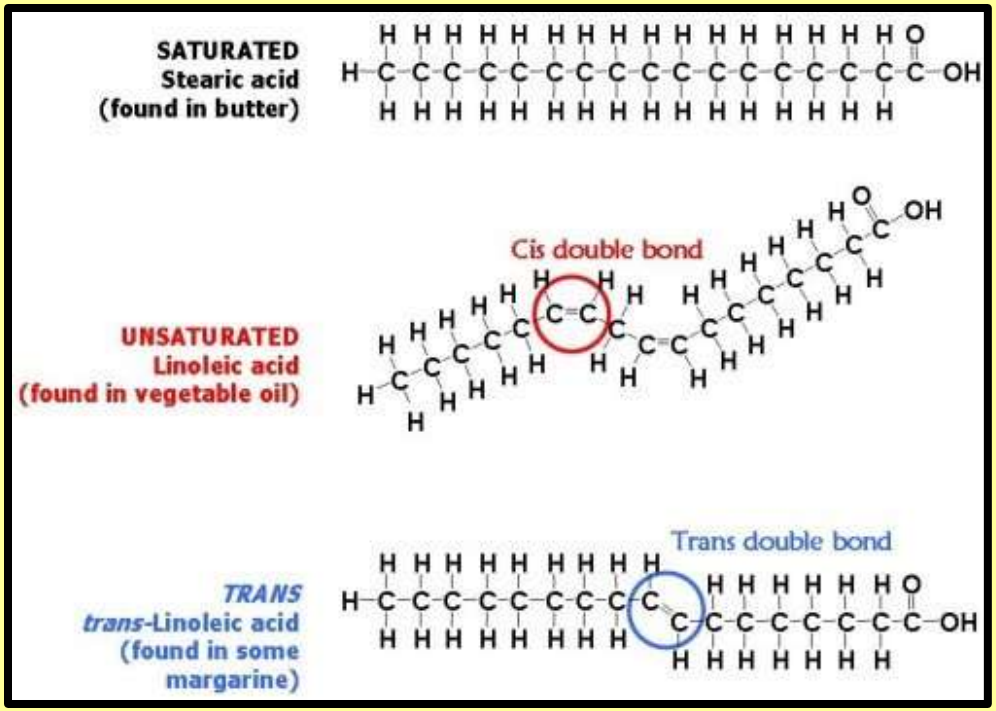
WHY ARE BAD/UGLY FATS BAD?

- Harder to break down
  - Less <u>nutritional benefits</u>



GOOD FATS

- Have less H
- Plant oils
- Good in moderation



Cholesterol

- Cholesterol is **a steroid**

Cholesterol

- Too much **cholesterol**
  - Clogs arteries
  - **Heart problems**
- **Saturated fats**
  - Can increase bad cholesterol

Phospholipids

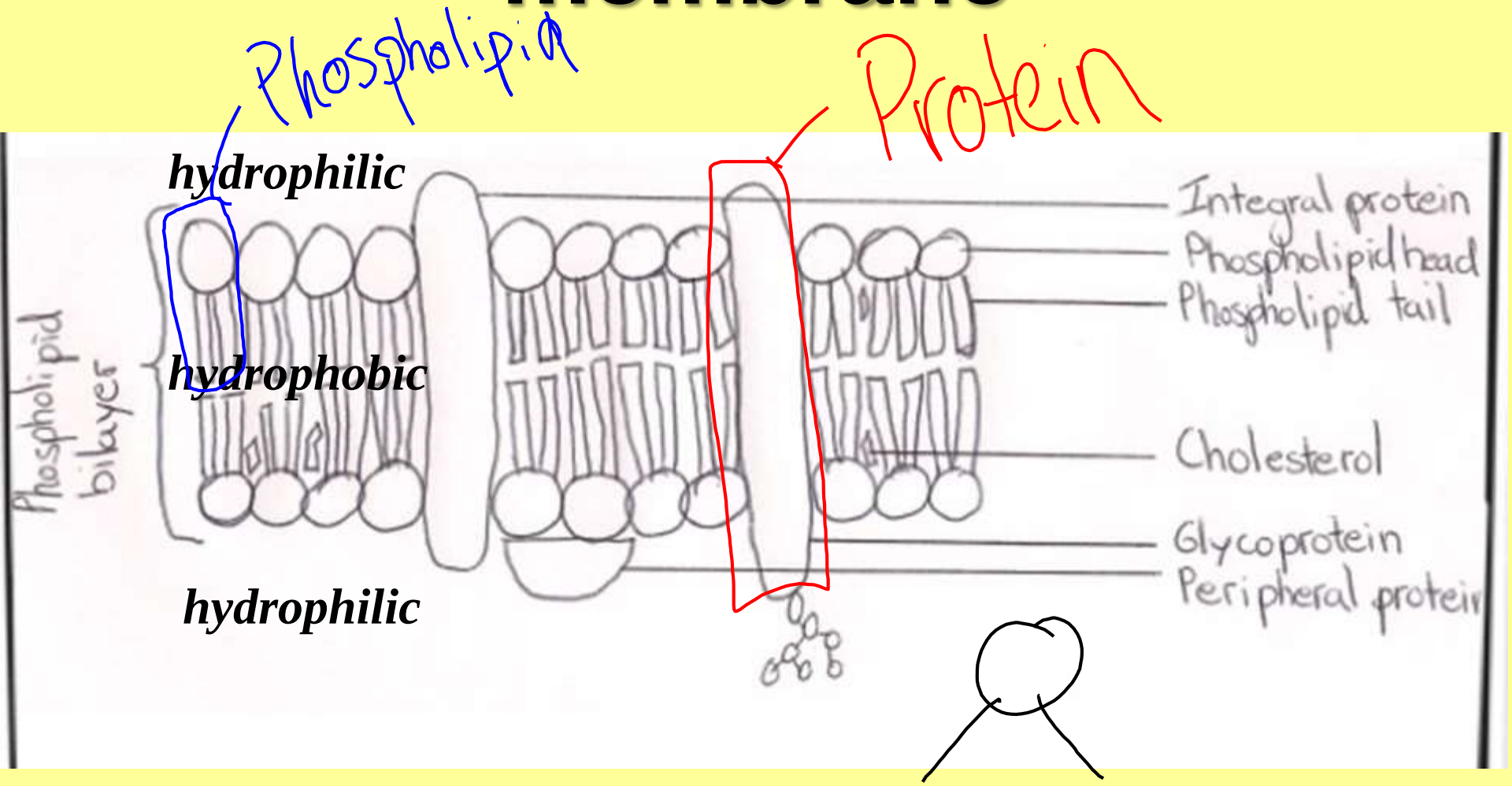
- Make up cell membranes

2 jobs of Cell Membranes

1. Controls what goes in and out
   - Selectively permeable

2. Receives messages from outside
   - Receptor proteins

Draw a picture of a cell membrane



Cell walls vs Cell m*embra*nes

Cell Wall

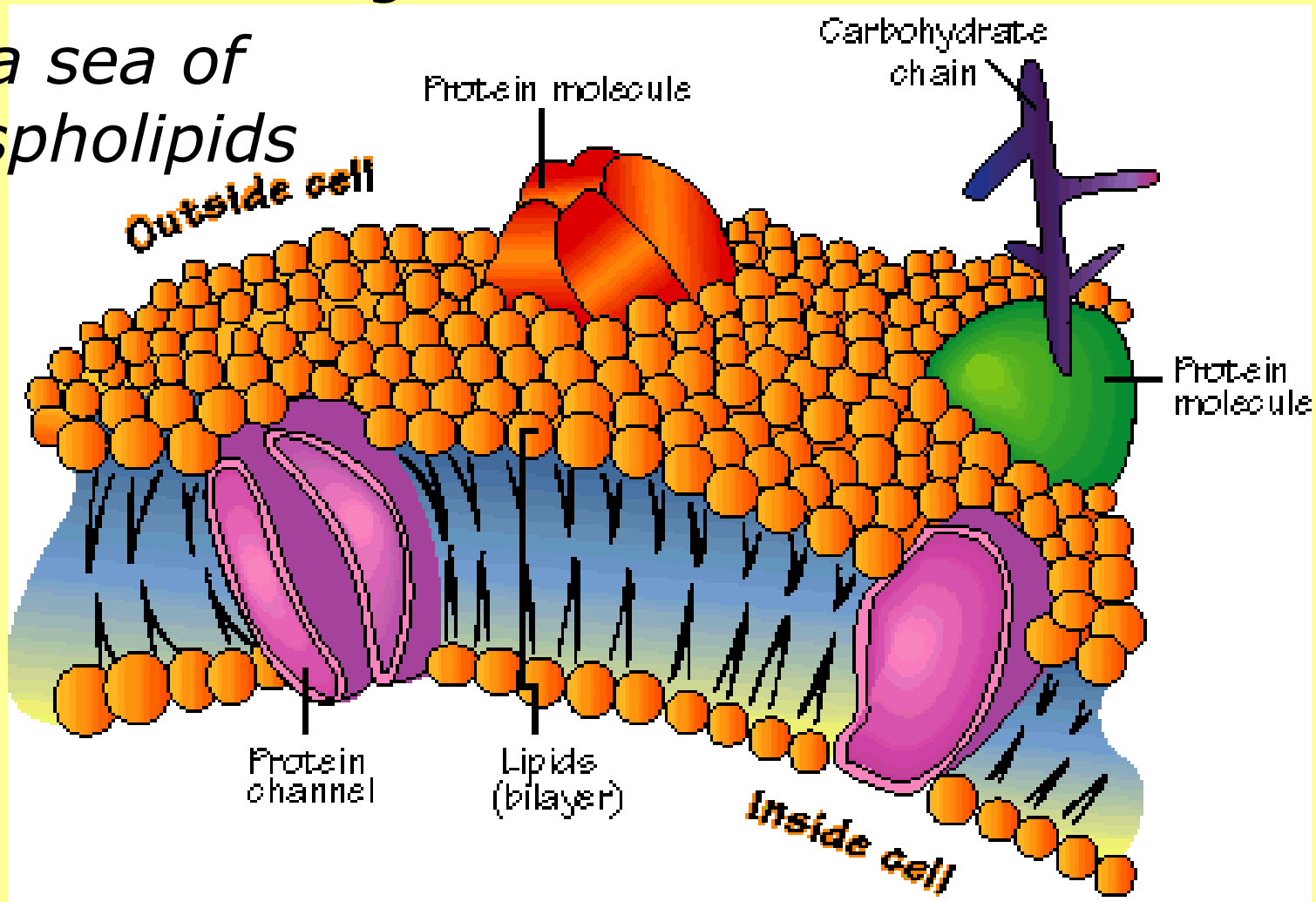
- Found on
  - Plants, some protists (algae), bacteria, fungi
- Made of
  - Cellulose
- Job
  - Structure and protection

Cell Membrane

- Found on
  - ALL LIVING THINGS including animals
- Made of
  - Phospholipids
- Jobs
  - Communication
  - Controls what goes in and out.

FLUID MOSAIC MODEL

- *proteins floating*
- *on a sea of phospholipids*



Sphecodina abbottii (Swainson)

Open notes quiz

1. List the 4 types of organic compounds.
2. What are cell walls made of?
3. Name a type of organism that does not have cell walls.
4. State 2 jobs of cell membranes
5. What are complex sugars made of?
6. Draw a picture of a cell membrane and label the 2 parts.

Diagnose the disease

GOAL: Determine what each person has

1.SYMPTOMS

- Diarrhea
- Nausea, and sometimes vomiting
- Abdominal cramps
- Bloating
- Gas

2. SYMPTOMS

- Diarrhea
- Fatigue
- Anemia
- Pain Crises
- Dactylitis (swelling and inflammation of the hands and/or feet) and Arthritis
- Bacterial Infections
- Sudden pooling of blood in the spleen
- Lung and Heart Injury
- Leg Ulcers
- Death of portions of bone
- Eye Damage

3. SYMPTOMS

- deafness
- progressive blindness
- decreased muscle strength
- increased startle response
- paralysis or loss of muscle function
- seizure
- muscular stiffness (spasticity)
- delayed mental and social development
- slow growth
- red spot on the macula (an oval-shaped area near the center of the retina in the eye)

4. SYMPTOMS

- Unexplained and excessive bleeding from cuts or injuries, or after surgery or dental work
- Many large or deep bruises
- Unusual bleeding after vaccinations
- Pain, swelling or tightness in your joints
- Blood in your urine or stool
- Nosebleeds without a known cause
- In infants, unexplained irritability

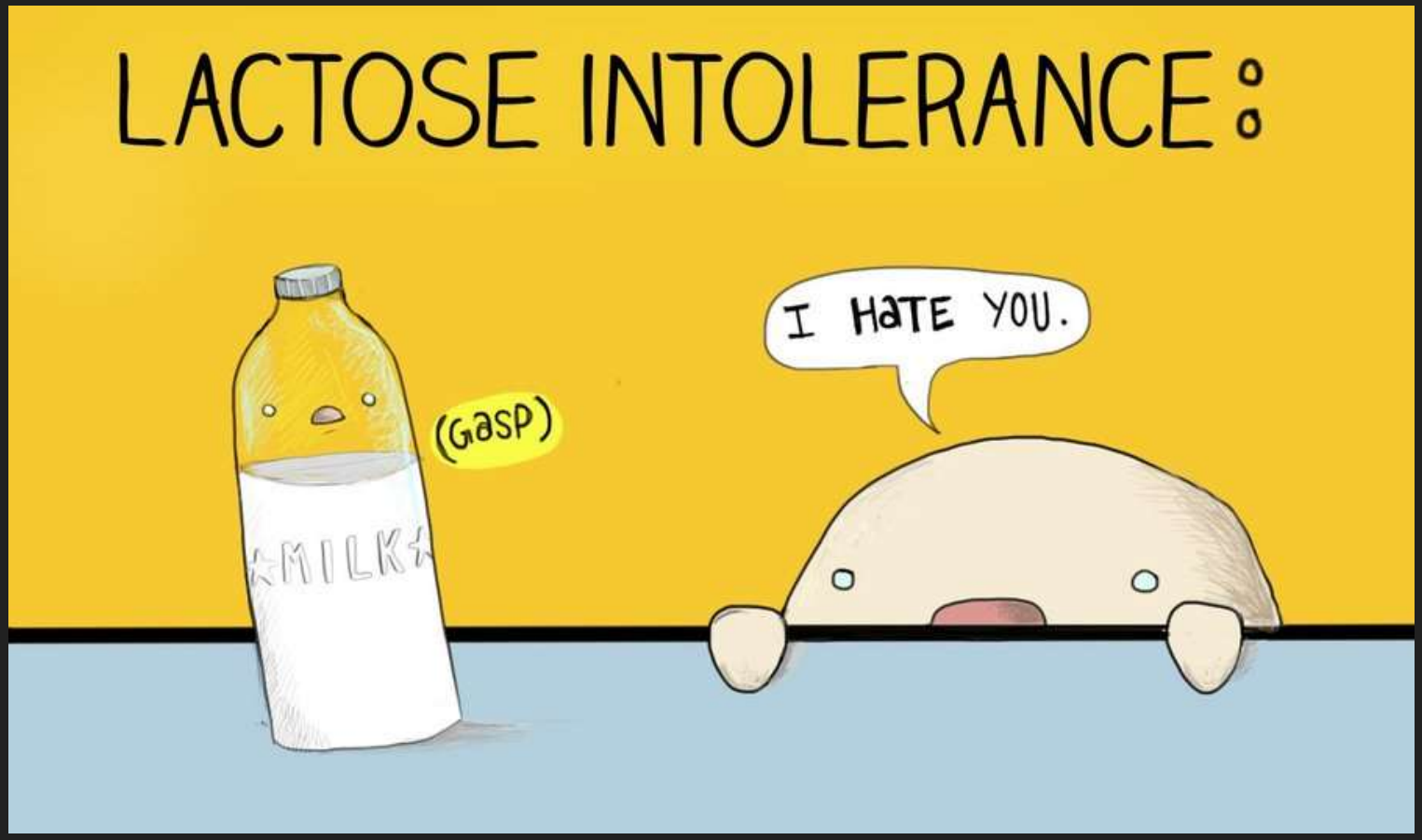
5. SYMPTOMS

- Rapid, involuntary back and forth movement of the eyes
- Extreme nearsightedness
- Exposure to light → moles with or without pigment

WHAT DO THEY ALL HAVE IN COMMON?

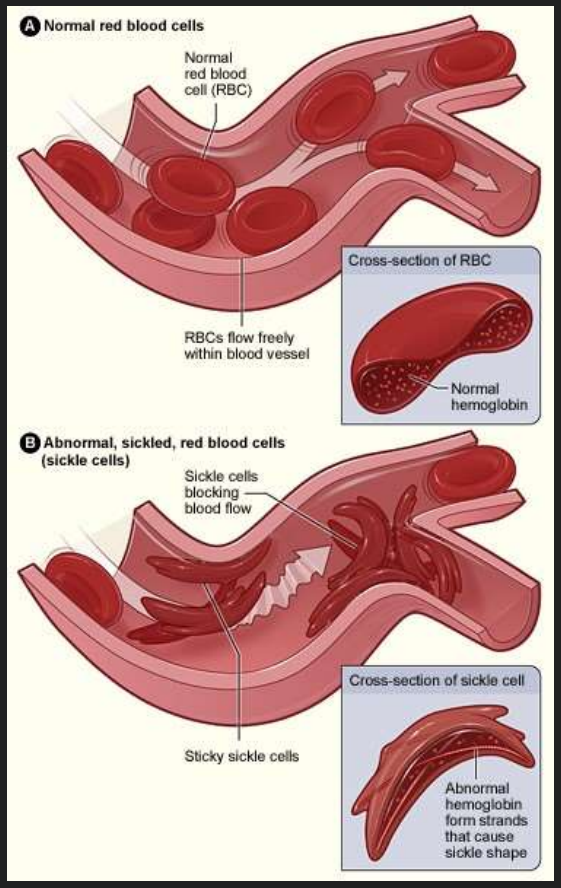
ANSWERS

1. Lactose Intolerance
2. Sickle Cell Anemia
3. Tay Sachs
4. Hemophilia
5. Albinism
    a. Lack of a protein to make pigments



Small intestine can’t make enough of a protein

Number 2: Sickle Cell Anemia



Change in a gene for a protein in red blood cells (hemoglobin)

3. Tay Sachs

Fatal Change in a gene for a protein needed to make healthy nerve cells (Hex-A)

4. Hemophilia

Change in a gene needed to make blood clotting proteins (platelets)

- **ALBINISM**
- **Screw up in genes that make proteins (melanin)**

1) Describe Genes and Proteins

2) State the relationship between genes and proteins

4 types of Organic Compounds

- Carbohydrates (sugars)
- Lipids (fats)
- **Proteins**
- Nucleic acids (DNA and RNA)

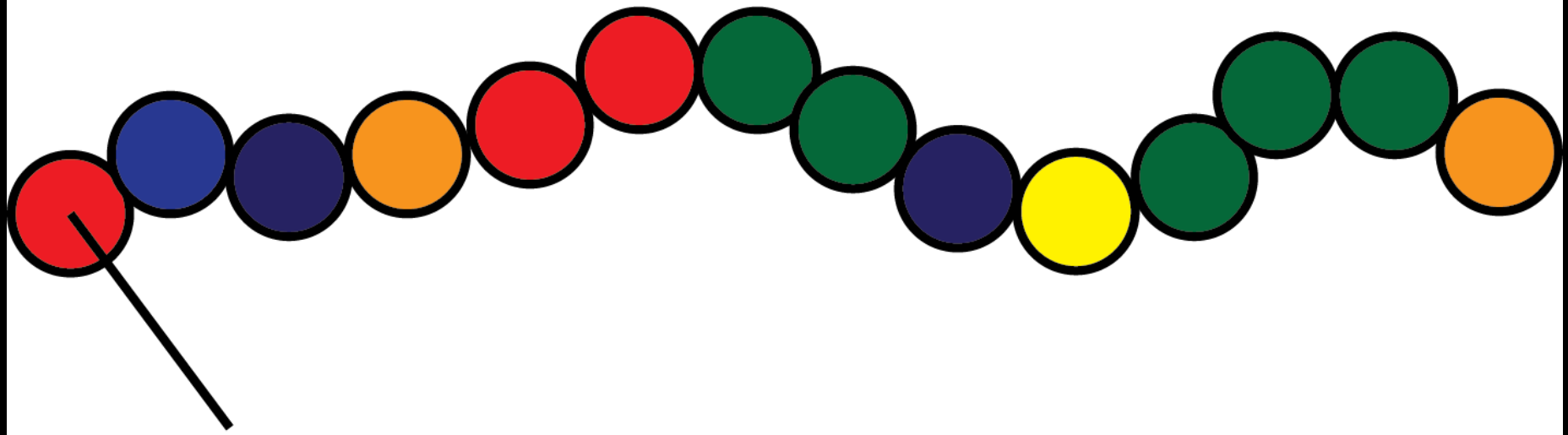

PROTEINS

PROTEINS

- Contain
  - C,H,O,N
- More than ½ the dry weight of living organisms
- Made of amino acid chains

http://www.ucl.ac.uk/~sjjgsca/peptide1.gif

Protein

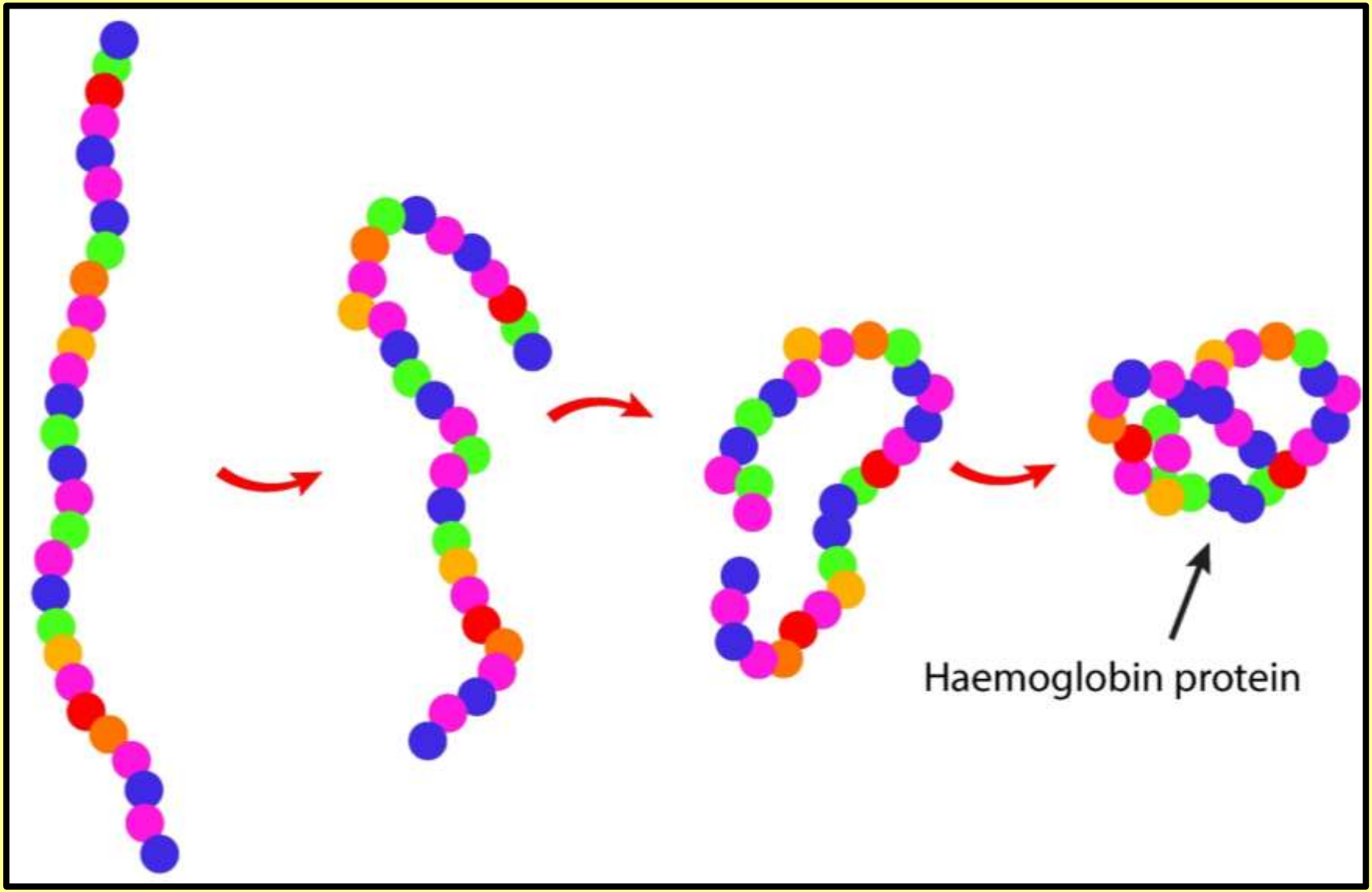


Amino acid

- Amino acids are linked together in a process called
  - Dehydration synthesis
    - Removing water to make something

AA + AA + AA + AA → AA-AA-AA-AA - H_2O

- Amino acid chains are folded in **specific shapes**



- If you change one AA
  - Wrong shape
  - Protein might not work

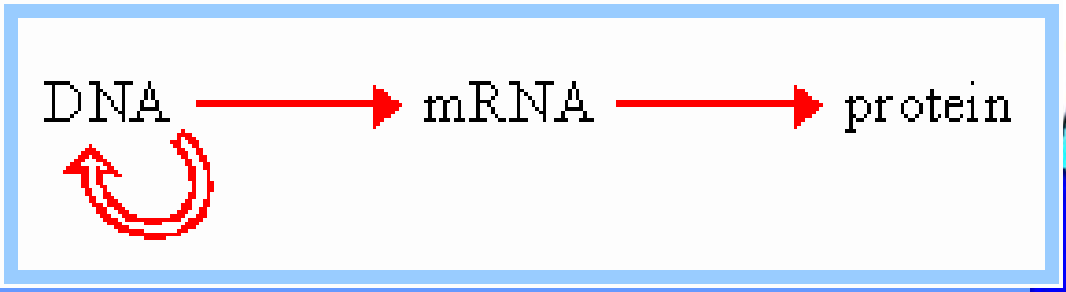
HOW WOULD AN AMINO ACID CHANGE?

- DNA = template

- DNA has instructions for making proteins

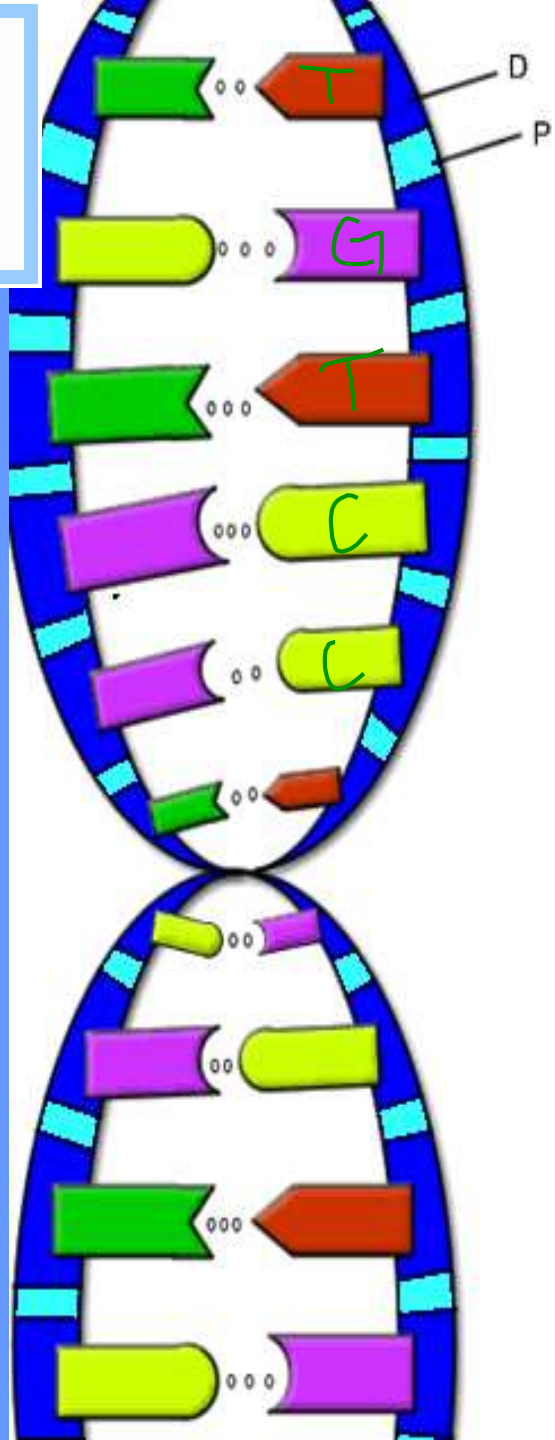
http://www.biologycorner.com/resources/DNA-colored.gif

DNA → mRNA → protein

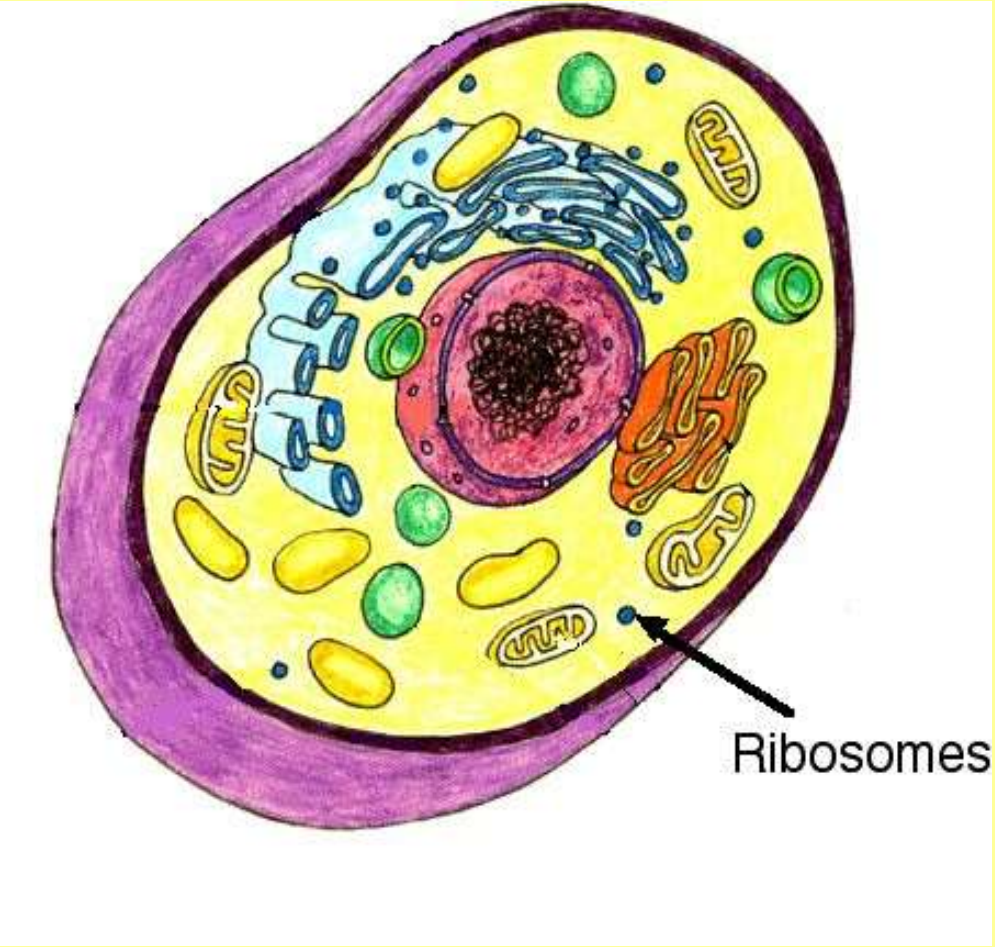


- **Order of DNA bases→**
- **Amino acid sequence**

- **Mutation =**
  - **Change in DNA**
  - **Change in protein**

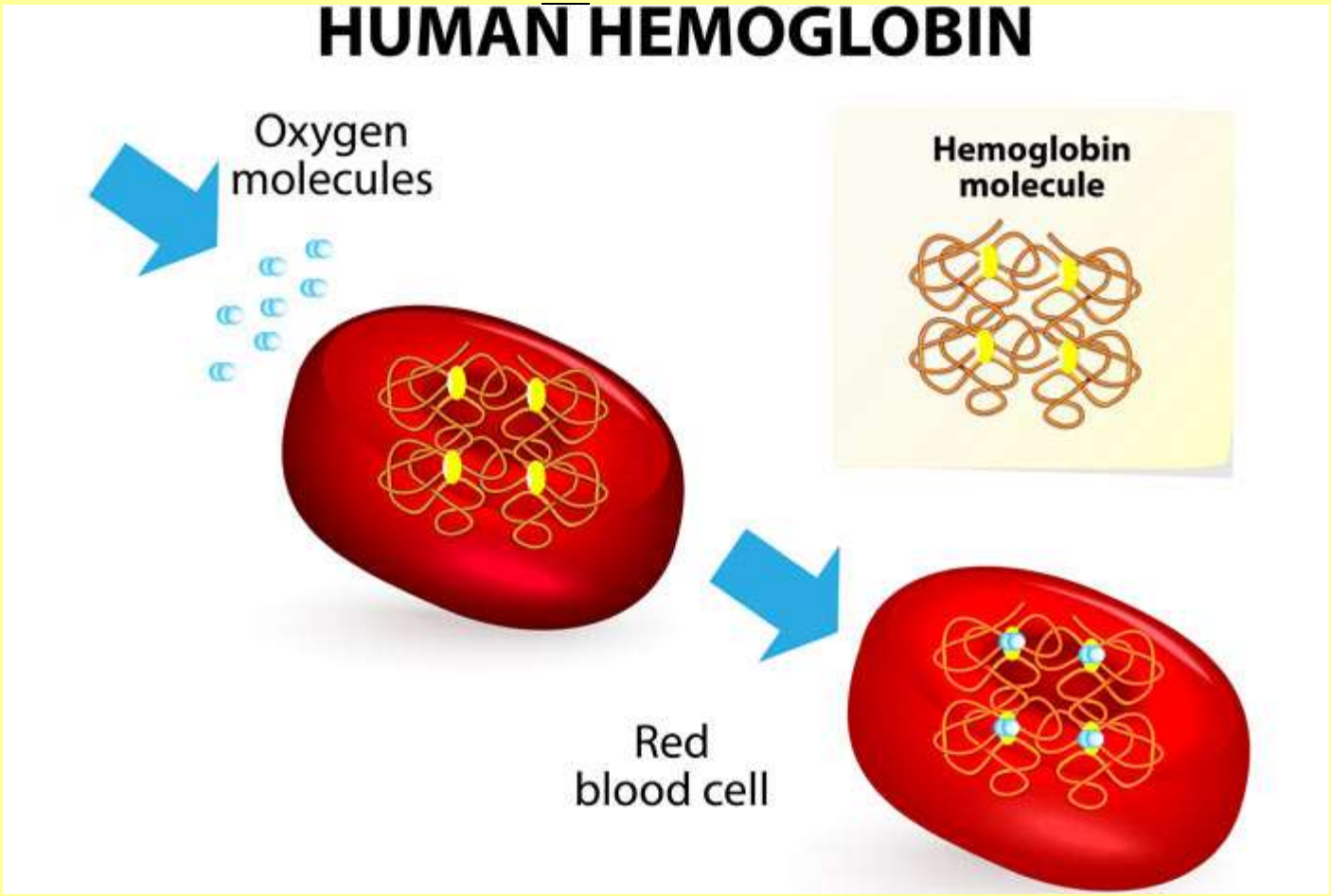


- **Protein synthesis =**
  - **Making of a protein**
- **Occurs in**
  - **Ribosomes**

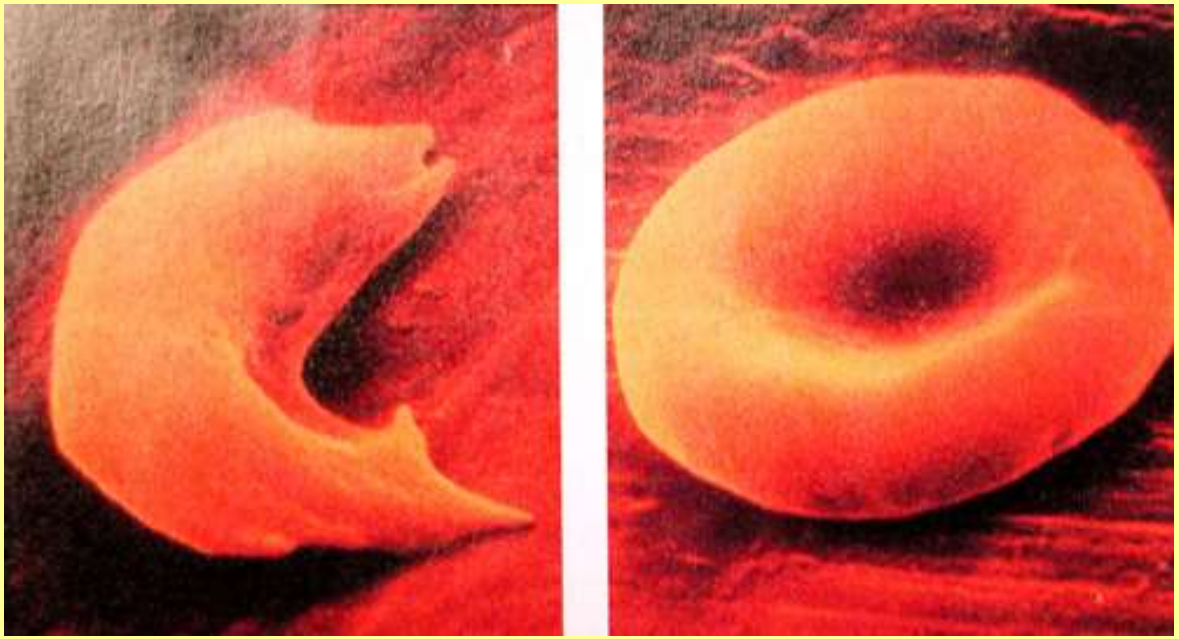


EXAMPLES OF PROTEINS

1. Hemoglobin = protein in red blood cells that **carries O_2**

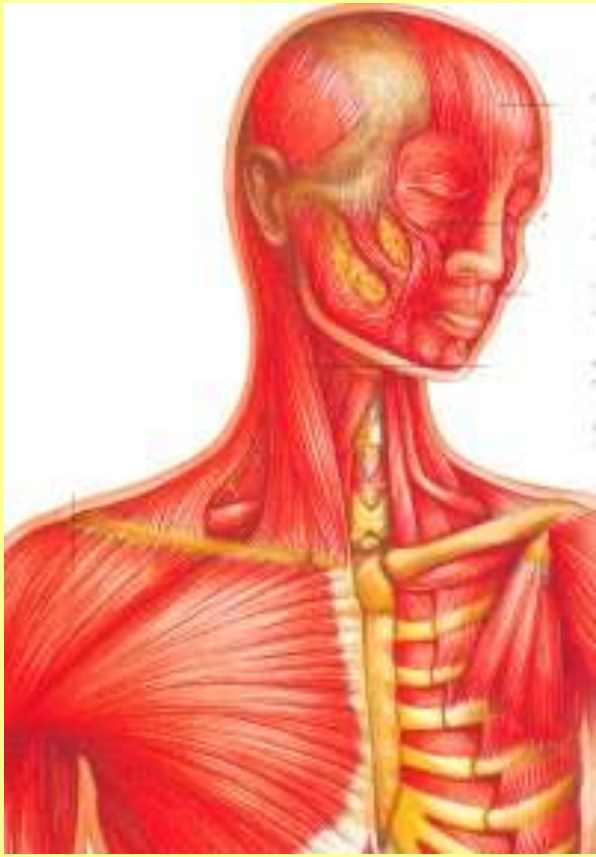


- Sickle cell anemia = disease caused by mutation
- Mutation changes 1 AA →
  - Funny shaped RBC
  - Can't carry O_2 as well



2. Hormones =
   - Chemical messengers
     - Very **specific** because of their **shape**
     - Control:
       - **Growth**
       - **Development**

3. Building materials for:
   - **Muscle**
   - **Skin**
   - **Hair**
   - Other tissues
   - Ex: collagen = protein found in skin and bone



4. ***Antibodies*** = proteins produced by **white blood** cells

- Help **fight disease**
- Very **specific** because of their **shape**

x

5. Cell Membrane Proteins

- Receptor molecules
- Transport channels

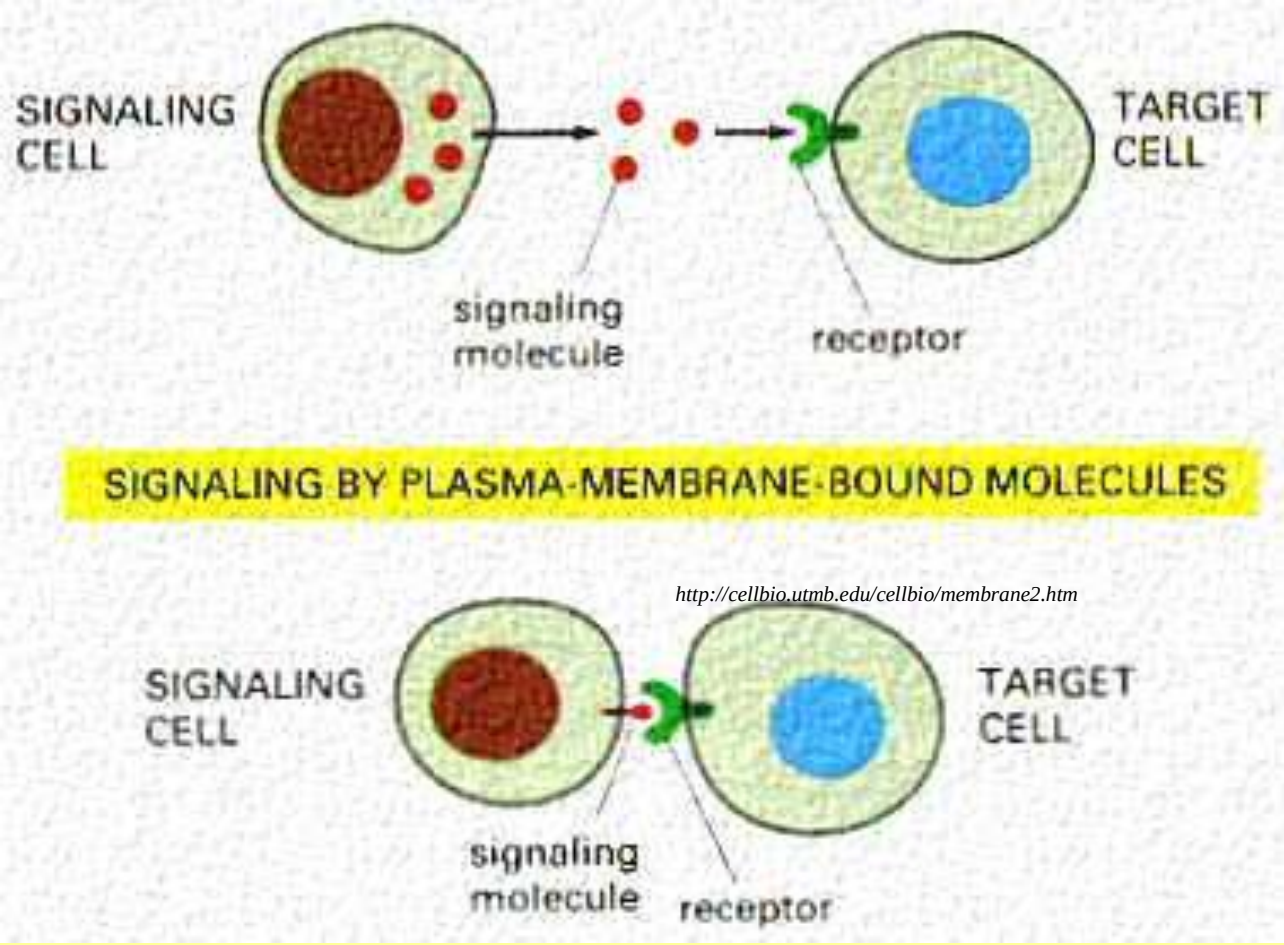
http://legacy.hopkinsville.kctcs.edu/sitecore/instructors/Jason-Arnold/VLI/Module%202/m2cellstructure/m2cellstructure3.html

http://www.scq.ubc.ca/conversing-at-the-cellular-level-an-introduction-to-signal-transduction/

Protein Receptor Molecules

= Proteins in cell membrane that

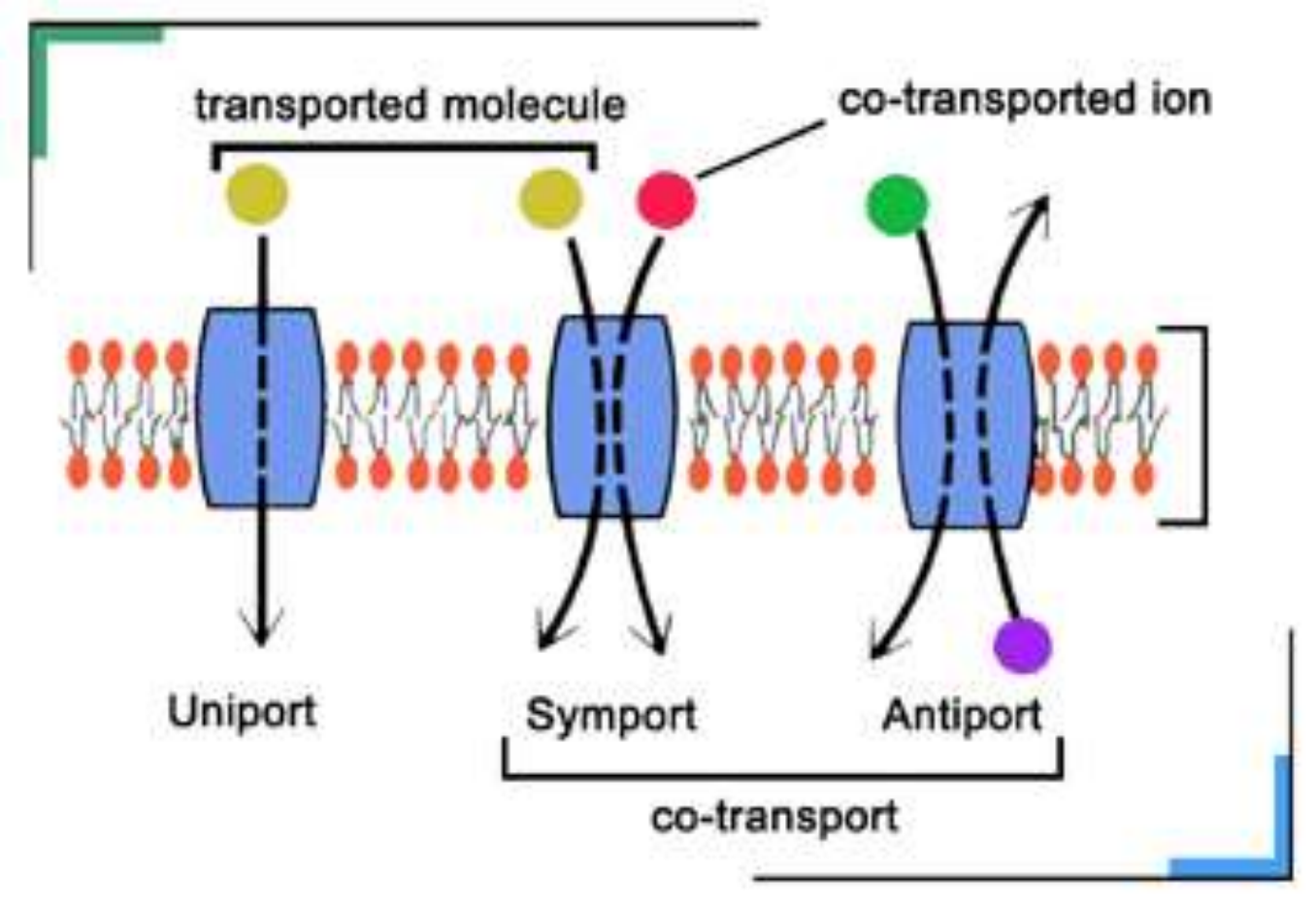
receive signals from outside the cell



Receptor molecules are

- very **specific** because of their **shape**

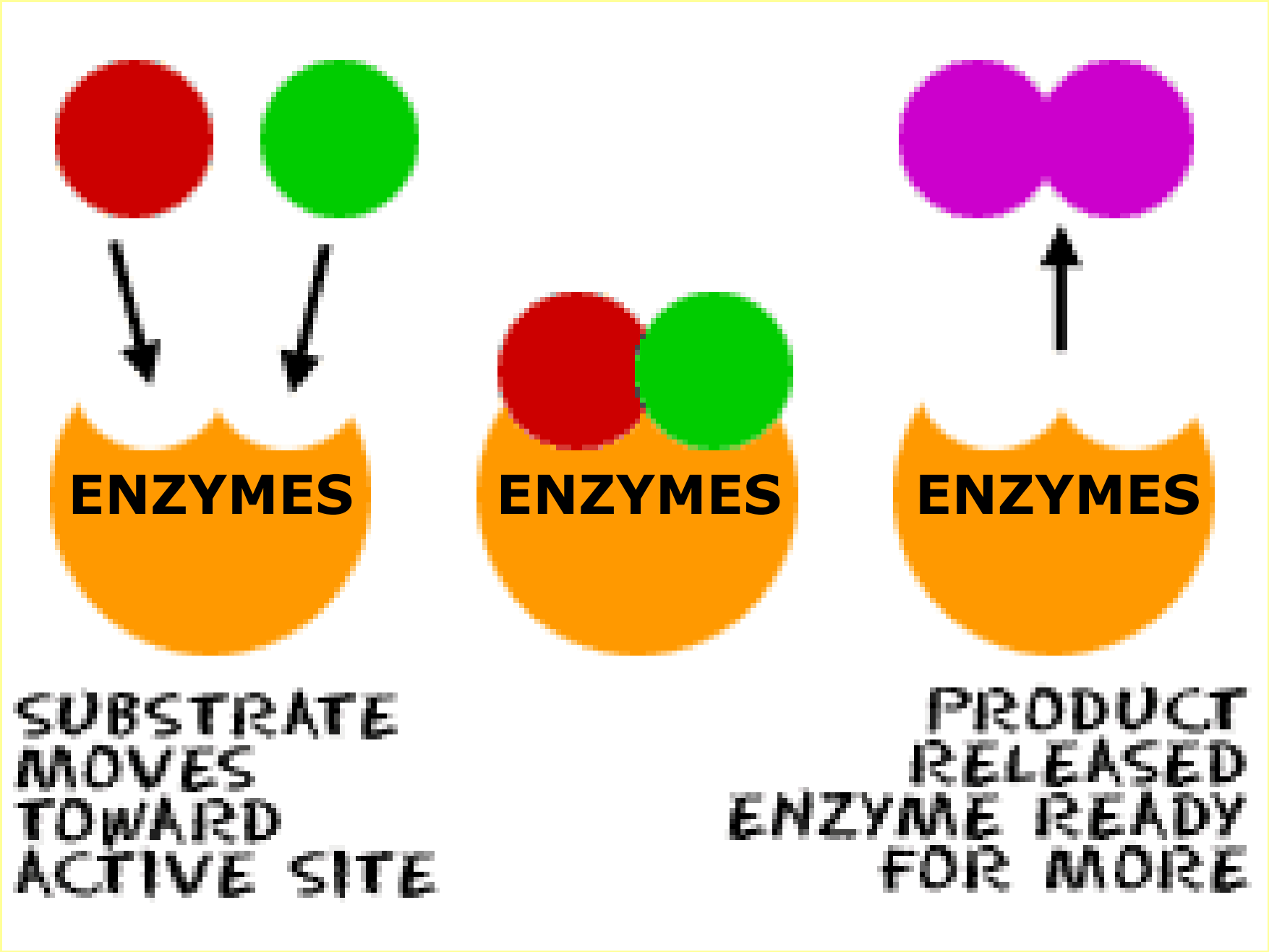
Protein transport channels



Help large molecules get into cells

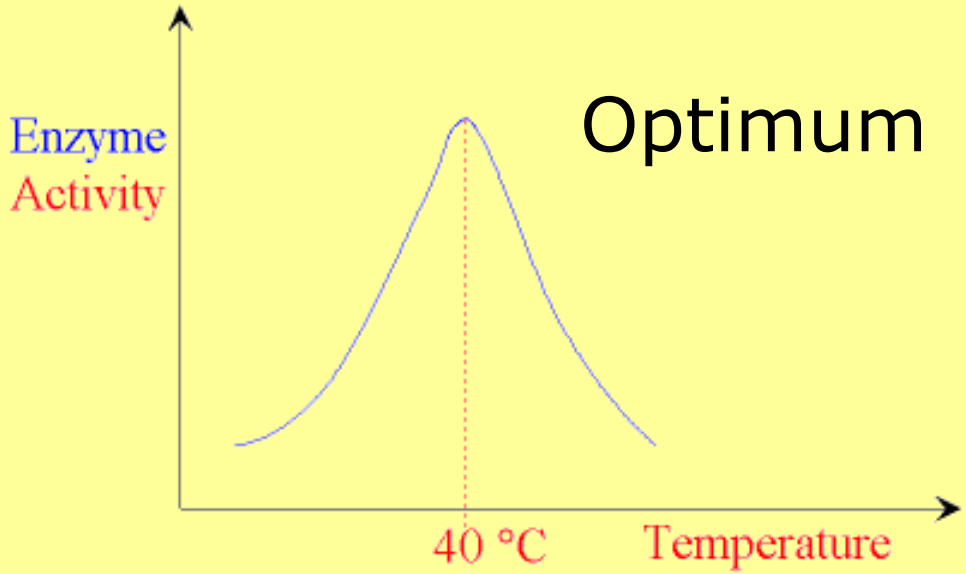
http://library.thinkquest.org/C004535/media/membrane_transport.gif

6. Enzymes =
   - Proteins that **control chemical reactions**
   - Very **specific** because of their **shape**


ENZYMES
ENZYMES
ENZYMES
SUBSTRATE MOVES TOWARD ACTIVE SITE
PRODUCT RELEASED
ENZYME READY FOR MORE

3 things can affect enzyme reactions

1. Temperature
2. pH
3. Substrate concentration



Optimum conditions

Co-enzymes

- **<u>Help enzymes work</u>**
- Vitamins and minerals act as **co-enzymes**
  - Examples: Mg, Vit. A, Ca

Chemical reactions are represented by equations

Reactants or substrates → Products

$$A + B \rightarrow C$$

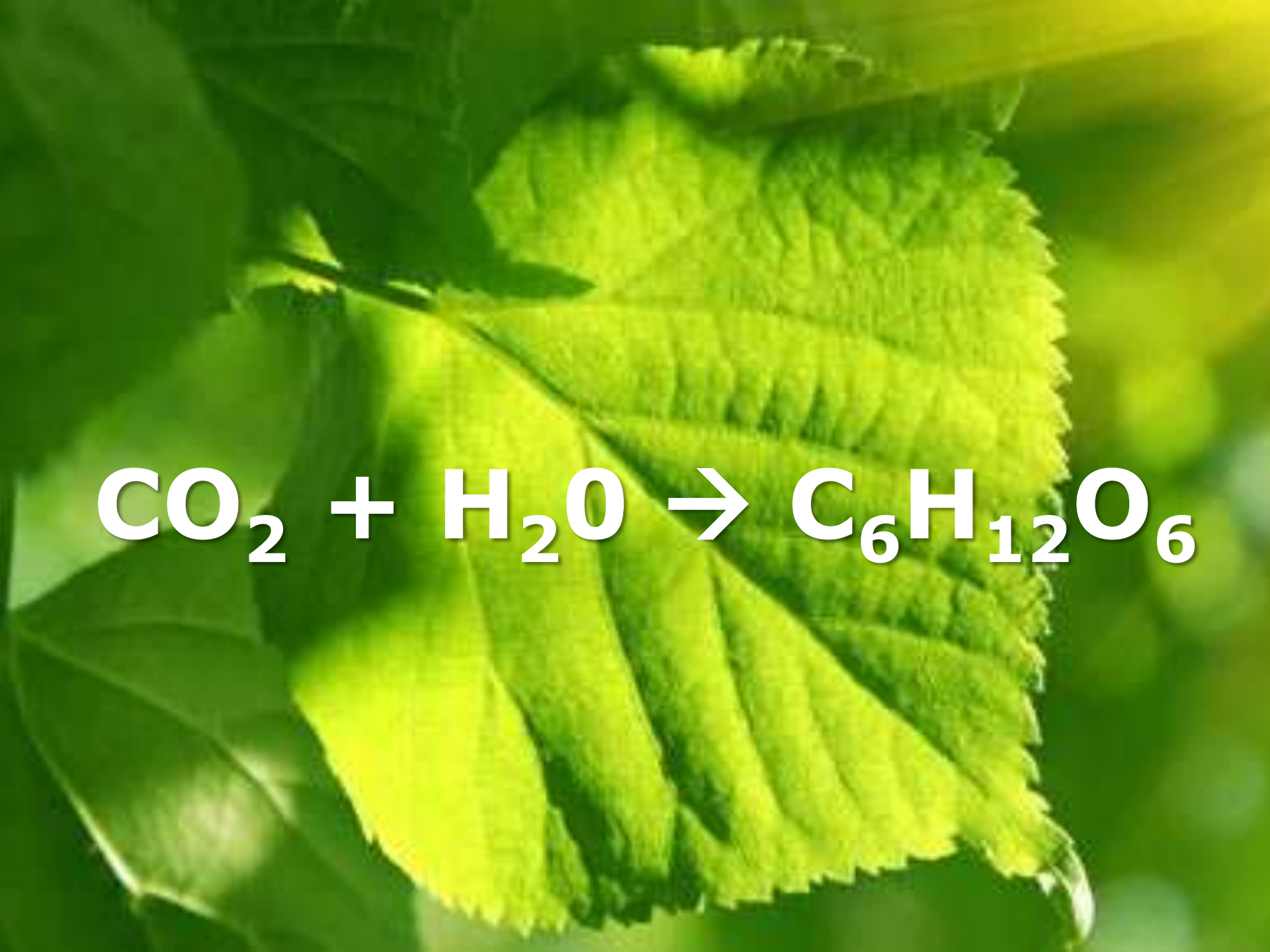
$$C \rightarrow A + B$$

2 types of reactions

1) Synthesis (Making)
   a. Ex:

      A + B → C

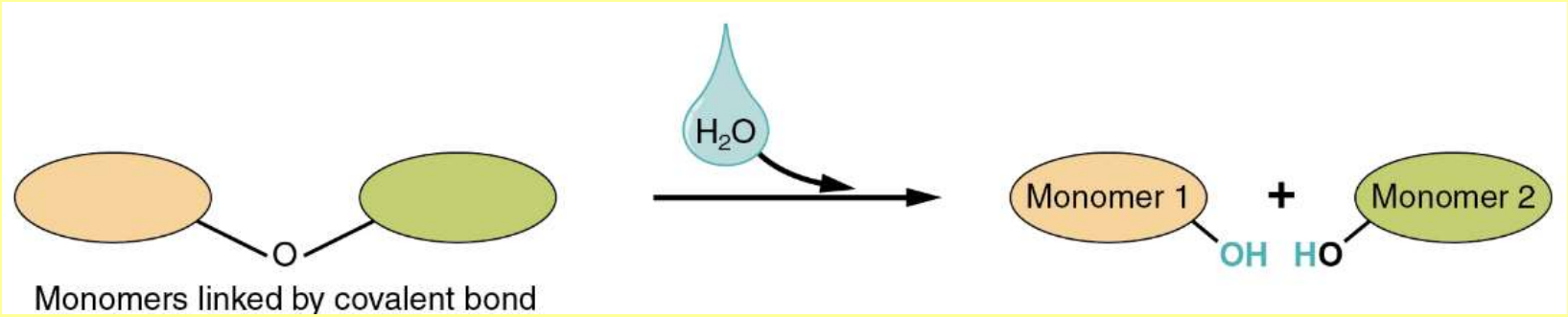
   b. Ex: photosynthesis


$CO_2 + H_20 \rightarrow C_6H_{12}O_6$

2. Lysis Reactions (breaking) = digestion

   - Hydrolysis = add water to breakdown

     - Complex sugars and proteins can be broken down this way


O
Monomers linked by covalent bond
H_2O
Monomer 1
+
Monomer 2
OH
HO

Enzymes

Enzymes

- End in –ase
- Very specific shape
- Have optimum pH and temp
- Control chemical reactions = catalysts
- Can be reused because they are not changed by the reaction

Metabolism

Metabolism = all the chemical reactions that occur in a body

4 types of organic compounds

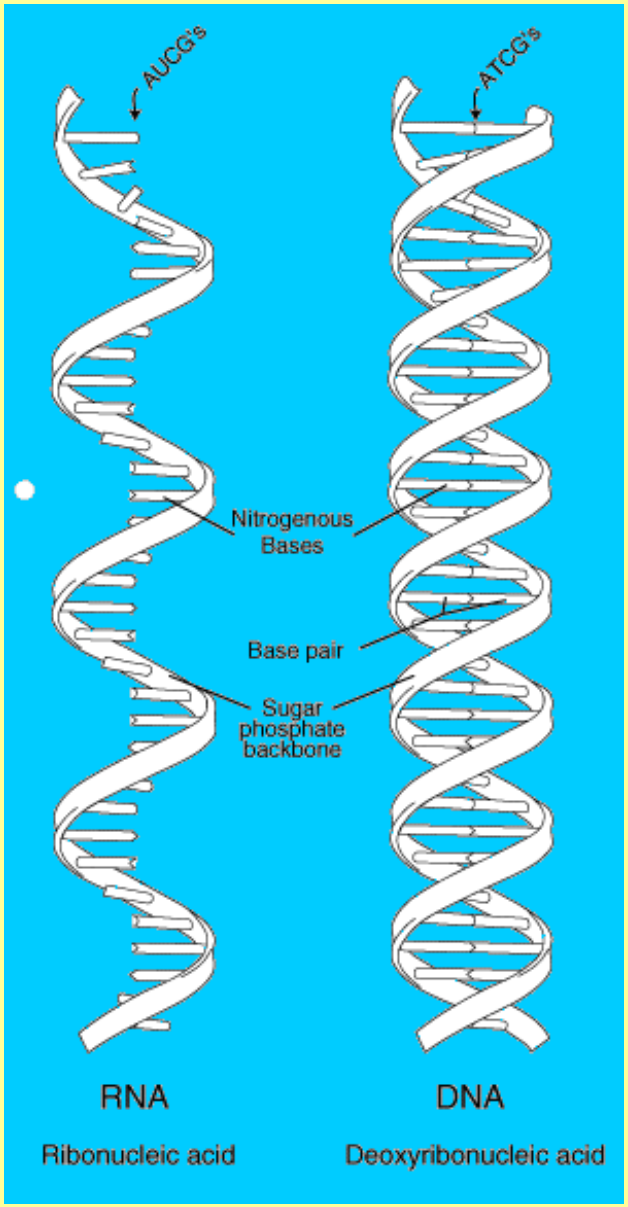
- Carbohydrates
- Proteins
- Lipids
- Nucleic acids

Unit 2

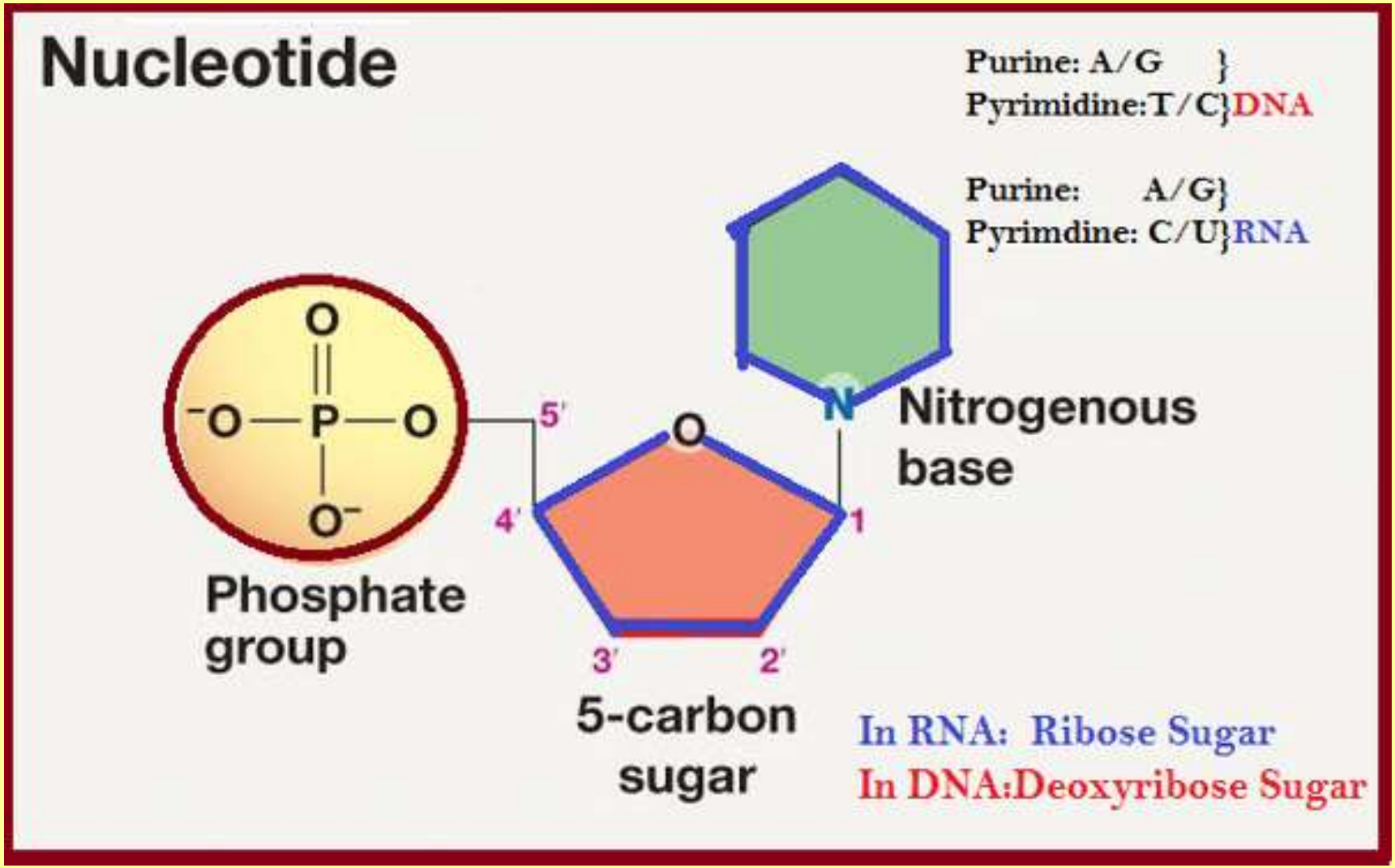
Part 4: Nucleic Acids
=DNA and RNA

4. Nucleic Acids

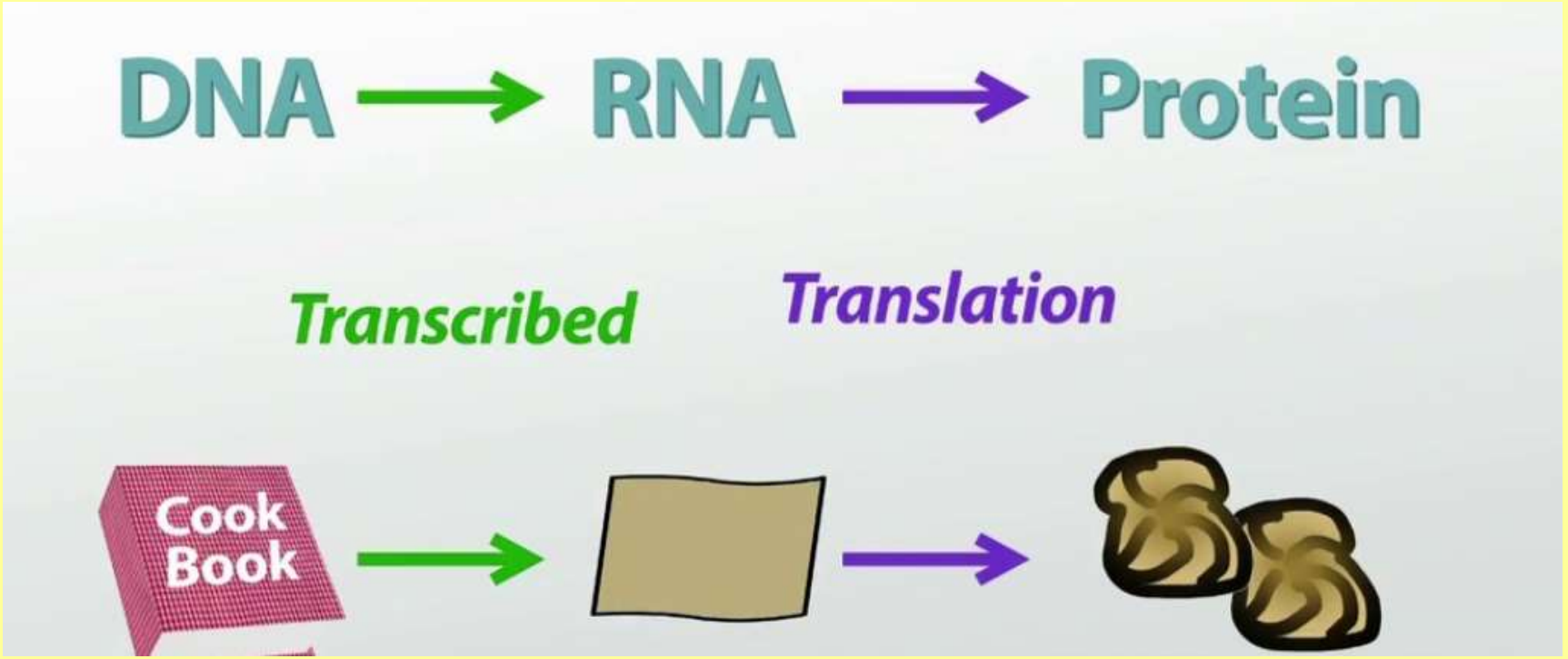
- DNA = deoxyribonucleic acid
- RNA = ribonucleic acid



Both RNA and DNA made of nucleotides

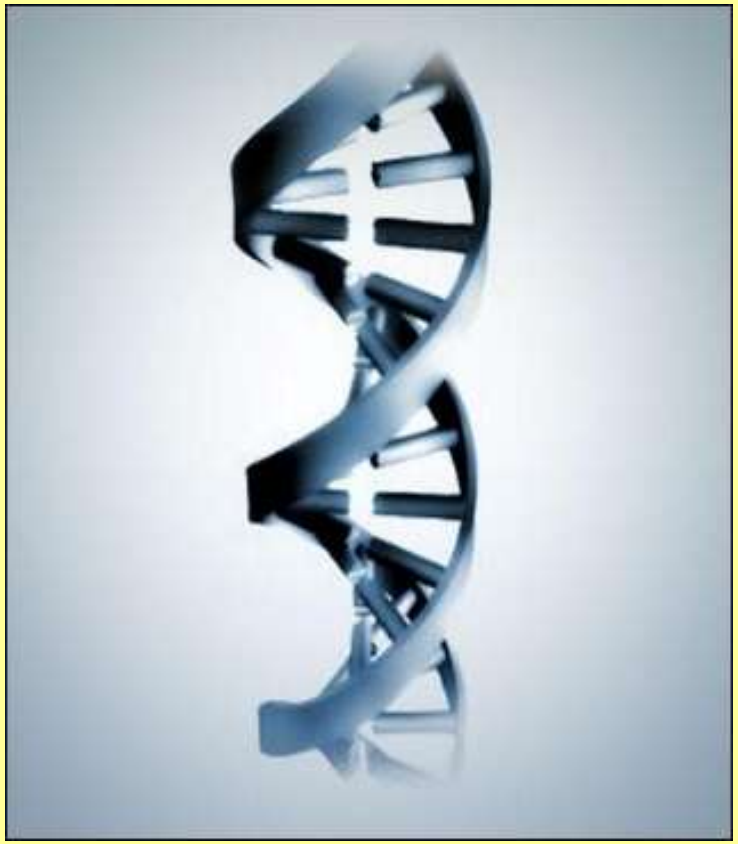


Both involved in protein synthesis



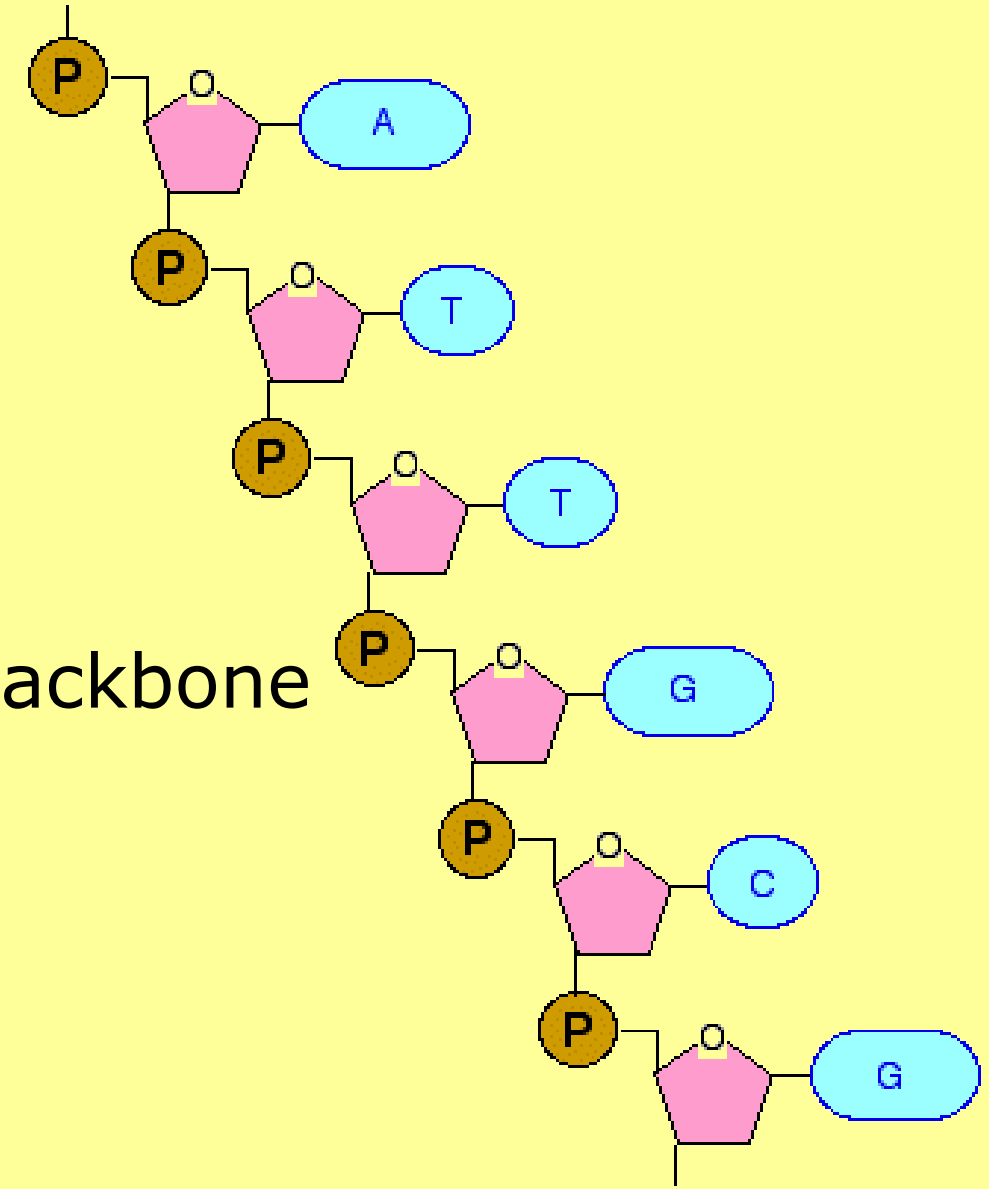
DNA

- Double helix shape

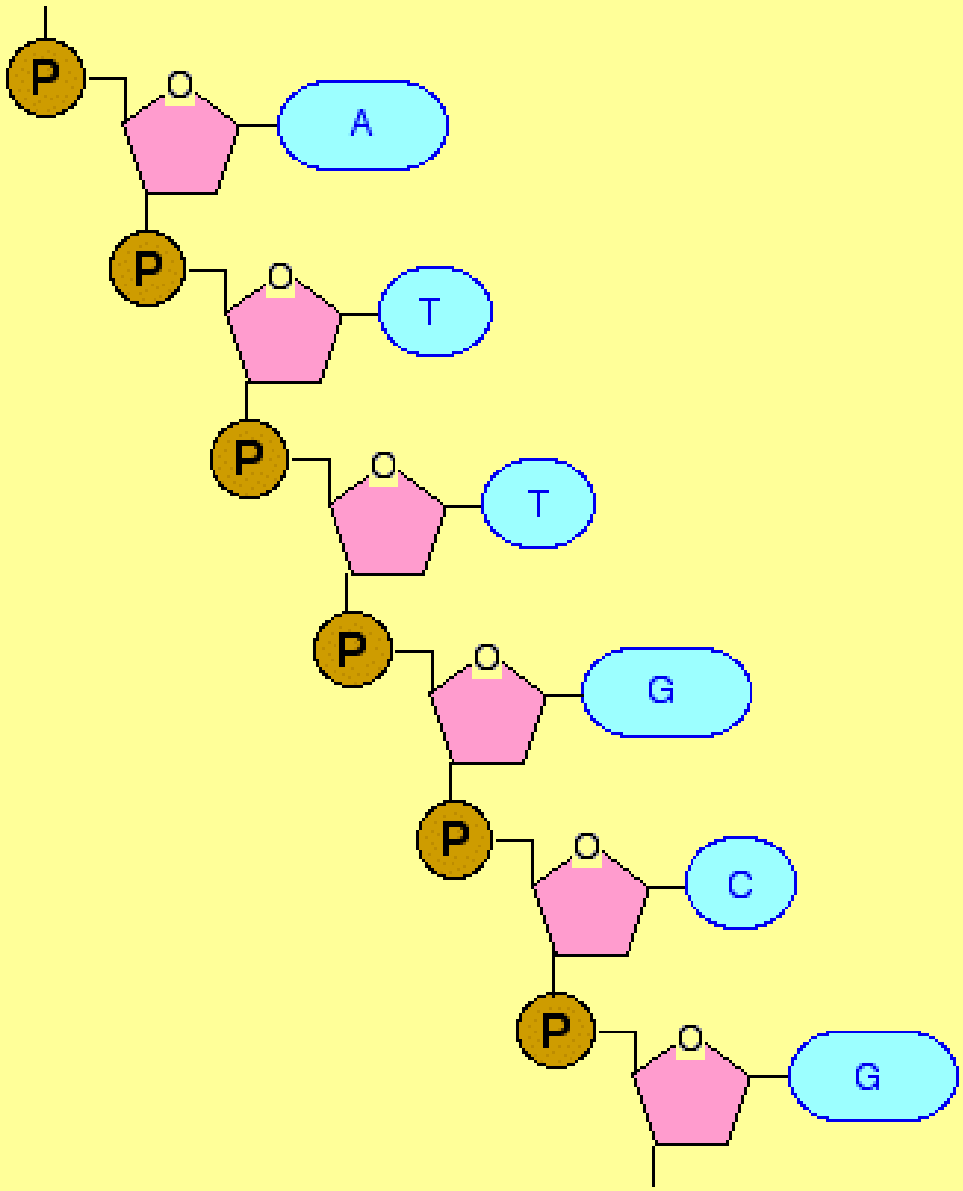


DNA

- Sugar – phosphate backbone
- Sugar = deoxyribose



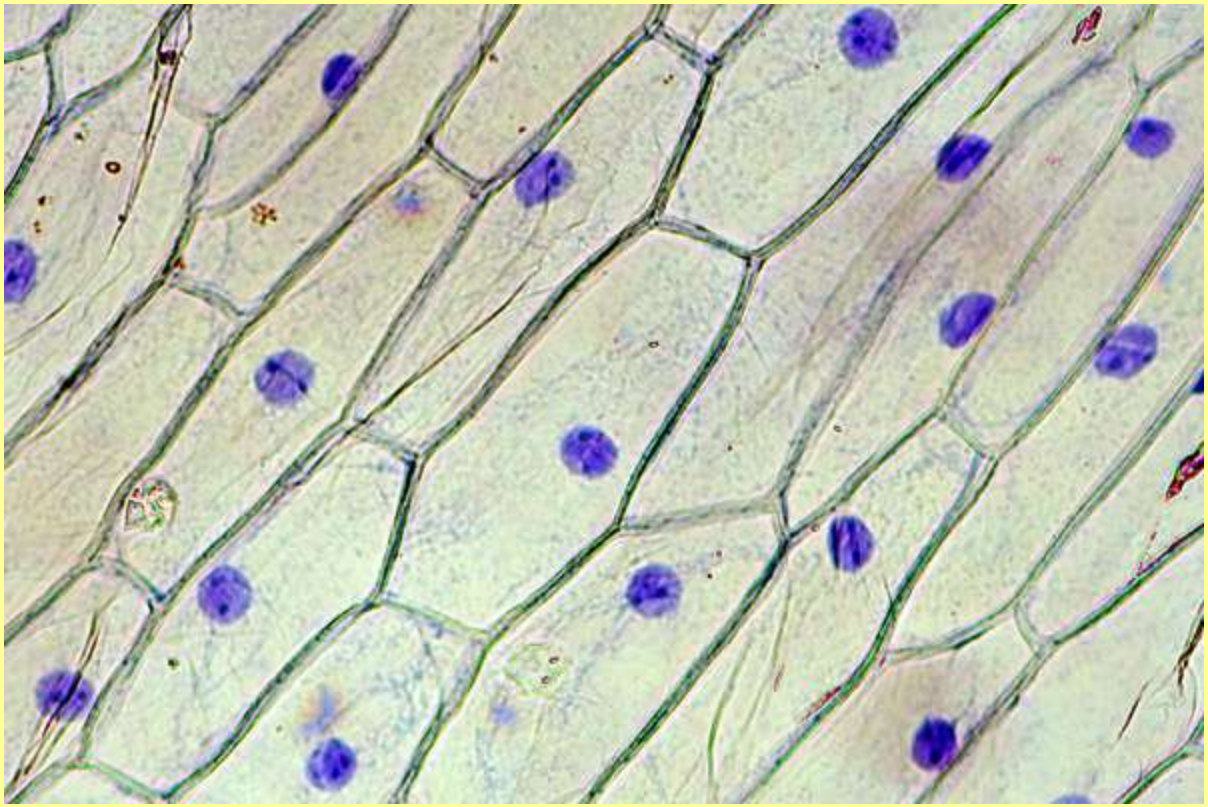
DNA



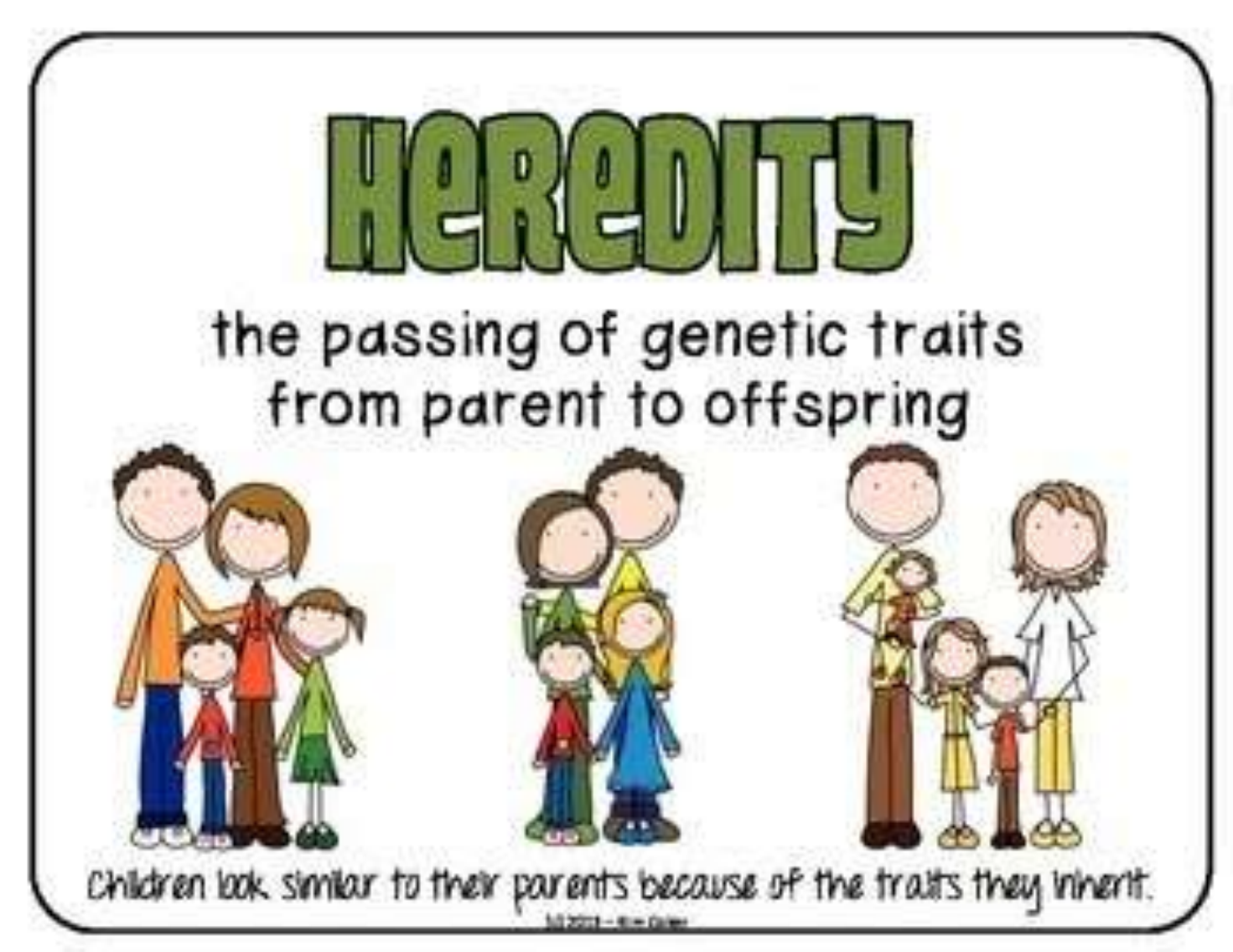
- Bases = A,T,C,G

DNA

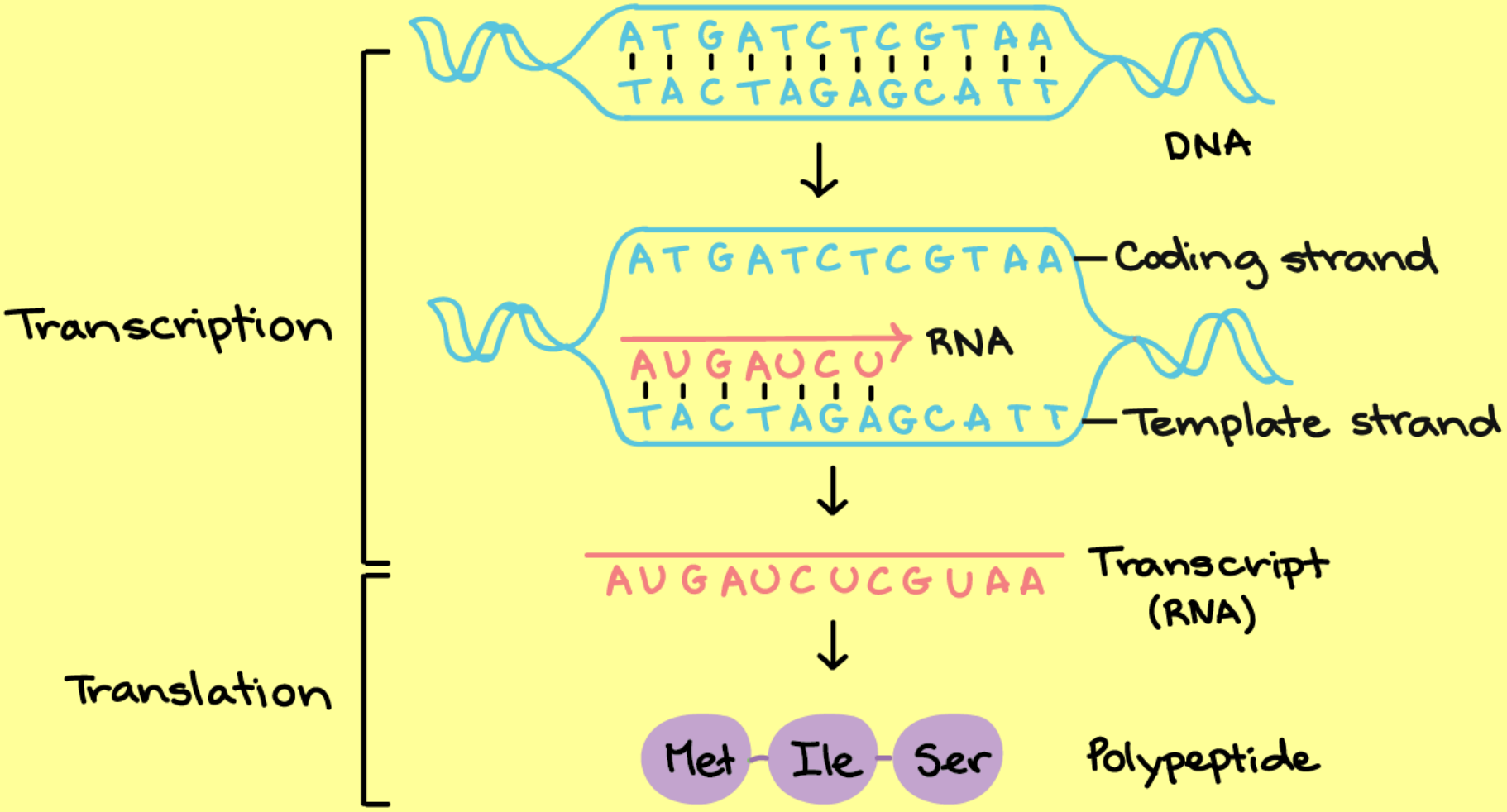
- Found in nucleus



DNA = Heredity molecule

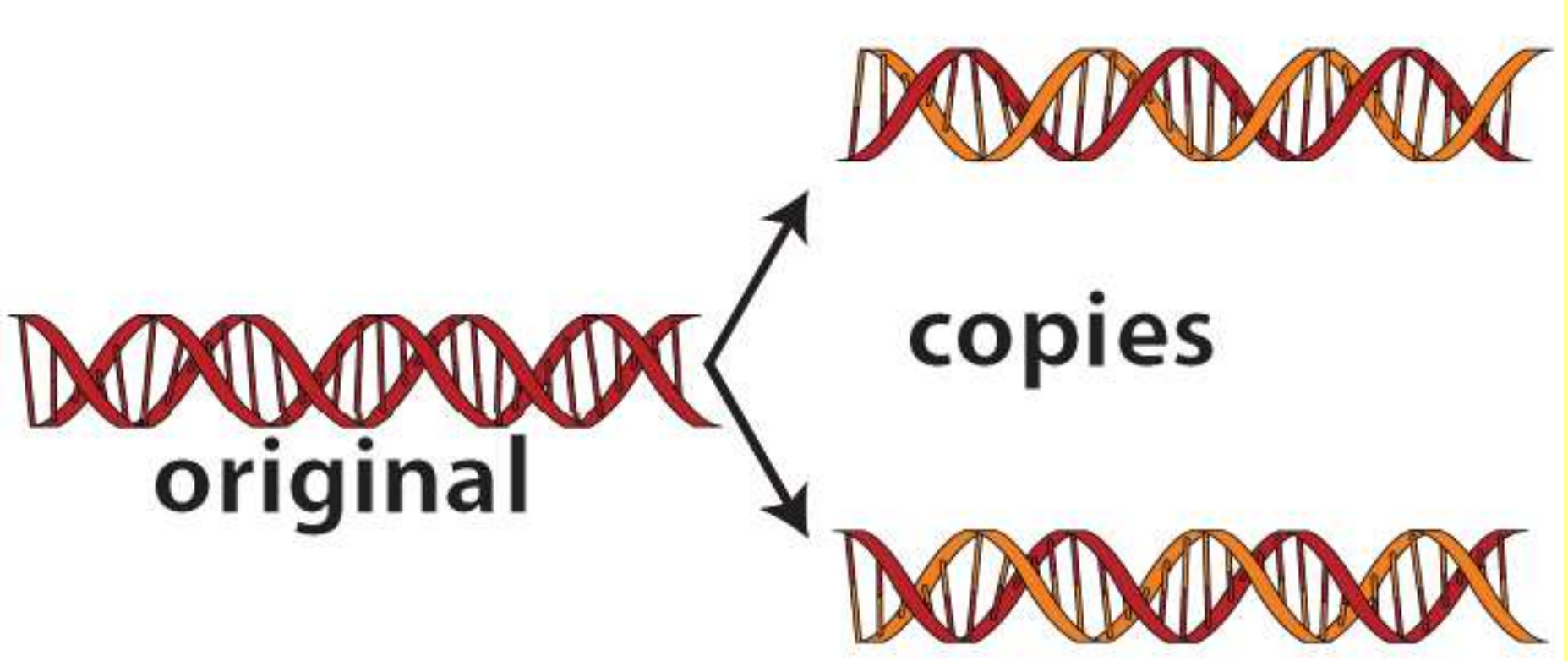


DNA = template for proteins



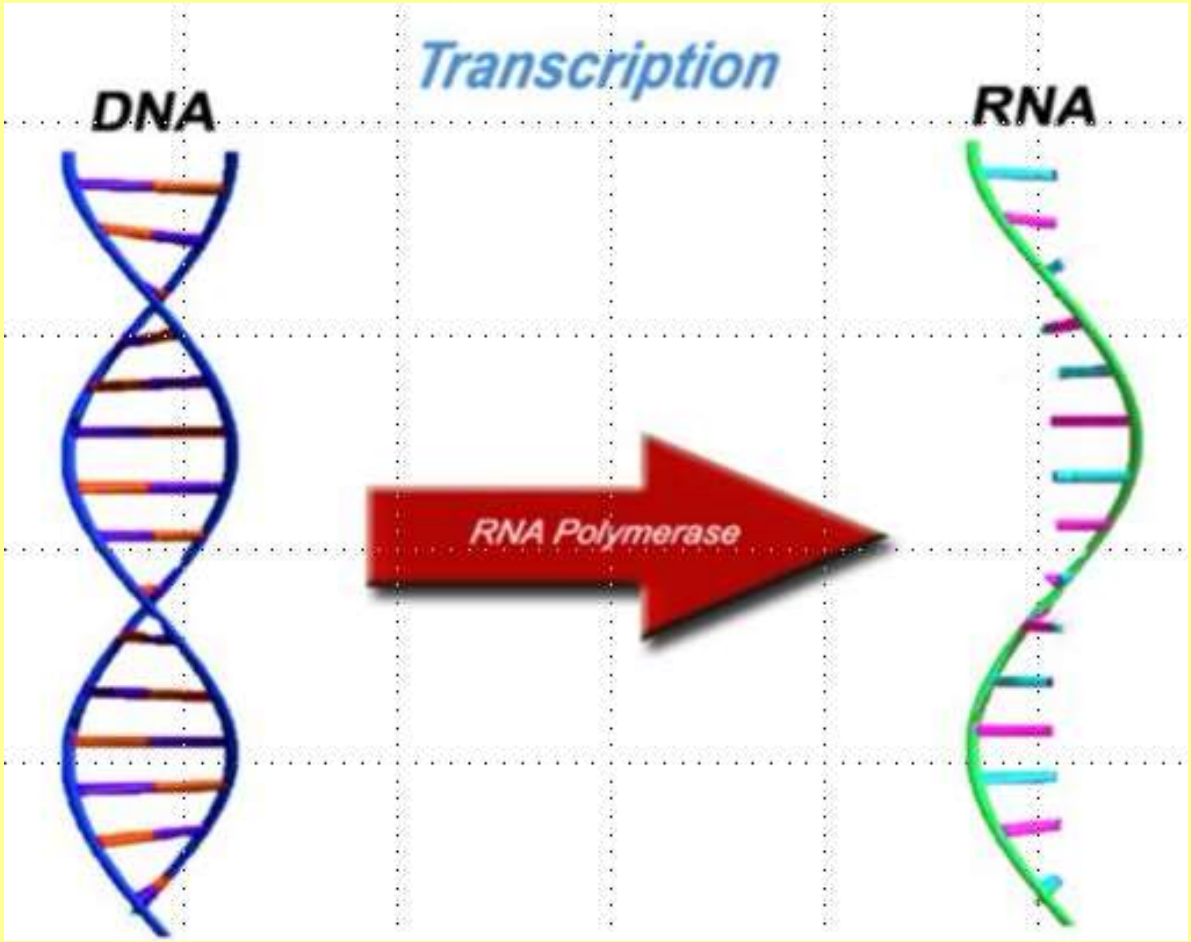
DNA

Replicates = makes copies of itself



RNA

- Single stranded



RNA

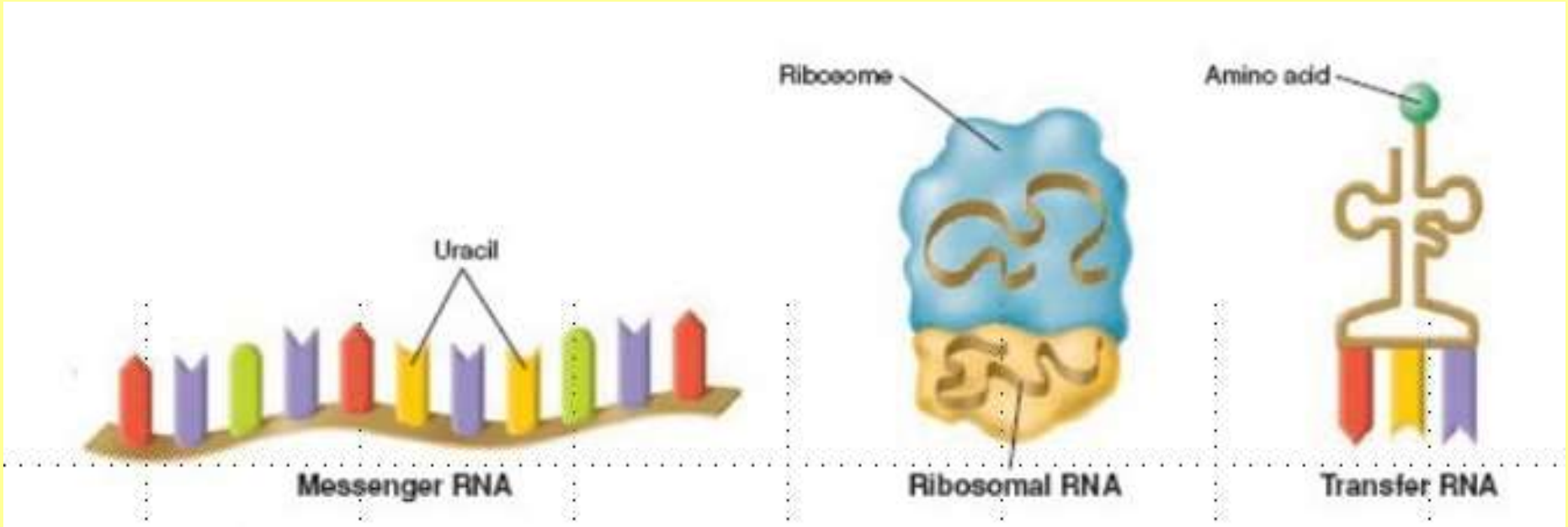
- Sugar = ribose
- Bases = A,U,C,G

Complementary base pairing

DNA Base	Complementary RNA Base
G	C
C	G
A	U
T	A

RNA

- 3 types
  - Messenger (mRNA)
  - Ribosomal (rRNA)
  - Transfer (tRNA)



Organic compounds

Type of Compound	**Building Block**
Carbohydrate	Simple sugars → complex Monosaccharide → poly
Proteins	Amino Acids
Lipids	Fatty acids and glycerol
Nucleic acids	Nucleotides (sugar, phosphate base)

Protein synthesis

- DNA → mRNA
- A → U
- T → A
- C → G
- G → C
- mRNA brings instruction to the ribosome
- mRNA codon → tRNA anticodon
- tRNA brings amino acids to ribosome