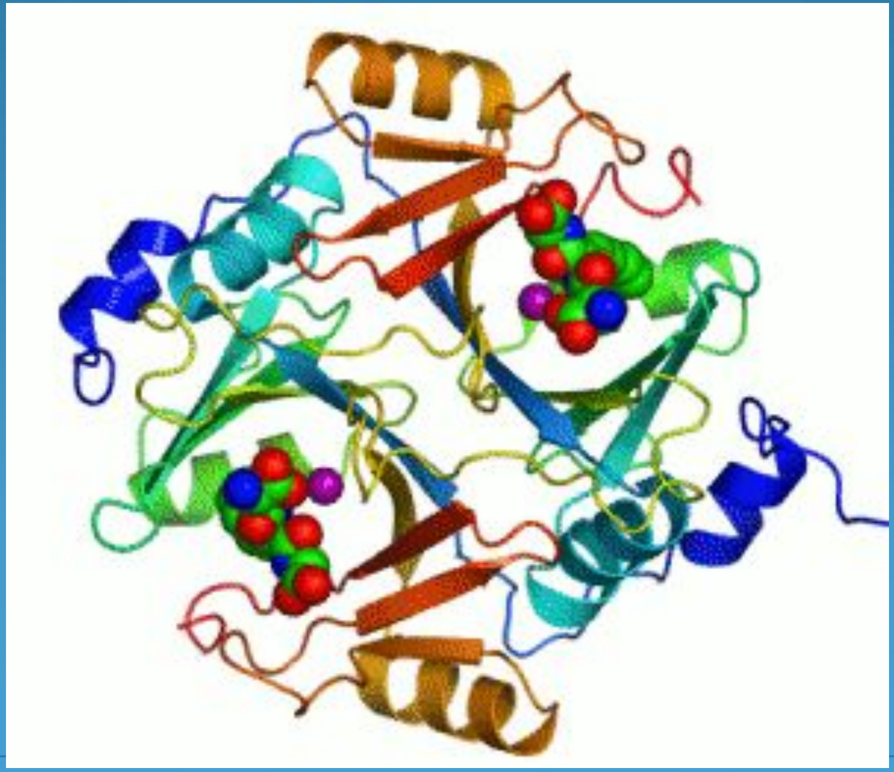
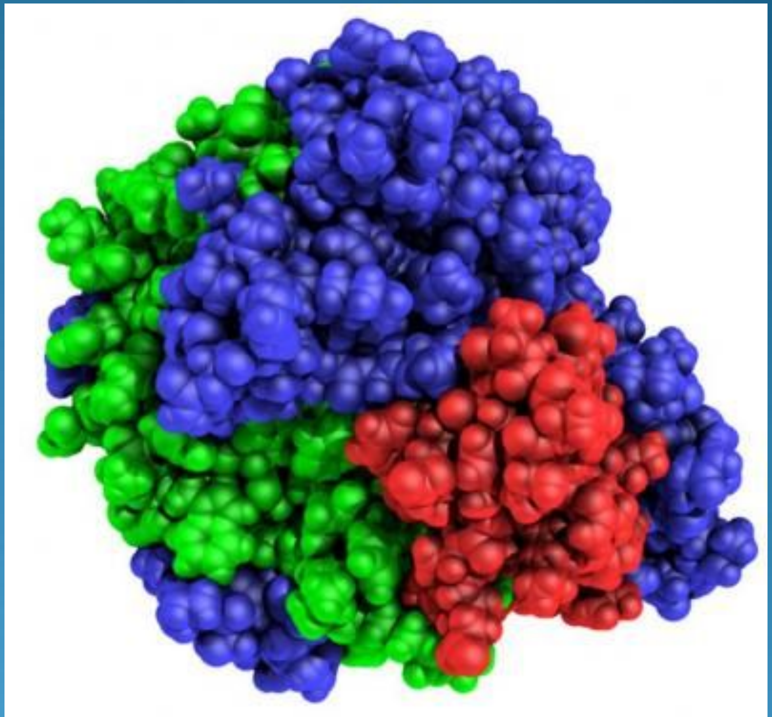
Macromolecules and Enzymes



What is an enzyme?

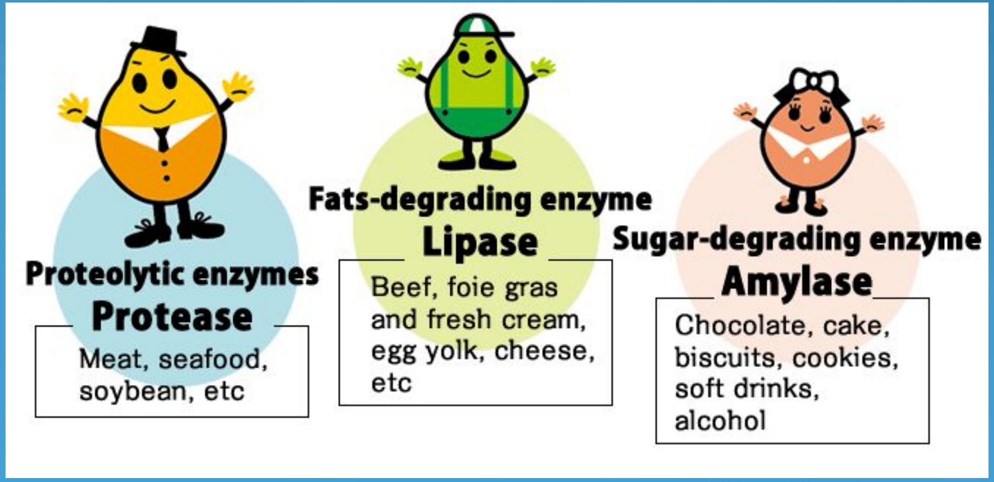
- Most enzymes are proteins
- Act as a catalyst to speed up a chemical reaction by helping molecules react with each other faster
- *They decrease the activation energy!*



What is an enzyme?

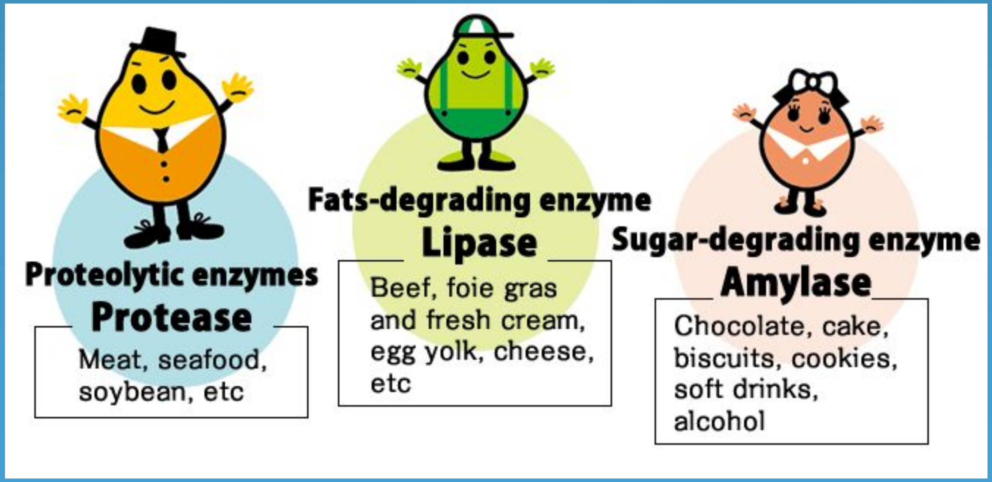
Enzymes are…

- Reusable! (specificity)
- Specific for what they catalyze (speed up)
  - End in "-ase"
  - Named for the reaction they help. For example…
    - Sucrase breaks down sucrose
    - Proteases break down proteins
    - Lipases break down lipids
    - DNA polymerase builds DNA



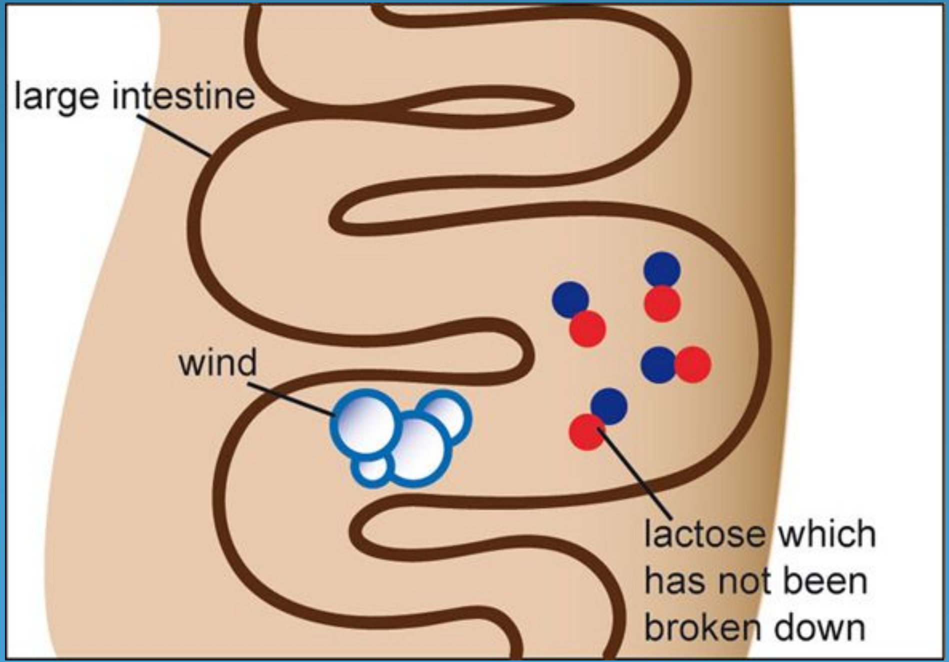
Think about it:

- Explain why people lacking the enzyme lactase cannot digest milk.



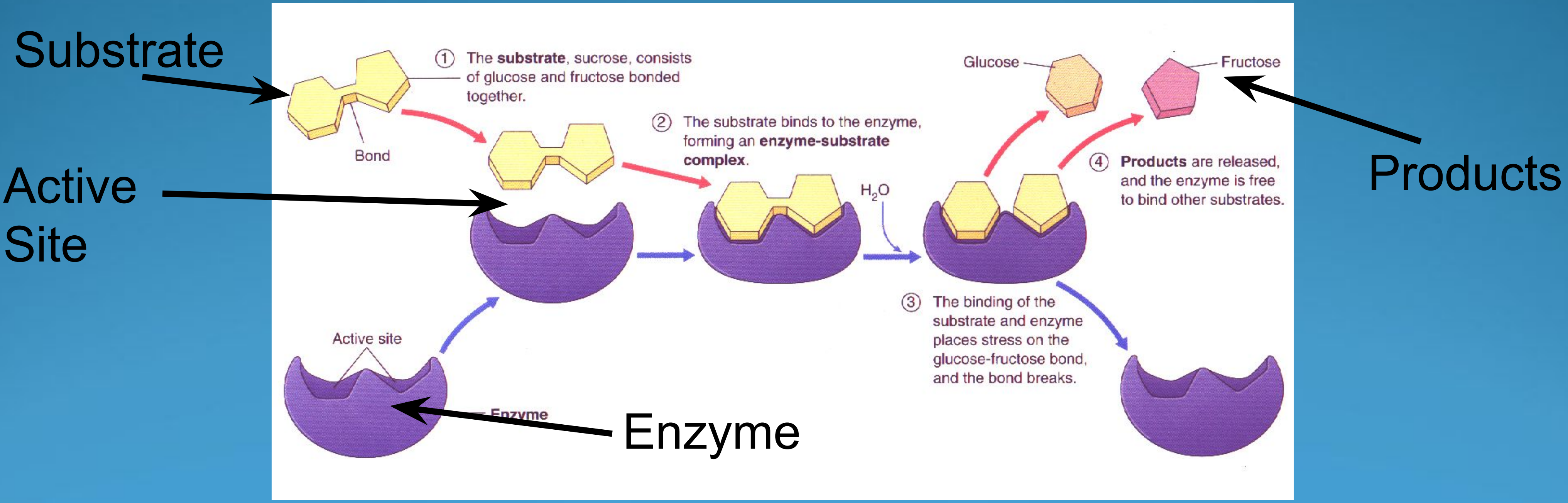
CASE STUDY: LACTOSE INTOLERANCE

- Lactase breaks down lactose, a common component of dairy products (like milk)
- People lacking the enzyme lactase are considered “lactose intolerant”-they can’t digest large amounts of milk!!



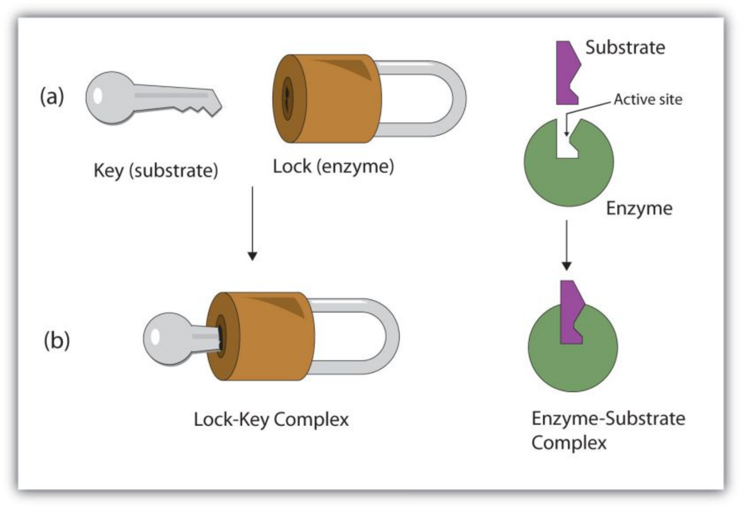
ENZYME REACTIONS: ENZYMES ARE NOT USED UP!

- Re-used again for the same reaction with other molecules
- Very little enzyme is needed to help in many reactions!



LOCK AND KEY MODEL

- Remember, enzymes are specific!
- Lock and Key Model: Shape of enzyme allows substrate to fit
  - Specific enzyme for each specific reaction



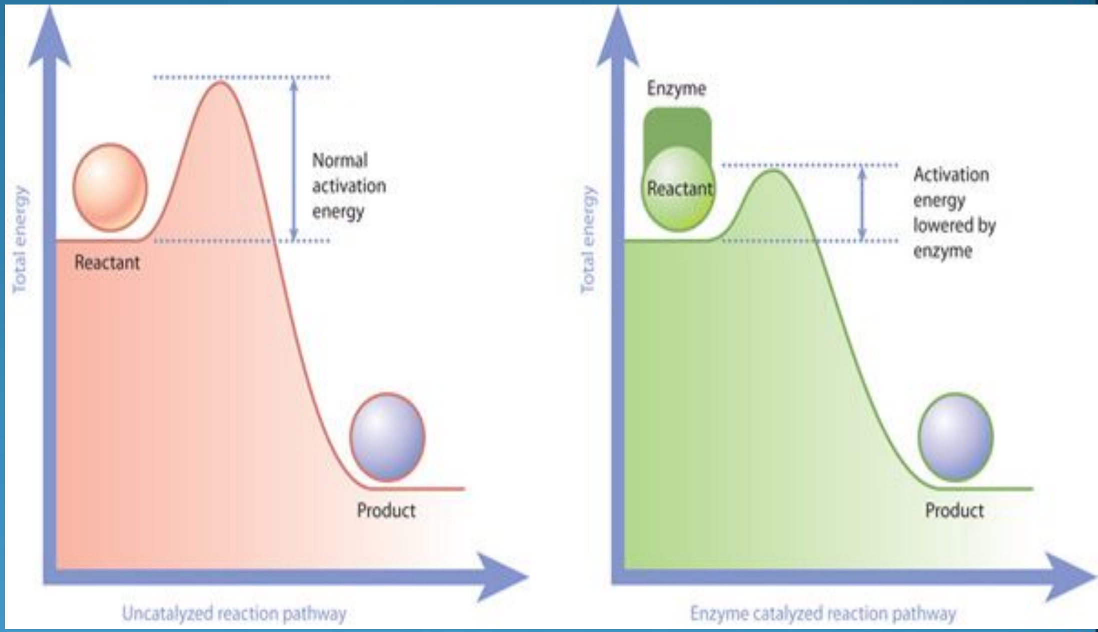
Chemical Reaction

Enzyme + Substrate → Enzyme + Product

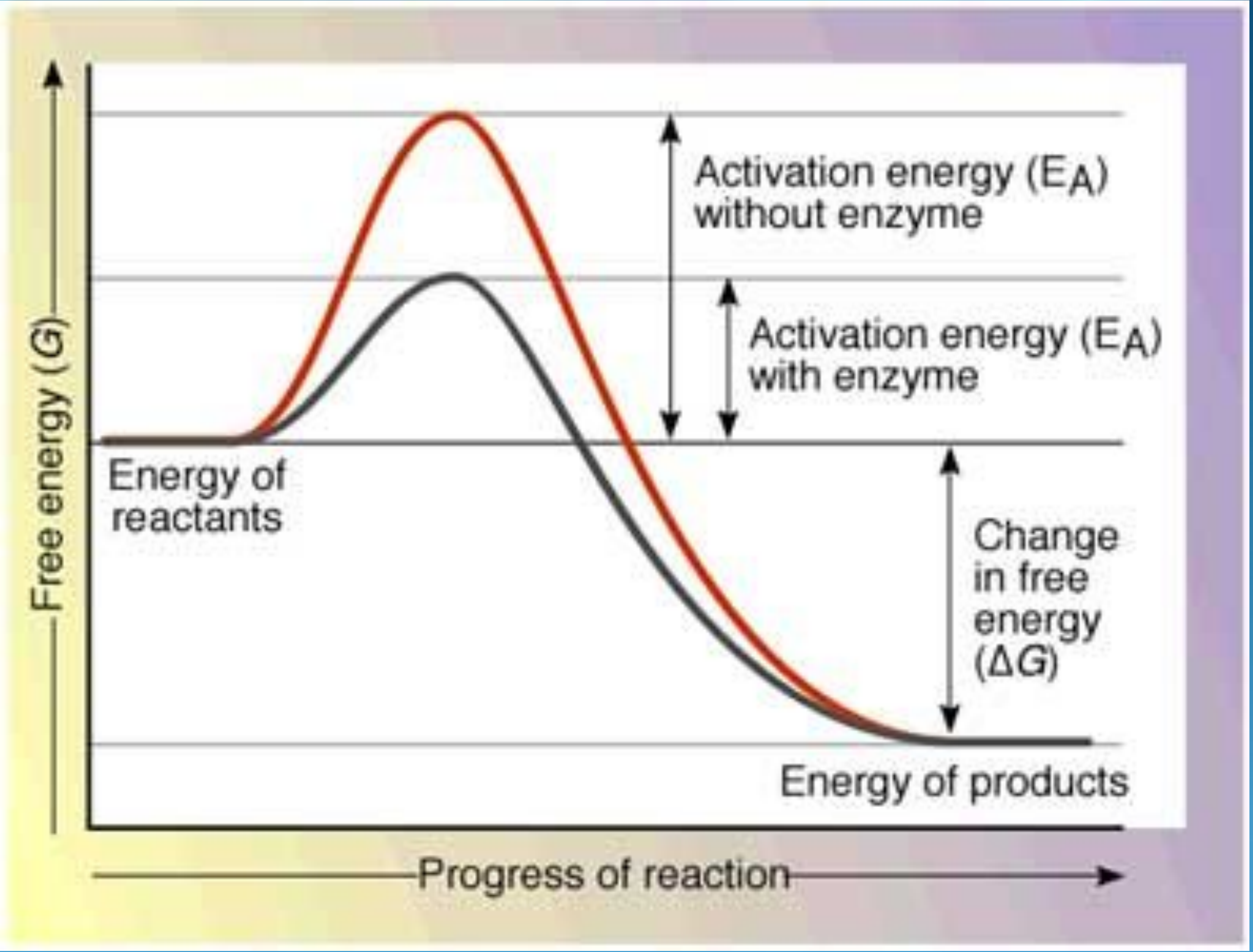
REACTANTS ***PRODUCTS***

SO...HOW DO ENZYMES WORK?

- **Enzymes work by weakening bonds, which lowers ACTIVATION ENERGY**
  - Activation Energy=energy needed for the chemical reaction to occur (energy needed to activate!)
  - By lowering the activation energy, the reaction can occur faster!

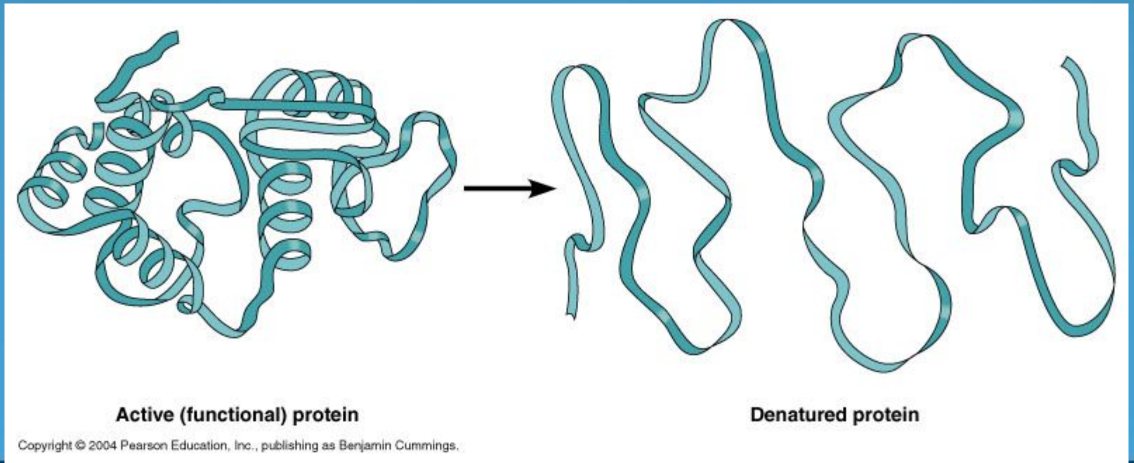


*Reactions can occur without the help, BUT not at the speed that our bodies need!


Free energy (G)
Activation energy (E_A) without enzyme
Activation energy (E_A) with enzyme
Energy of reactants
Change in free energy (ΔG)
Energy of products
Progress of reaction

WHAT AFFECTS ENZYME ACTIVITY?

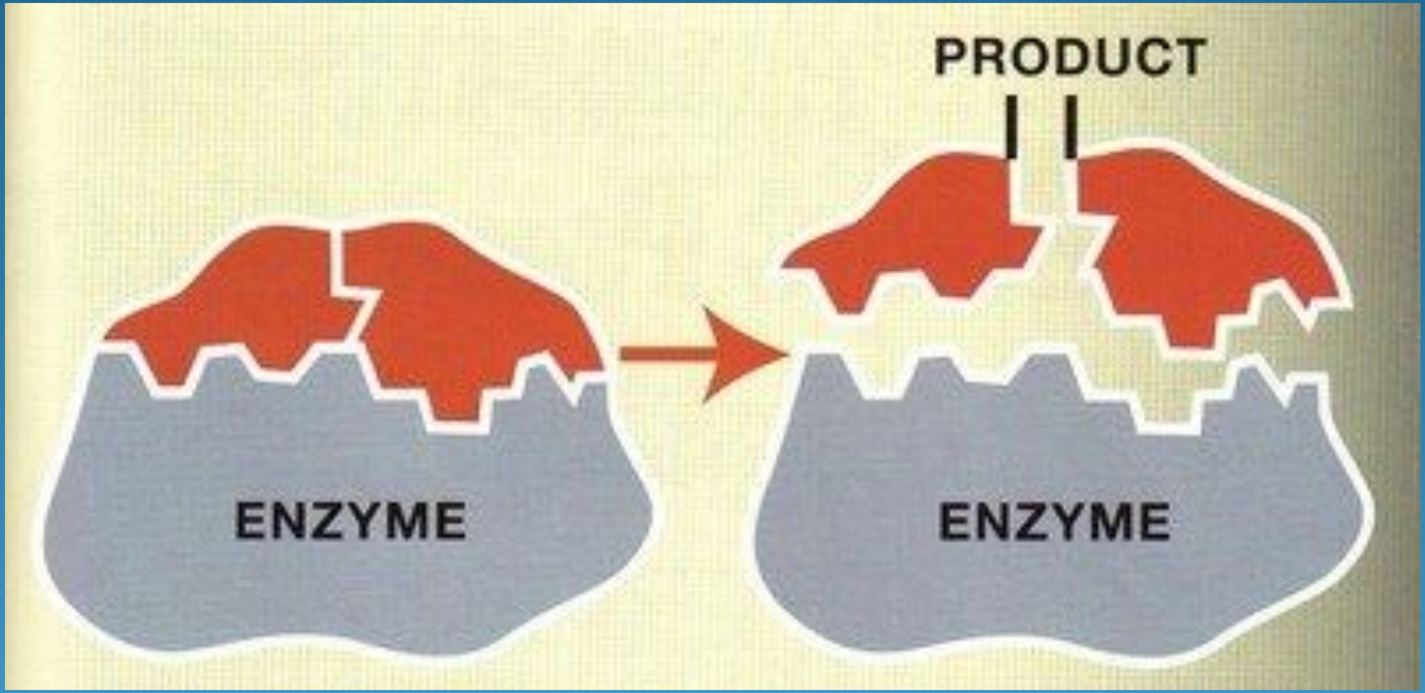
- **Temperature**
  - High temperatures can cause enzymes to denature (unfold and lose shape), while low temperatures slow molecules down
- **pH**
  - Changes in pH changes protein shape (most human proteins sit at a pH of 6-8)
- **Denaturing** = extreme temperature and pH can change enzyme shape, rendering it useless!



WHY ARE ENZYMES IMPORTANT?

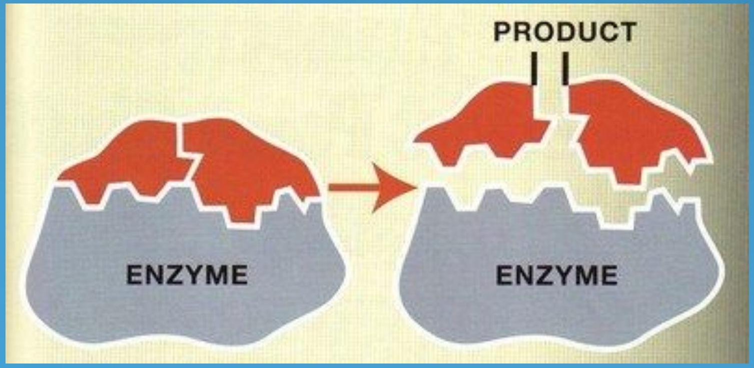
- Every reaction in your body is helped by an enzyme. They are necessary for all biological reactions!

Review Enzymes

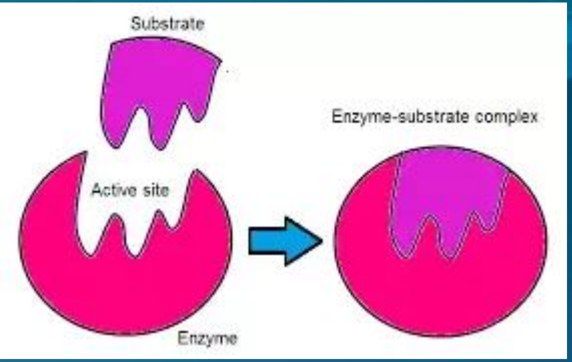


Review Enzymes

- biological catalyst
- proteins
- speed up a chemical reaction
- reusable
- usually end in -ase
- react best at a specific temperature (optimum)
- react best at a specific pH (optimum)
- specific
- decrease activation energy



Review



- Substrate - substance acted upon by an enzyme
- Denatured Proteins - high temperatures or extreme changes in pH, changes the shape
- Sucrase - enzyme, breaks down sucrose
- Proteases - enzyme, break down proteins
- Lipases - enzyme, break down lipids

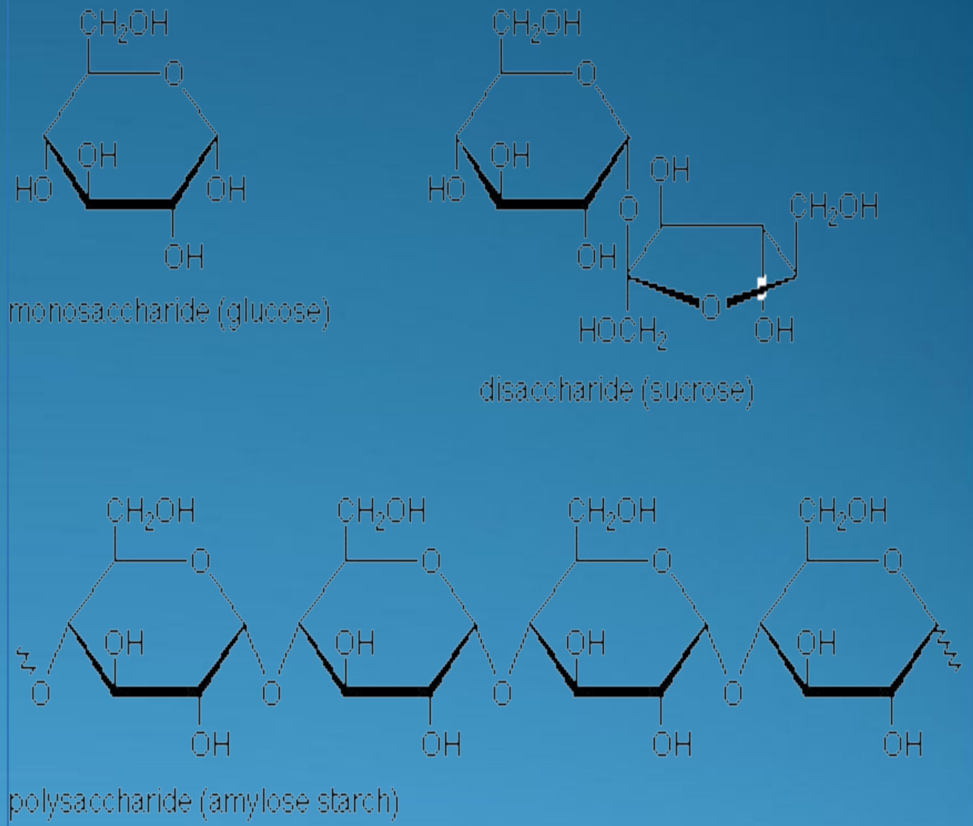
Macromolecules

- Organisms contain a number of large, organic molecules. We call these macromolecules.
- Some examples include:
  - Carbohydrates
  - Lipids
  - Proteins
  - Nucleic Acids

Carbohydrates

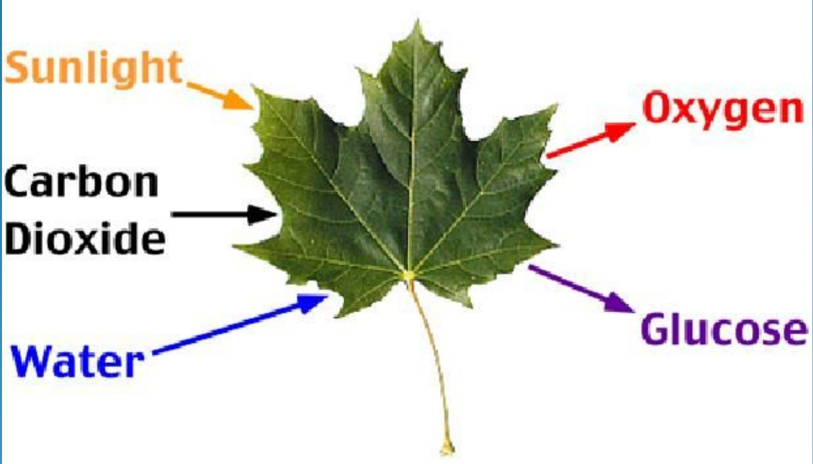
Carbohydrates

- Carbohydrates are composed of sugar molecules. They can be single, simple sugars or complex sugars.
  - Building block: monosaccharides
  - Function: Energy storage



Examples of Carbohydrates

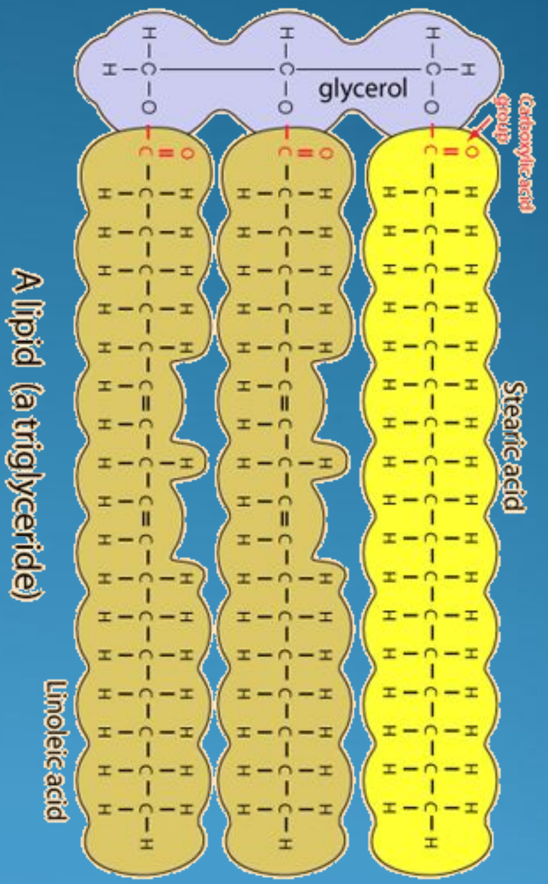
- Glucose: The main source of energy for organisms.
- Cellulose: Makes up cell walls of plants
- Starch
- Glycogen



Lipids

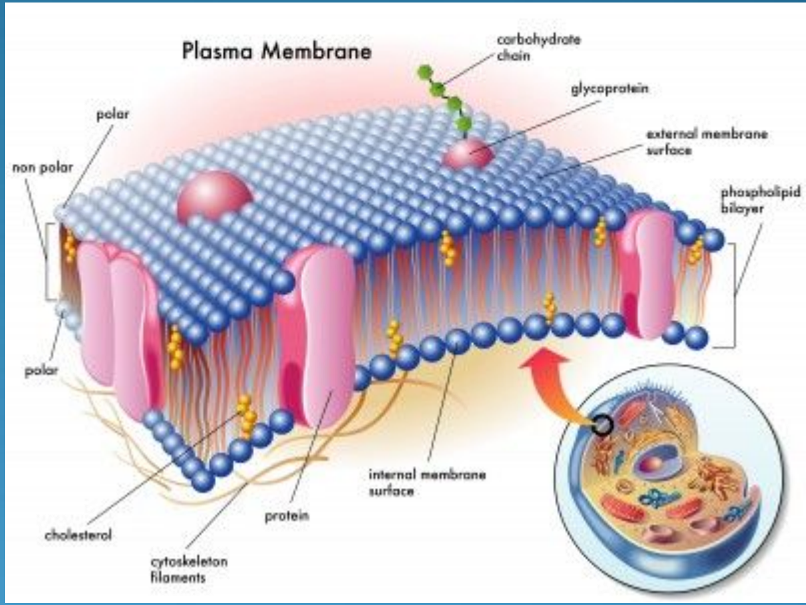
Lipids

- Lipids are fatty compounds not soluble in water
  - Building block: glycerol and three fatty acids
  - Function: Long term energy storage, insulation, makeup the cell membrane



Examples of Lipids

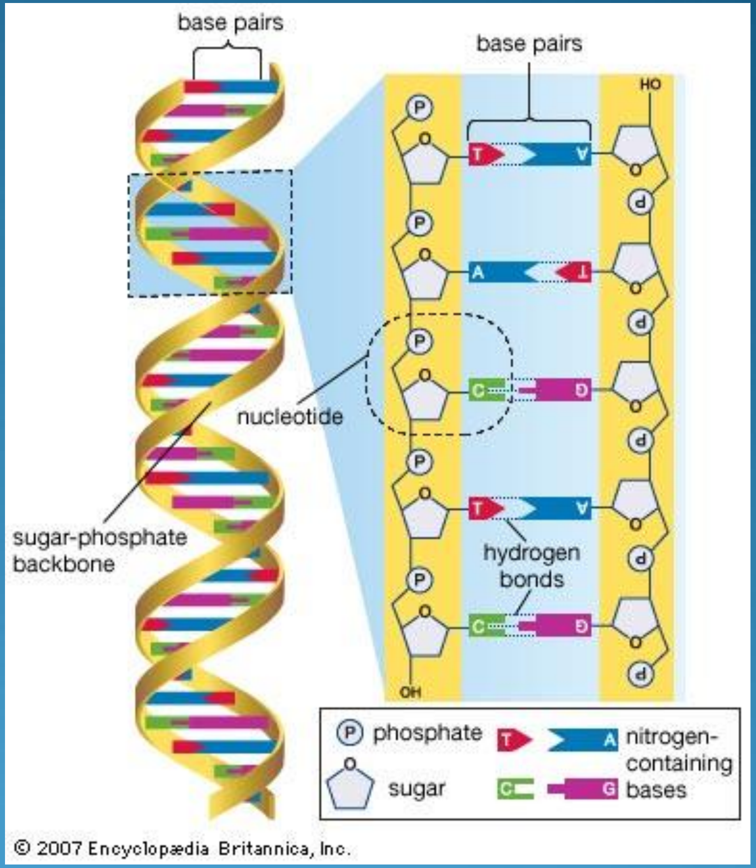
- **Phospholipids: The lipids that make up the cell membrane. We will be discussing this in depth in a later unit.**
- **Steroids**
- **Fats/Oils**



Nucleic Acids

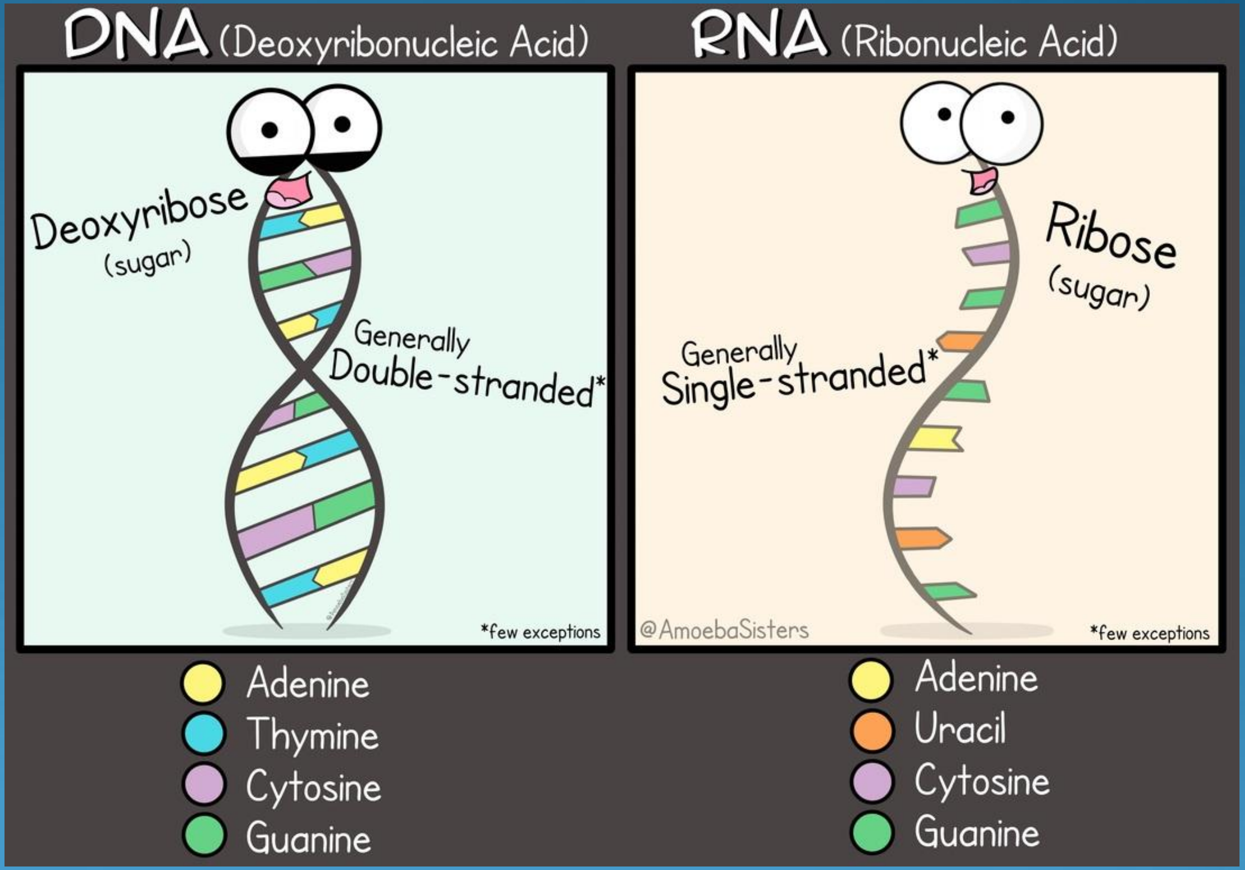
Nucleic Acids

- Nucleic acids are what make up genetic material in our bodies (DNA and RNA)
  - Building block: nucleotides
  - Function: Storing and transmitting genetic information



Examples of Nucleic Acids

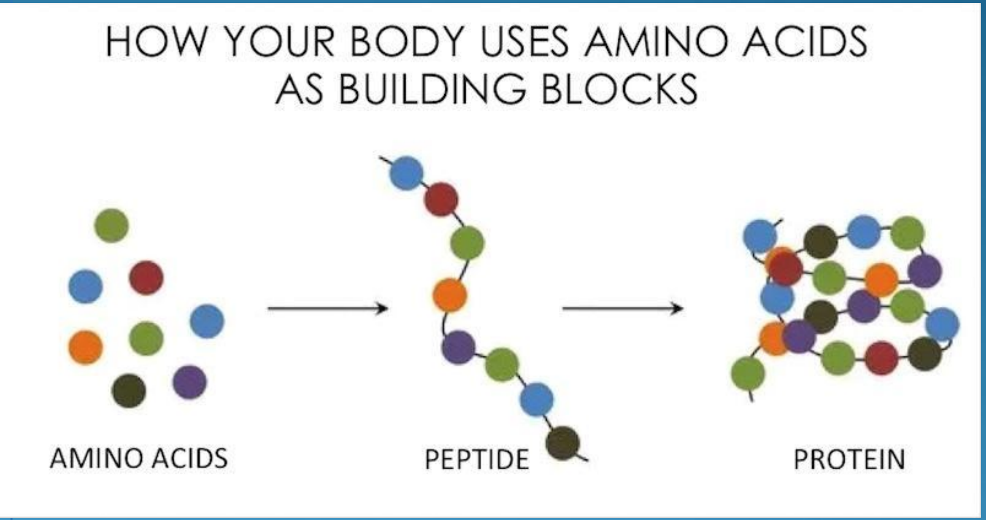
- DNA
- RNA



Proteins

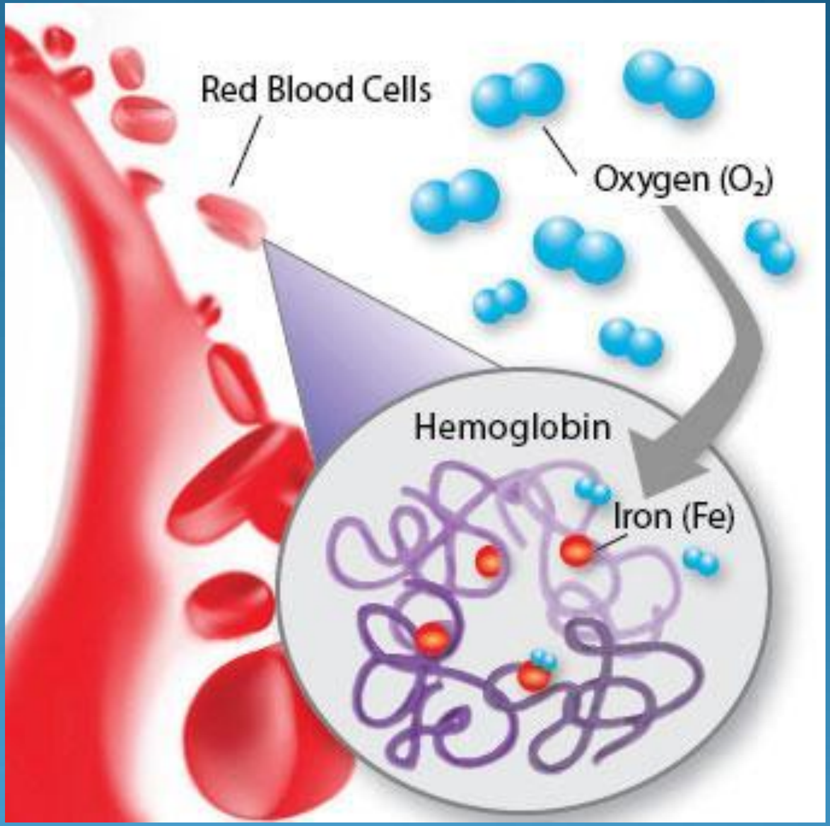
Proteins

- Proteins: Chains of amino acids; can be simple chains or complex folded structures
  - Building block: Amino acids
  - Function: Storage, transport, movement, structure, etc.



Examples of Proteins

- Insulin
- Hemoglobin
- Enzymes: Speed up chemical reactions in your body

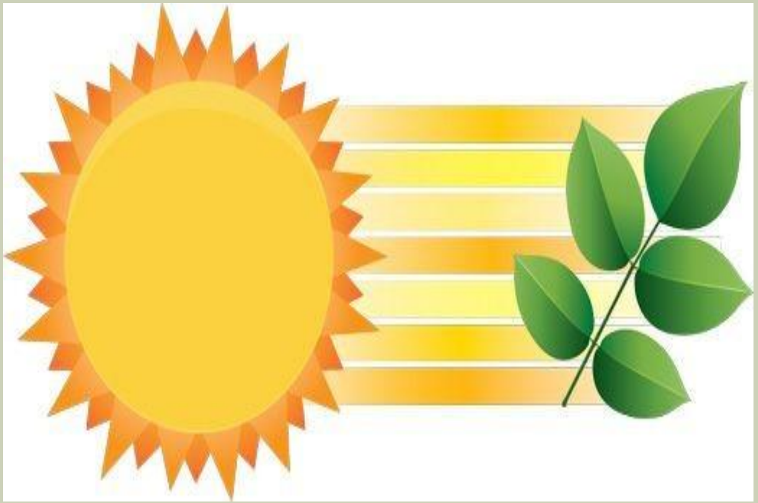


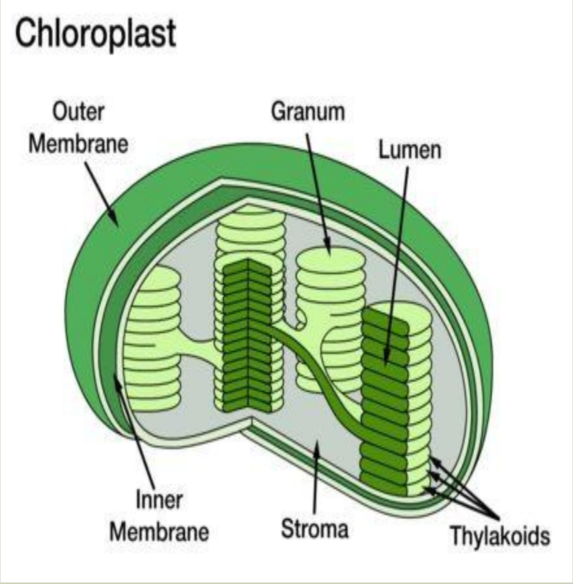
PHOTOSYNTHESIS

Energy in the cell

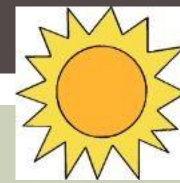
WHAT IS PHOTOSYNTHESIS?

- Process that uses the sun's energy to make glucose (food for the plant)
- Performed in: Green plants and some bacteria
- Occurs in the chloroplasts of the plant cell



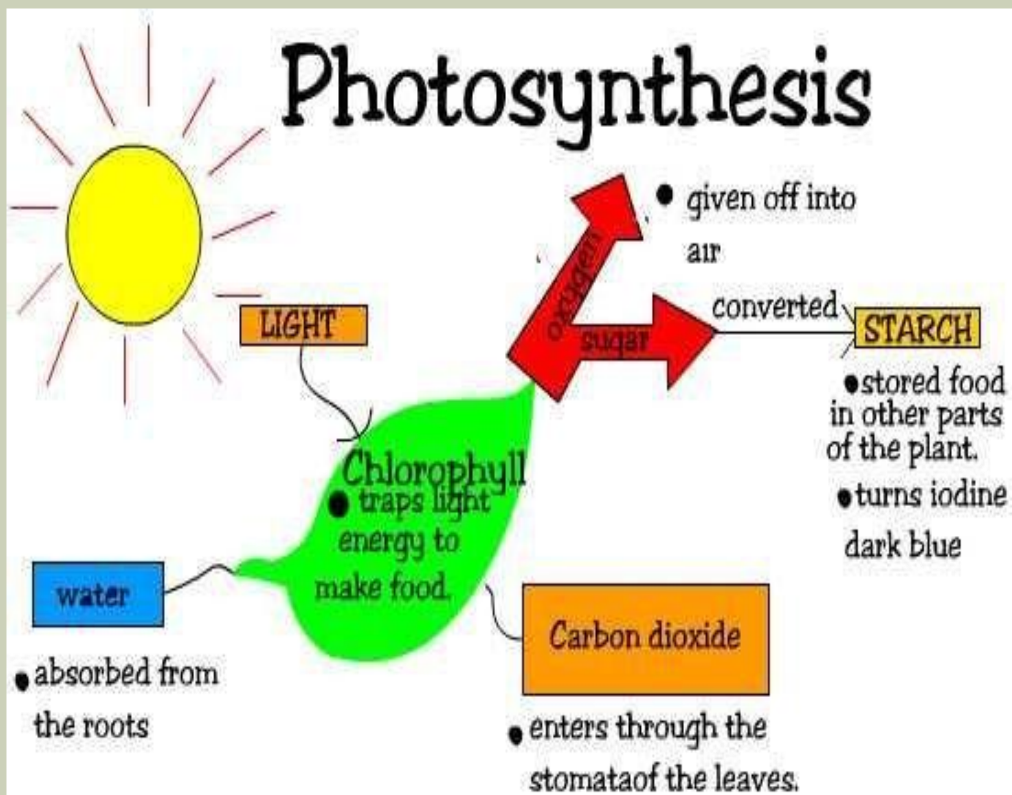


PHOTOSYNTHESIS FORMULA



$$6CO_2 + 6H_2O \longrightarrow C_6H_{12}O_6 + 6O_2$$

Carbon dioxide water glucose oxygen



RATE OF PHOTOSYNTHESIS

The rate (speed) at which a plant performs photosynthesis is based on a number of things:

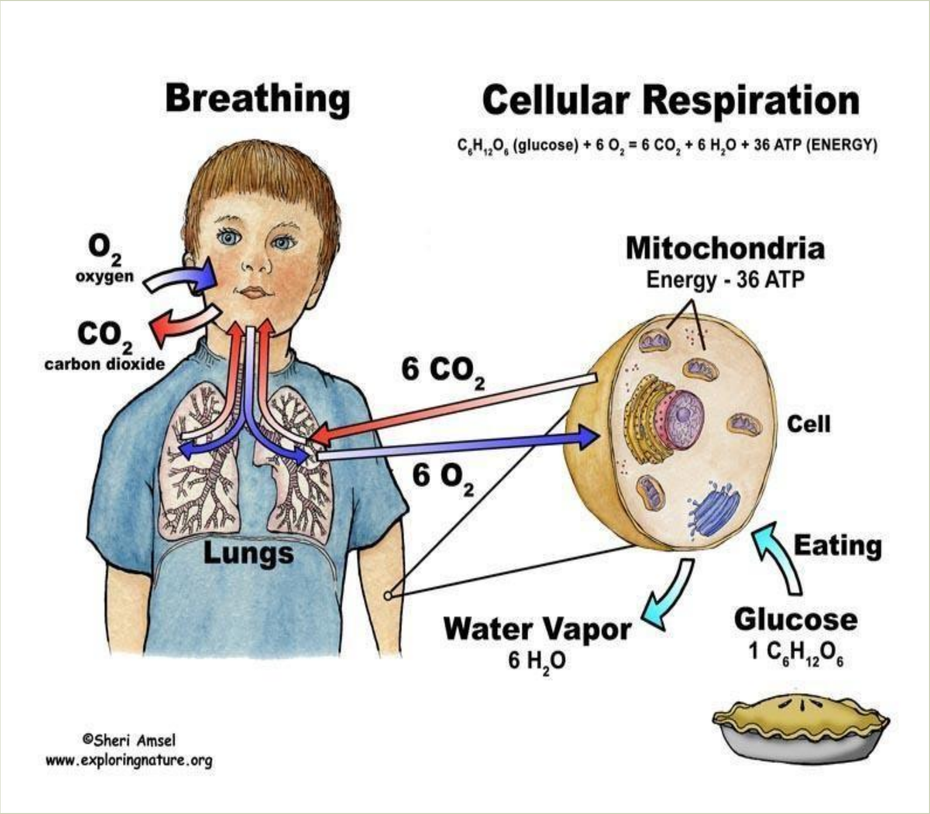
- # of reactants
  - More reactants yields more products
- Temperature and pH
  - Recall that enzymes are directly impacted by these factors!
- Light
  - No light=no photosynthesis

CELLULAR RESPIRATION

Energy in the Cell

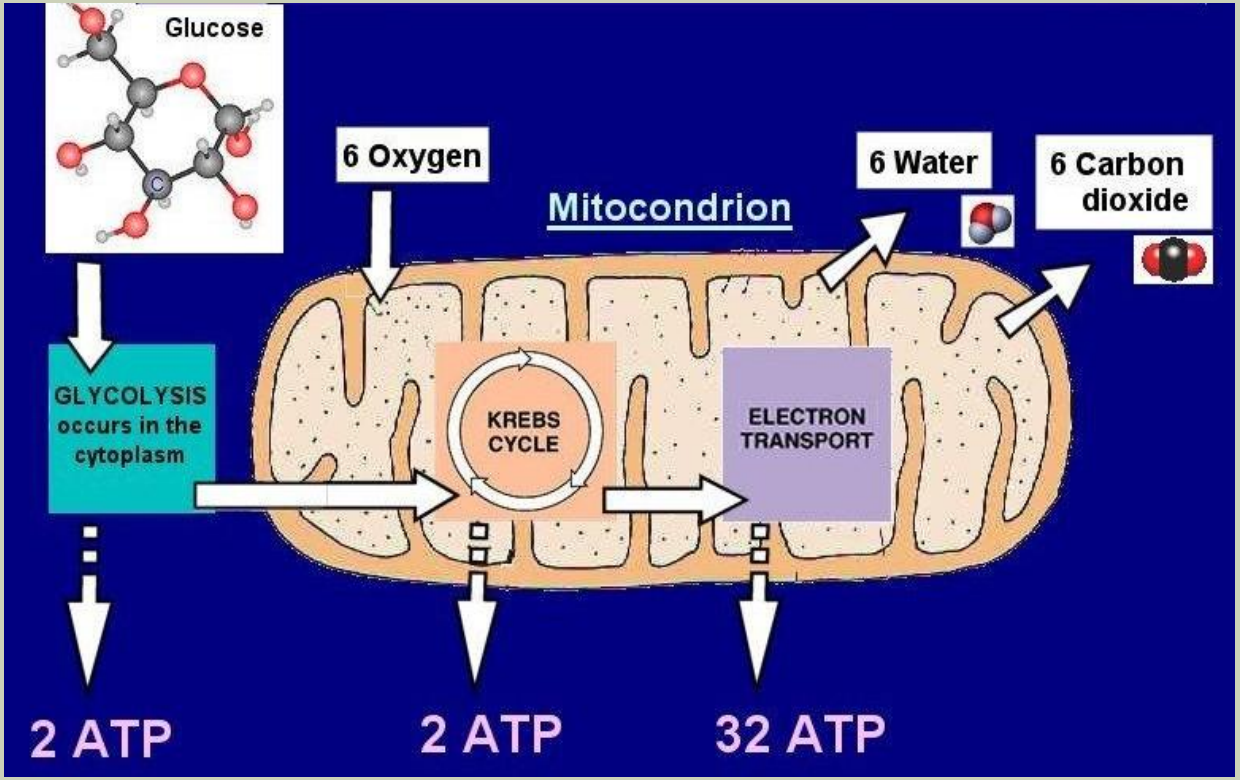
WHAT IS CELLULAR RESPIRATION?

- Process where molecules of glucose are broken down to make CO_2, water and ATP
- Occurs in the mitochondria of eukaryotes



RESPIRATION FORMULA

$$\underset{\text{glucose}}{C_6H_{12}O_6} + \underset{\text{oxygen}}{6O_2} \longrightarrow \underset{\text{carbon dioxide}}{6CO_2} + \underset{\text{water}}{6H_2O} + \underset{\text{energy}}{ATP}$$

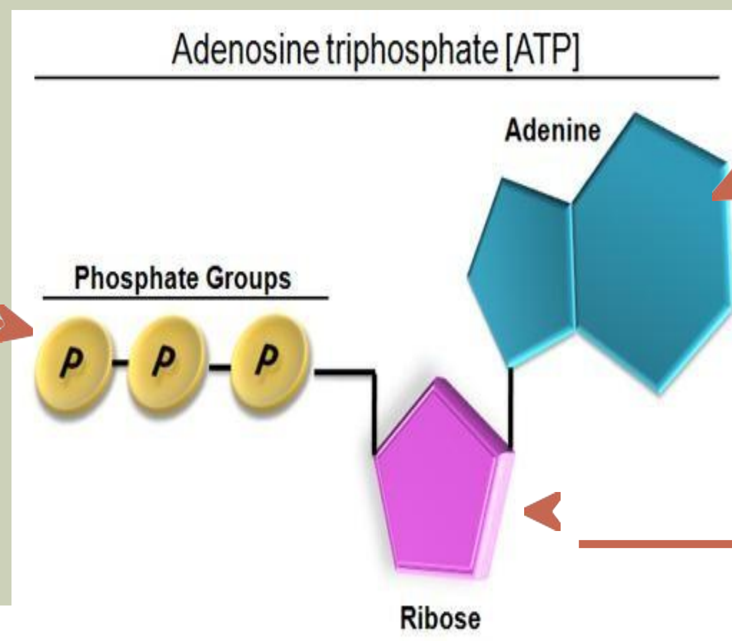


CELLULAR RESPIRATION

- The point of cellular respiration is to make ATP!
  - ATP is ENERGY
  - All organisms require energy to live (movement, cell division, active transport, etc…)

Adenine

Three phosphates

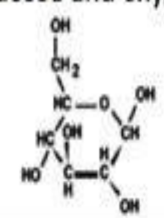
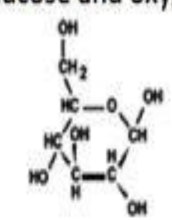


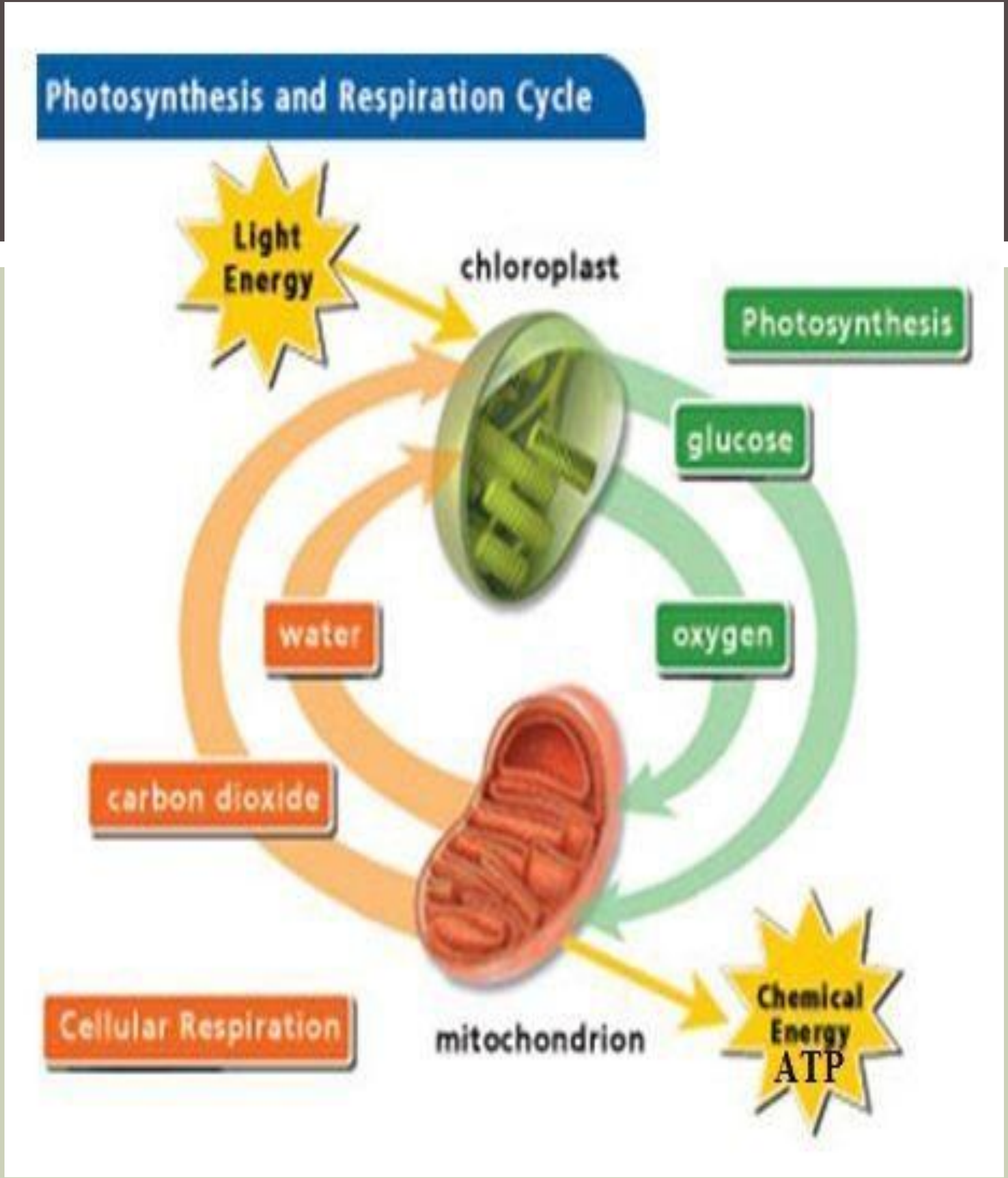
Ribose

<u>Nucleotide</u>

- ***Nucleic Acid***
- ***Phosphate Group***
- ***Sugar***

PHOTOSYNTHESIS AND RESPIRATION

	PHOTOSYNTHESIS	RESPIRATION
Where?	Chloroplasts 	Mitochondria 
When?	In the presence of light 	All the time 
Input	Carbon dioxide and water 	Glucose and oxygen 
Output	Glucose and oxygen 	Carbon dioxide and water 
Energy sources	Light	Chemical bonds
Energy result	Energy stored	Energy released

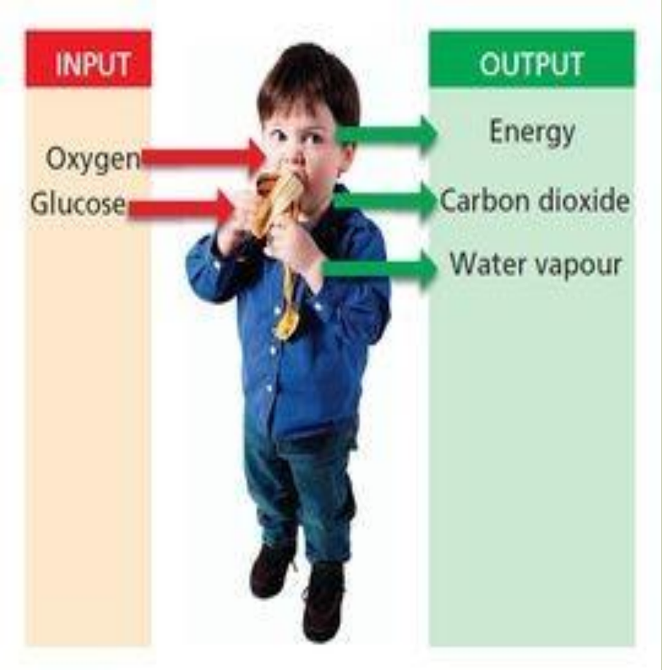

Photosynthesis and Respiration Cycle
Light Energy
chloroplast
Photosynthesis
glucose
water
oxygen
carbon dioxide
Cellular Respiration
mitochondrion
Chemical Energy
ATP

AEROBIC VS. ANAEROBIC RESPIRATION

Comparing Energy Processes

AEROBIC RESPIRATION

- Aerobic respiration takes place in the presence of oxygen
- This is most efficient-can produce up to 38 ATP's per glucose!
- Carried out in the mitochondria
- Sequence of reactions is known as the Krebs Cycle



BUT WHAT IF OXYGEN ISN'T AVAILABLE?

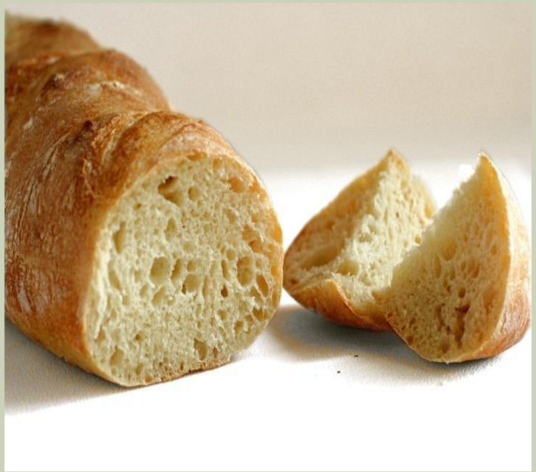
ANAEROBIC RESPIRATION

- Anaerobic Respiration (fermentation) occurs when oxygen is <u>NOT</u> present
- Less efficient-only 2 ATP's produced!
- Occurs in anaerobic bacteria, yeast, and muscle cells
- Carried out in the cytoplasm

WHAT IS FERMENTATION?

Alcoholic Fermentation

- Occurs in bacteria, yeast
- Makes Ethanol (alcohol)
- Used in making bread, wine, and beer

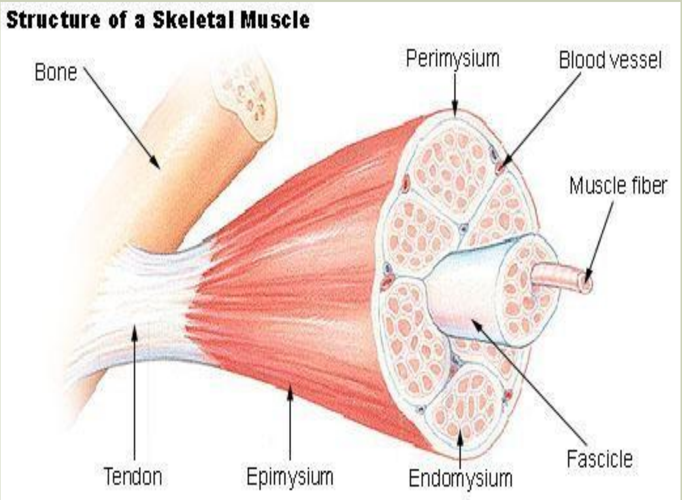


Lactic Acid Fermentation

- Occurs in muscle cells, bacteria
- Makes Lactic Acid

CASE STUDY: MUSCLE CRAMPS

- Anaerobic respiration can occur in muscle cells during vigorous physical activity
- Once your cells begin to lack sufficient oxygen, they will switch to lactic acid fermentation
- Lactic acid buildup and muscle fatigue leads to cramping!



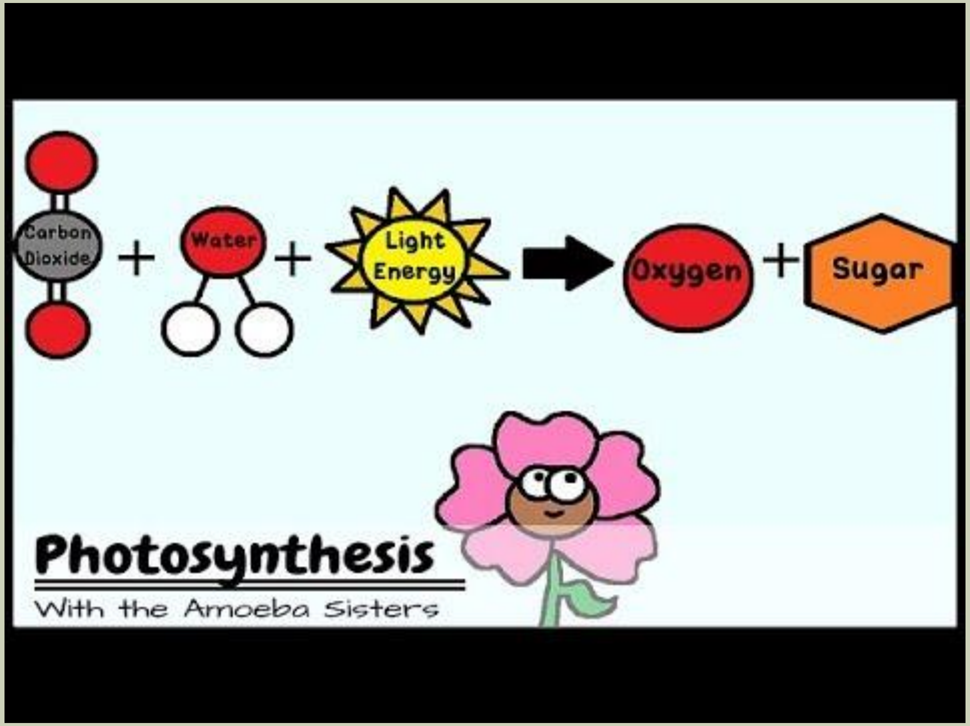
AEROBIC VS. ANAEROBIC

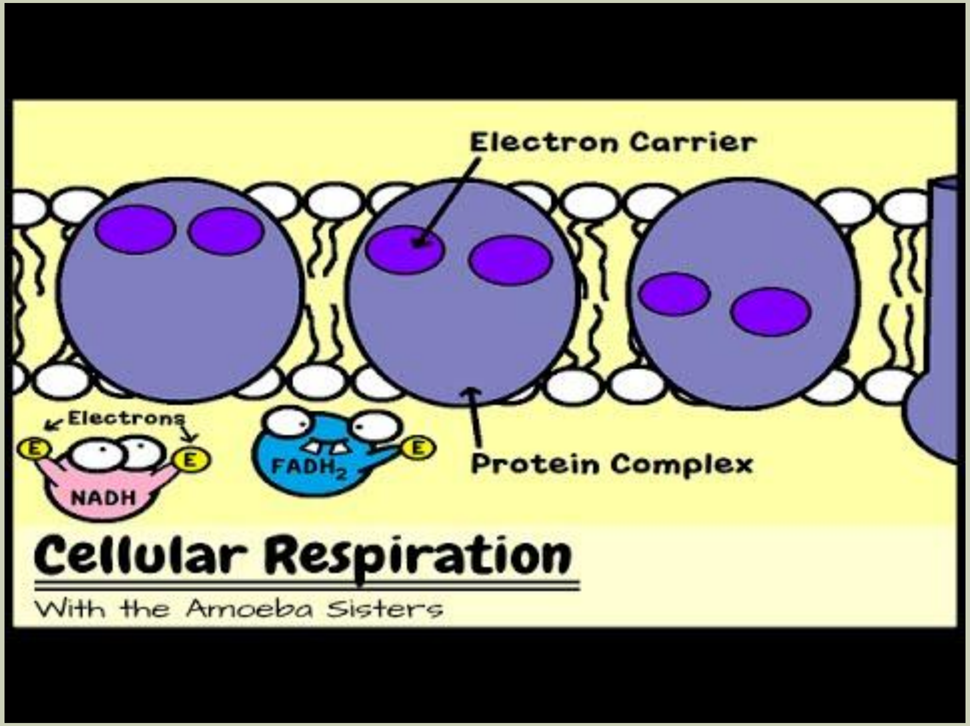
	Aerobic Respiration	Anaerobic Respiration
Oxygen Required?		
Occurs in? (part of the cell)		
ATP's Produced	Maximum of ___ ATP's per molecule of glucose	___ ATP's per molecule of glucose
End Product	_____ & _____	(in animals) - __________ (in plants) - ___________

AEROBIC VS. ANAEROBIC

	Aerobic Respiration	***Anaerobic Respiration***
Oxygen Required?	*Yes*	*No*
Occurs in? (part of the cell)	*Mitochondria*	*Cytoplasm*
ATP's Produced	*Maximum of 38 ATP's per molecule of glucose*	*2 ATP's per molecule of glucose*
End Product	CO_2 & H_2O	*(in animals) - Lactic Acid* *(in plants) Ethanol &* CO_2

Amoeba Sisters:
“Photosynthesis and Cellular Respiration”





Vocabulary Review:

Autotroph -

organism that produces its own food

Vocabulary Review:

<u>Photosynthesis</u> -

conversion of radiant energy from the sun to chemical energy

Vocabulary Review:

<u>Cellular Respiration</u> -

where glucose is broken down to make CO_2, H_2O and ATP

Vocabulary Review:

Glucose -

sugar, food for plants

Vocabulary Review:

<u>ATP</u> -

(adenosine triphosphate)

energy

Vocabulary Review:

Reactant -

substance that undergoes a change during a reaction

Vocabulary Review:

Product -

anything produced during a reaction

Vocabulary Review:

Enzymes –

Proteins or fatty
acids that are…
reusable, specific and end in -ase

Act as a catalyst to speed up a
chemical reaction by helping molecules
react with each other faster

Vocabulary Review:

<u>Krebs Cycle</u> -

Sequence of reactions using aerobic respiration to make ATP

Vocabulary Review:

Glycolysis -

The breakdown of glucose by enzymes

Produces 2 pyruvate (acid) molecules and 1 glucose molecule

	Aerobic Respiration	Anaerobic Respiration
Oxygen Required?	*Yes*	*No*
Occurs in? (part of the cell)	*Mitochondria*	*Cytoplasm*
ATP's Produced	*Maximum of 38 ATP's per molecule of glucose*	*2 ATP's per molecule of glucose*
End Product	CO_2 & H_2O	*(in animals) - Lactic Acid* *(in plants) Ethanol &* CO_2

TO WHICH CLASS OF ORGANIC COMPOUNDS CAN ENZYMES BELONG?

1. Carbohydrates
2. Fatty acids
3. Nucleic acids
4. Monosaccharides

TO WHICH CLASS OF ORGANIC COMPOUNDS CAN ENZYMES BELONG?

Fatty acids

TO WHICH CLASS OF ORGANIC COMPOUNDS DO MOST ENZYMES BELONG?

1. Carbohydrates
2. Proteins
3. Nucleic acids
4. Monosaccharides

TO WHICH CLASS OF ORGANIC COMPOUNDS DO MOST ENZYMES BELONG?

Proteins

WHICH IS A DIFFERENCE BETWEEN AEROBIC RESPIRATION AND ANAEROBIC RESPIRATION?

1. Anaerobic respiration requires oxygen
2. Anaerobic respiration does not require oxygen
3. Anaerobic respiration occurs only at the cellular level
4. Anaerobic respiration only occurs outside of the cell

WHICH IS A DIFFERENCE BETWEEN AEROBIC RESPIRATION AND ANAEROBIC RESPIRATION?

Anaerobic respiration does not require oxygen

MANY ENZYMES IN THE HUMAN BODY FUNCTION BEST AT 37 DEGREES CELSIUS. WHAT IS THE MOST LIKELY RESULT OF A GREAT INCREASE IN BODY TEMP?

1. Enzymes become hormones
2. Enzymes become denatured
3. Enzymes become more active
4. Enzymes become more sluggish

MANY ENZYMES IN THE HUMAN BODY FUNCTION BEST AT 37 DEGREES CELSIUS. WHAT IS THE MOST LIKELY RESULT OF A GREAT INCREASE IN BODY TEMP?

Enzymes become denatured

HOW DOES THE AMOUNT OF ENERGY RESULTING FROM FERMENTATION COMPARE WITH THAT OF AEROBIC RESPIRATION?

1. Aerobic respiration results in less energy
2. Aerobic respiration results in more energy
3. Each process results in equal energy
4. Each process results in variable amounts of energy

HOW DOES THE AMOUNT OF ENERGY RESULTING FROM FERMENTATION COMPARE WITH THAT OF AEROBIC RESPIRATION?

Aerobic respiration results in more energy

WHICH MOST DIRECTLY CONTROLS THE RATE AT WHICH FOOD IS BROKEN DOWN TO RELEASE ENERGY?

1. Enzymes
2. Hormones
3. Nucleic acids
4. Vitamins

WHICH MOST DIRECTLY CONTROLS THE RATE AT WHICH FOOD IS BROKEN DOWN TO RELEASE ENERGY?

Enzymes

WHICH OF THESE IS A PRODUCT OF PHOTOSYNTHESIS AND A REQUIREMENT FOR CELLULAR RESPIRATION?

1. Carbon dioxide
2. Glucose
3. Water
4. Sunlight

WHICH OF THESE IS A PRODUCT OF PHOTOSYNTHESIS AND A REQUIREMENT FOR CELLULAR RESPIRATION?

Glucose

WHICH IS A WASTE PRODUCT OF PHOTOSYNTHESIS?

1. Carbon dioxide
2. Glucose
3. Oxygen
4. Water

WHICH IS A WASTE PRODUCT OF PHOTOSYNTHESIS?

Oxygen