Lesson 1:
The Biology of You

BIOL 1441

Cell & Molecular Biology

Learning Objectives (a.k.a. Study Guide)

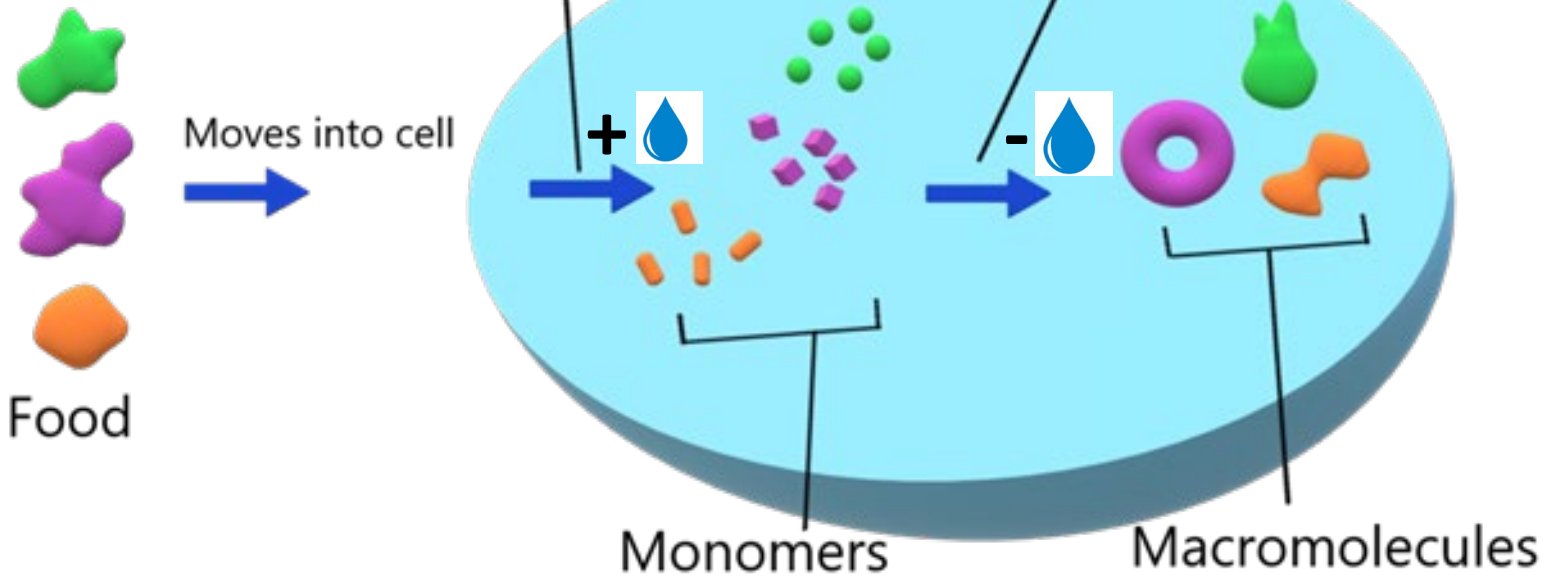
By the end of this lesson, students will be able to:

1. Explain how the human body is organized, from smallest (cells) to largest (organism).
2. List the structures found in all types of cells.
3. Explain how a prokaryotic cell is different from a eukaryotic cell, and give examples of each.
4. Describe the primary function of a cell's plasma membrane.
5. List the 4 main macromolecules found in the human body.
6. Identify examples of each of the major macromolecules.
7. Describe the function of each kind of macromolecule.
8. Explain what happens in catabolic & anabolic reactions.
9. Explain what happens in hydrolysis & dehydration synthesis.

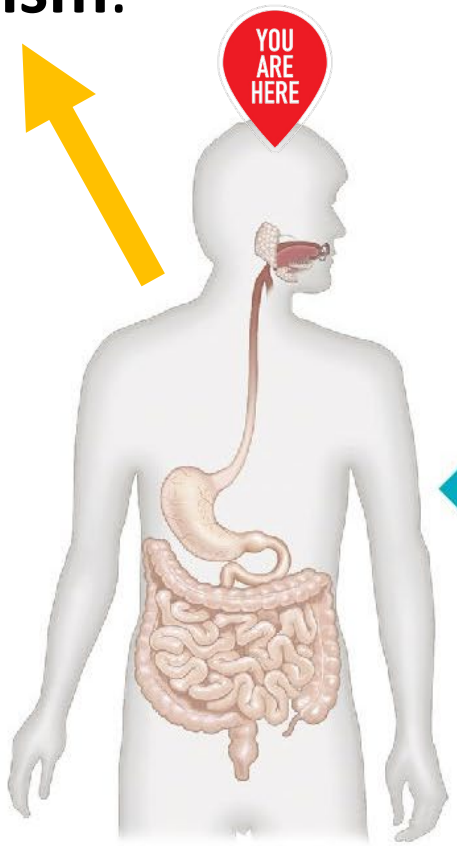
What Happens When You Eat?

The **macromolecules** in the food you eat are broken into **monomers** through the process of hydrolysis.

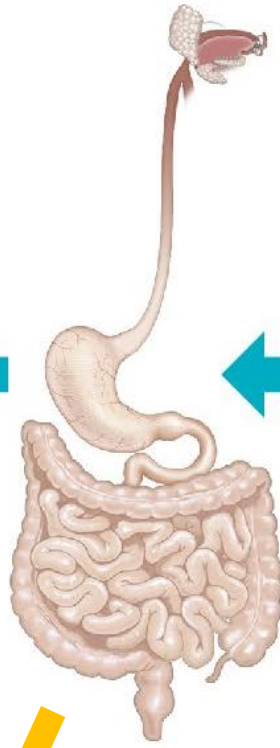
The **monomers** from your food are used to build **macromolecules** using dehydration synthesis.



You are an **organism**.

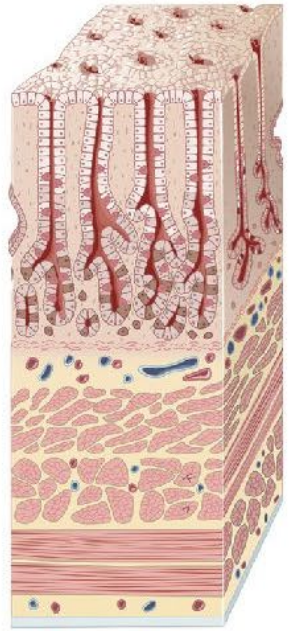


Your **organ systems** do complex functions to keep you alive.



Each of your **organs** has a specific job in its organ system.

Tissues (a.k.a. groups of cells) work together to form organs.



Your body is made of 30 trillion **cells**!

Cells

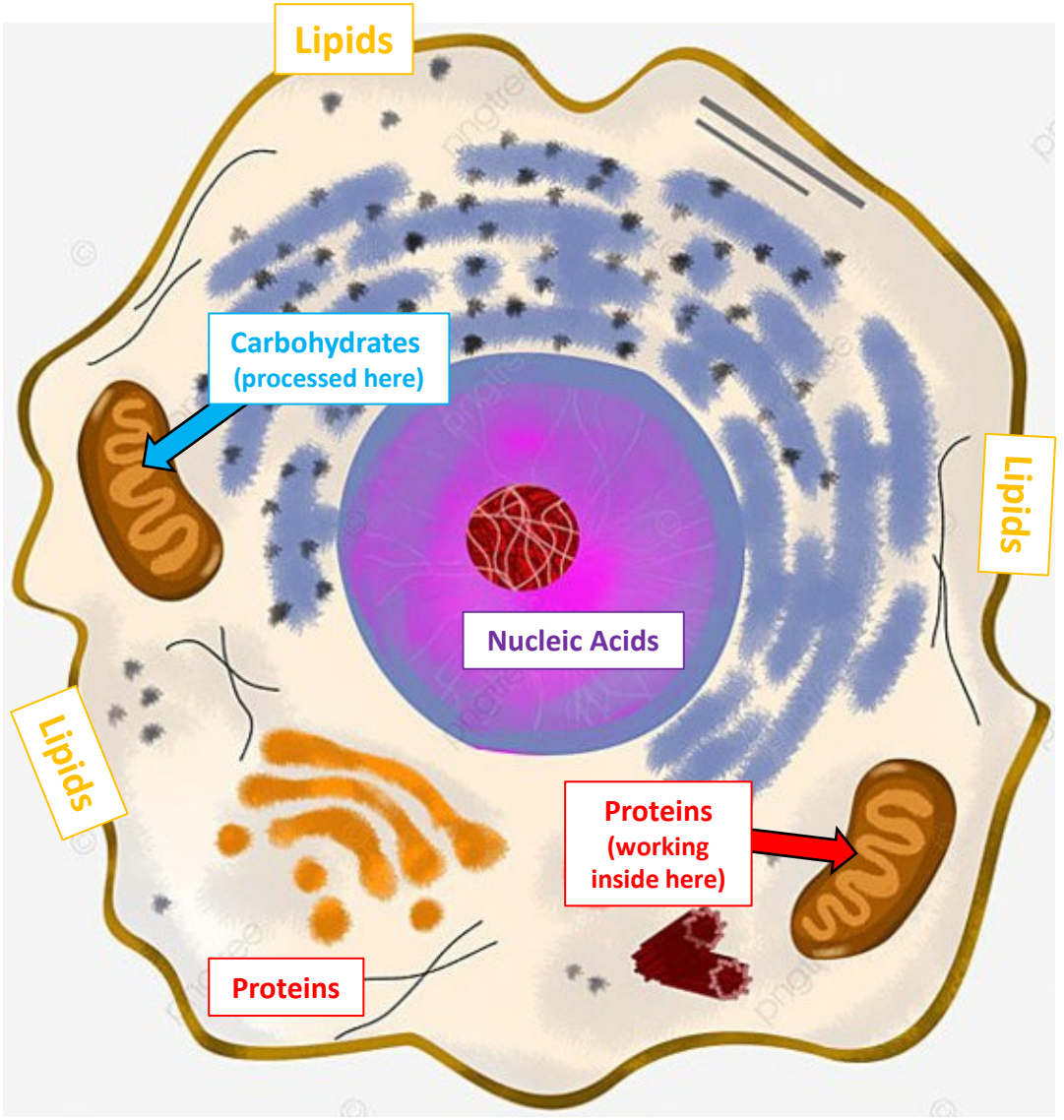
Cells are the smallest living things

To be alive, a cell must:

- Be separate from its environment
- Be able to create energy from food
- Be able to grow
- Be able to reproduce

The **macromolecules** that cells are built from help it do these things:

- **Lipids** form a plasma membrane barrier between inside & outside
- **Carbohydrates** are an easy energy source
- **Proteins** help the cell perform complex tasks
- **Nucleic acids** store genetic information to pass along to offspring



Classifying Cells

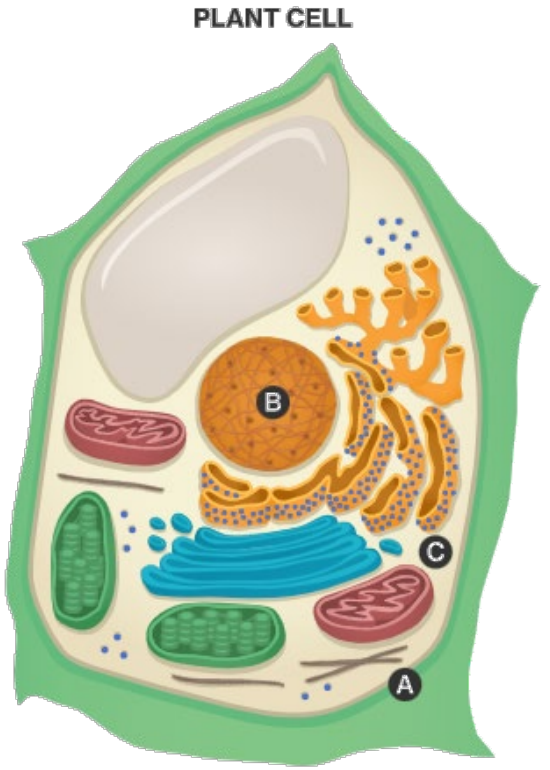
Cells can be classified based on the location of their genetic information

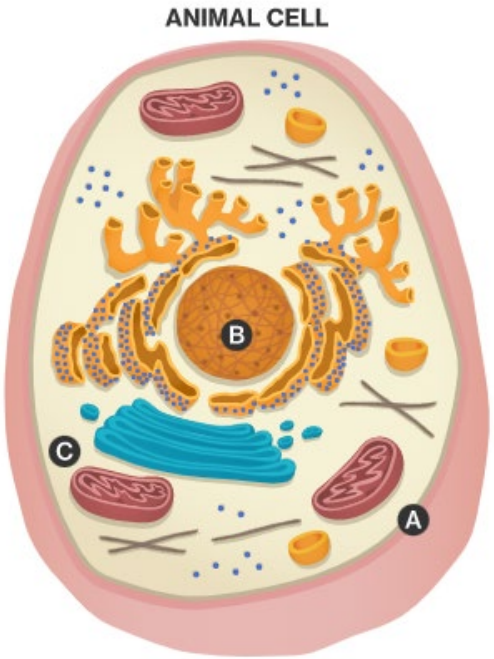
Some cells are **prokaryotic** cells

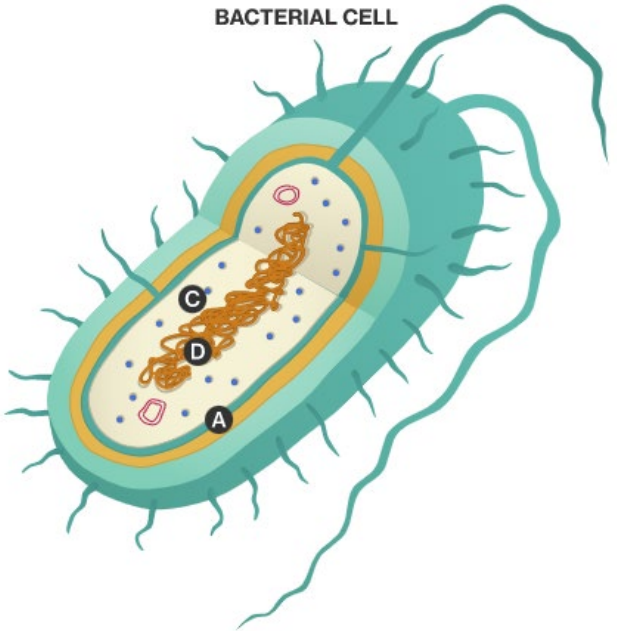
- Their genetic information is found in a nucleoid region (labeled D)
- Bacterial cells are prokaryotic cells

Some cells are **eukaryotic** cells

- Their genetic information is stored in a membrane-enclosed nucleus (labeled B)
- Animal cells & plant cells are eukaryotic cells







Let's Practice!

Observe the cell on the left.

This cell:

DOES / DOES NOT

have a membrane-enclosed nucleus.

This cell would be considered:

prokaryotic / eukaryotic

Let's Practice!

Observe the cells on the left.

These cells :

DO / DO NOT

have a membrane-enclosed nucleus.

These cells would be considered:

prokaryotic / eukaryotic

Cells

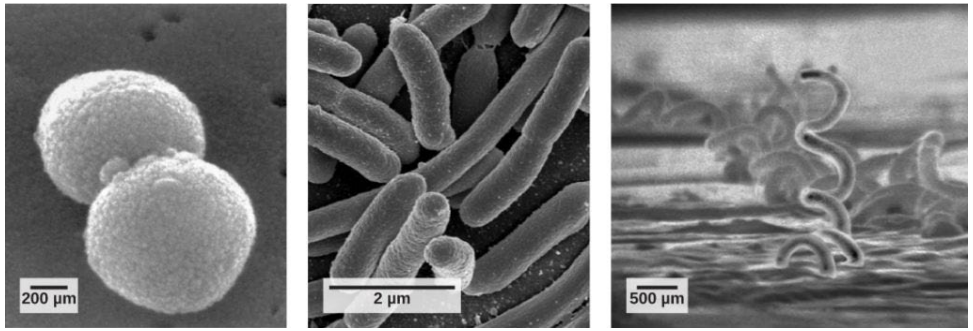
Prokaryotic & eukaryotic cells can look very different

Despite their many differences, all cells require some of the same structures to be alive:

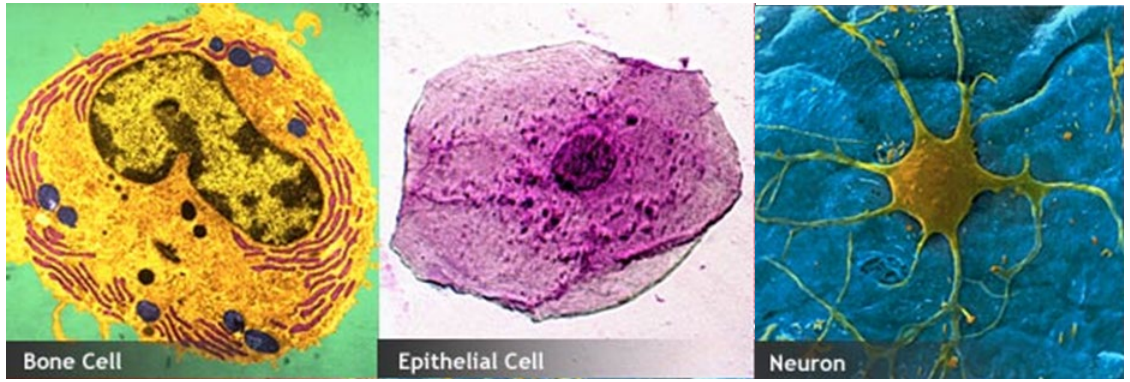
1. **DNA & RNA**, a set of genetic information
2. **Ribosomes**, protein-building structures
3. **A plasma membrane**, a dividing line between inside & outside
4. **Cytoplasm**, a sugar & protein solution inside the cell

Note: we may use **cytoplasm** and **cytosol** interchangeably this semester. Curious about the difference? See the short video on Canvas.

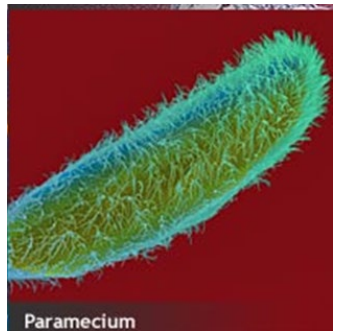
Bacterial (Prokaryotic) Cells



Eukaryotic Human Cells

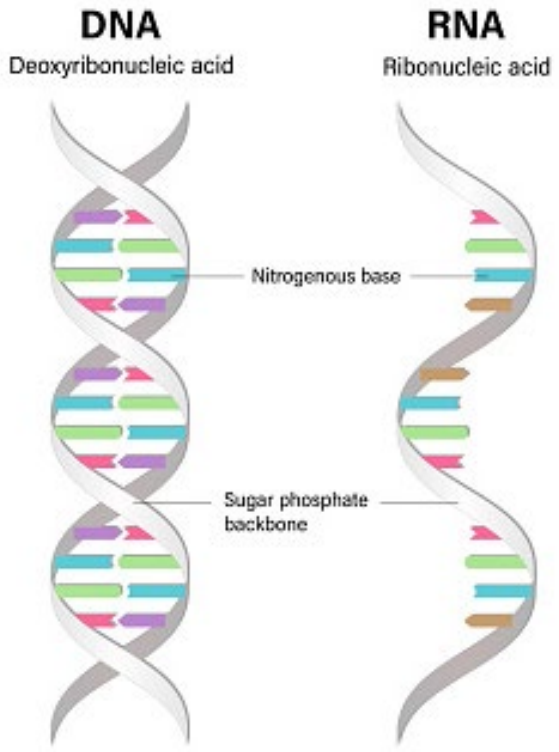


Other Eukaryotic Cells



MACROMOLECULE:
Nucleic Acids

All Cells Have: **DNA & RNA**

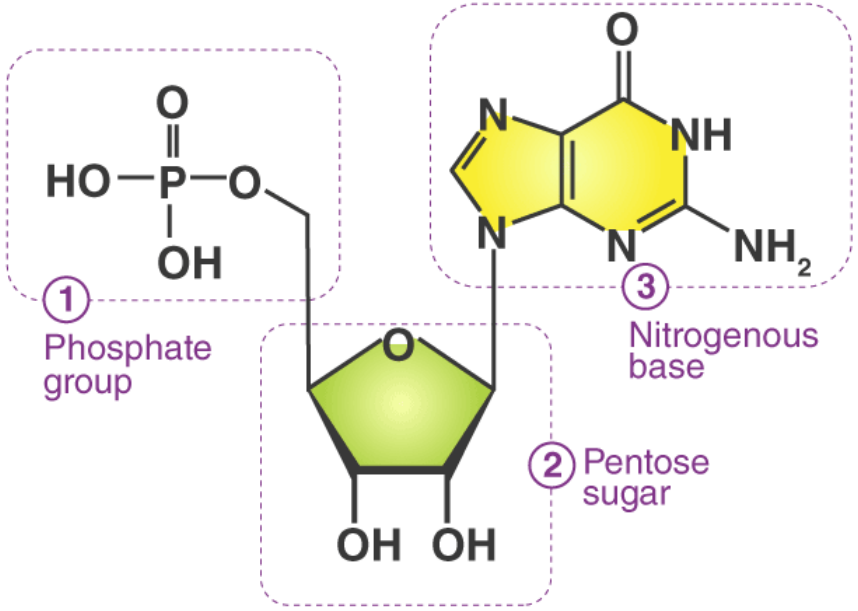


DNA & RNA are the genetic information molecules of cells

- DNA is double-stranded, with 2 lines of genetic information wrapped around each other
- RNA is usually single-stranded, with just 1 line of information

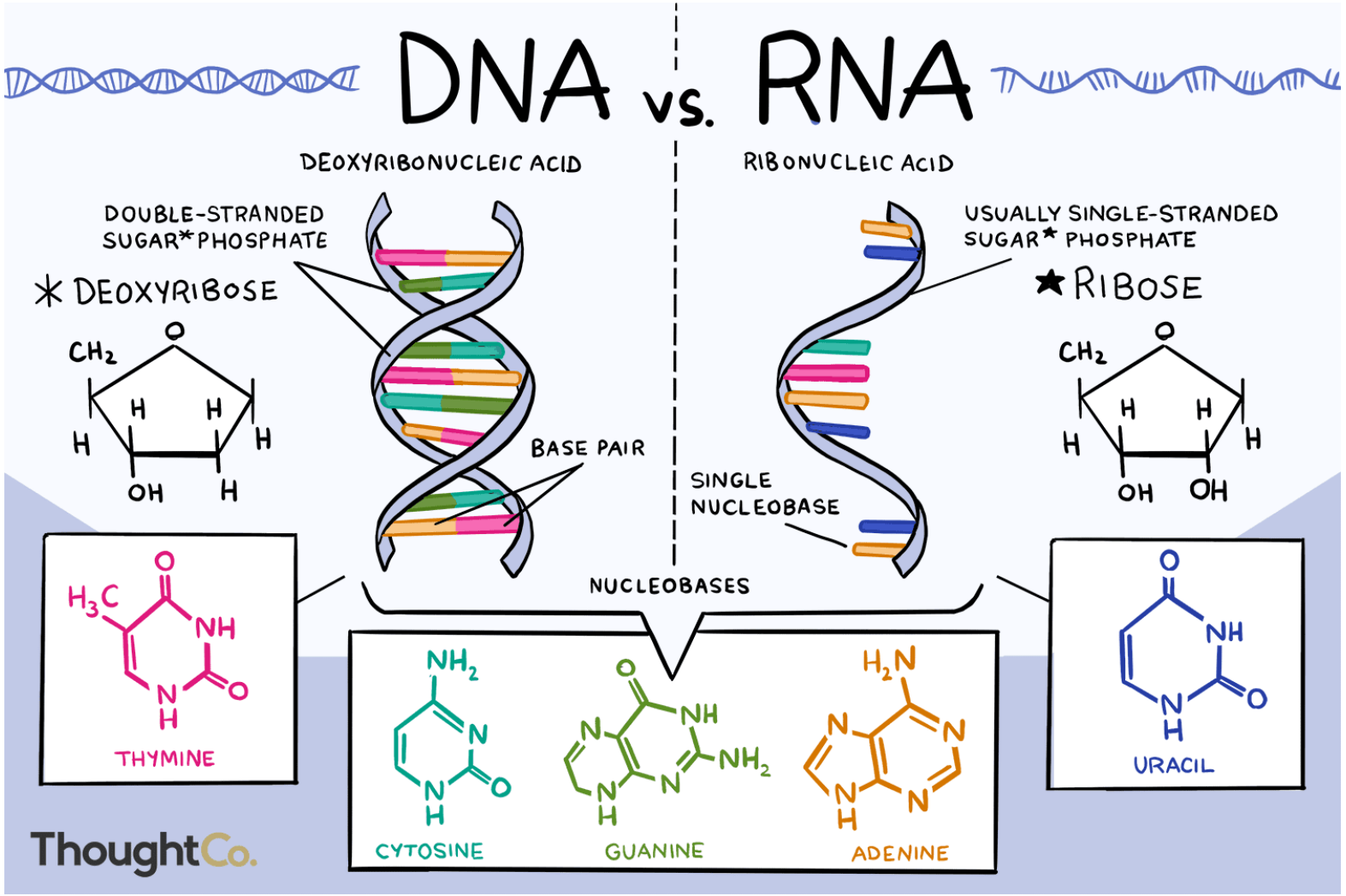
The **monomers** (a.k.a. pieces) used to build DNA & RNA are **nucleotides**

- Each nucleotide has a phosphate group, a sugar, and a nitrogenous base
- The <u>nitrogenous base</u> is what determines the identity of the nucleotide (A, T, G, C, or U)



MACROMOLECULE:
Nucleic Acids

All Cells Have: **DNA & RNA**

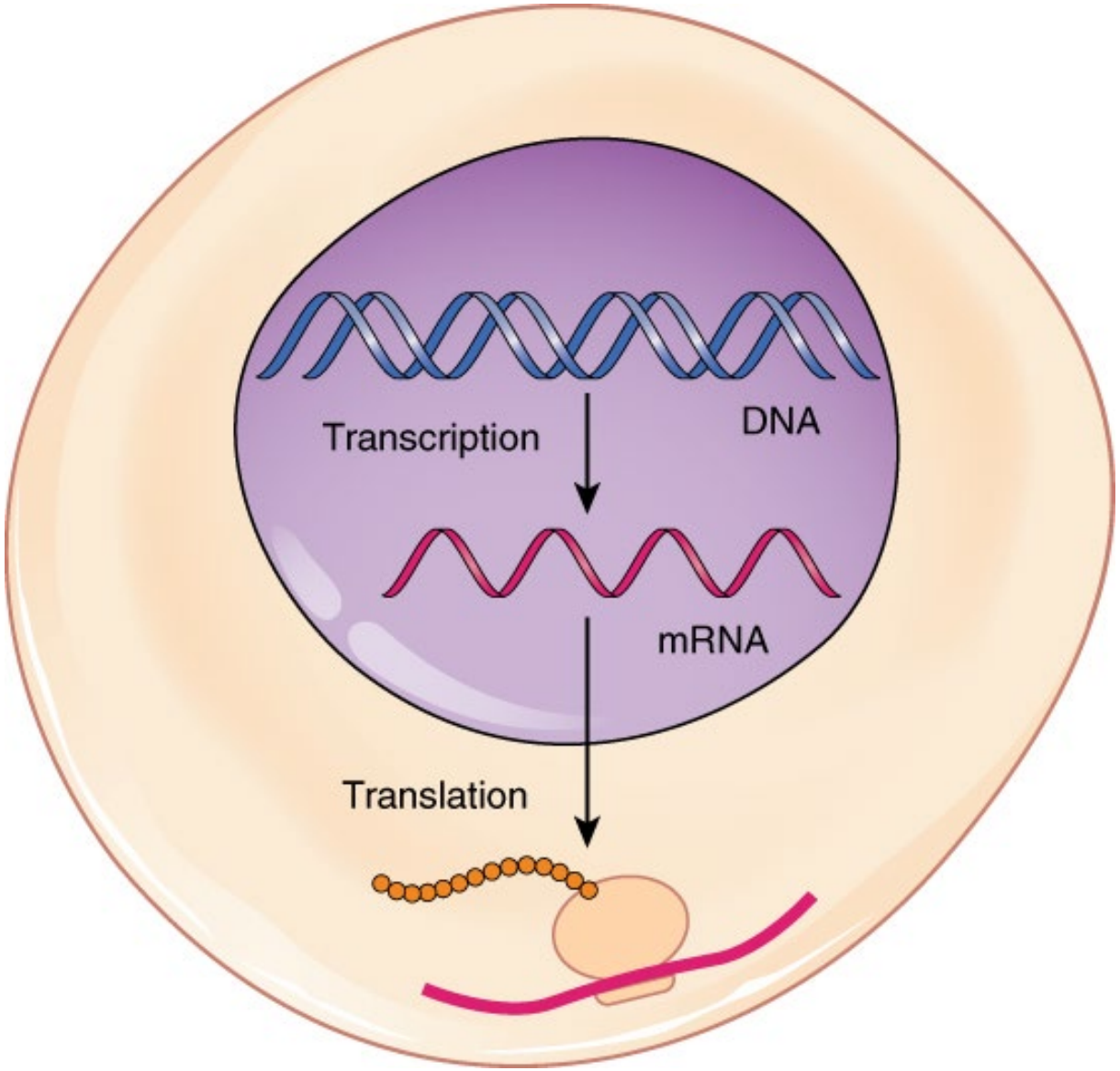


The <u>sugar</u> in each nucleotide determines if it is found in DNA or RNA

- DNA nucleotides have **deoxyribose** sugar
- RNA nucleotides have **ribose** sugar

The nucleotides found in DNA & RNA are different

- DNA: A, T, C, & G
- RNA: A, U, C, & G



DNA stores ALL the genetic information of a cell.

Regions called **genes** contain the directions for building specific proteins.

When a cell needs a specific protein, it makes an mRNA "copy" of the information stored in that gene.

This mRNA is sent to ribosomes so they can build the protein.

Stop & Think It Through!

Why do all cells (animal, plant, and bacterial) need to have DNA and RNA?

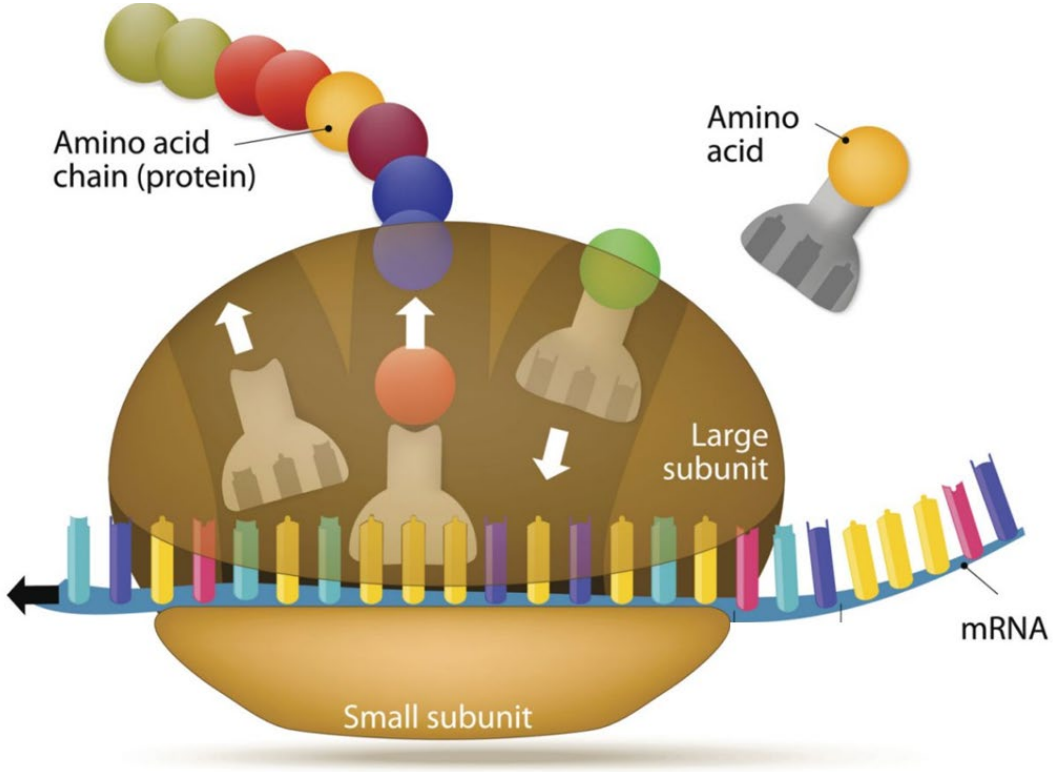
All Cells Have: **Ribosomes**

Ribosomes are a cell's protein-building "machines"

- In bacteria, ribosomes are found throughout the cytoplasm
- In animal & plant cells, ribosomes are also attached to the rough endoplasmic reticulum

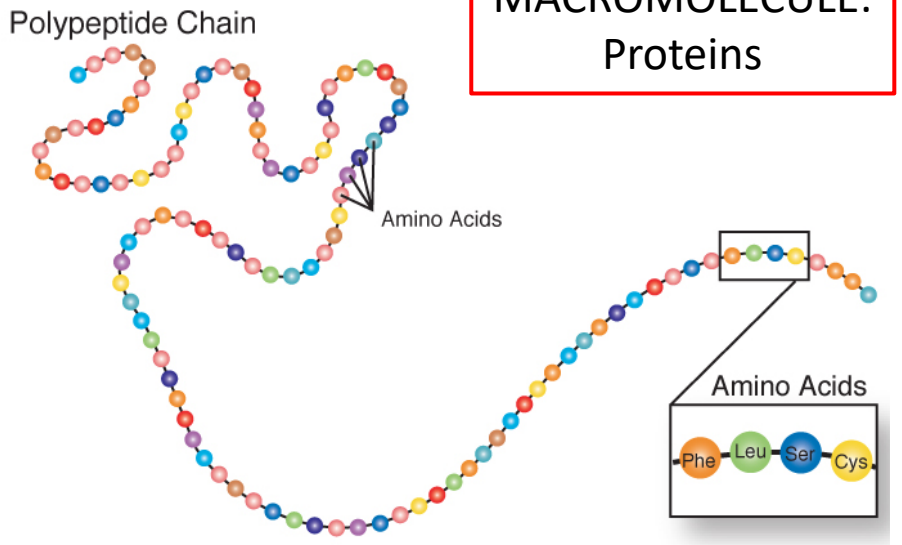
To build proteins, ribosomes need mRNA & monomers called **amino acids**

- First, they "read" the mRNA instructions
- Then, they connect amino acids in the correct order



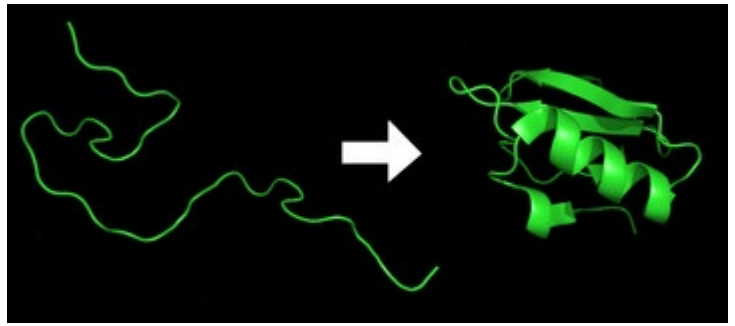
MACROMOLECULE:
Proteins

Proteins



Proteins (a.k.a. polypeptides) are long chains of amino acids

- After each chain is built, it folds into its 3D shape
- Sometimes, more than one folded chain connect, making a larger functional protein



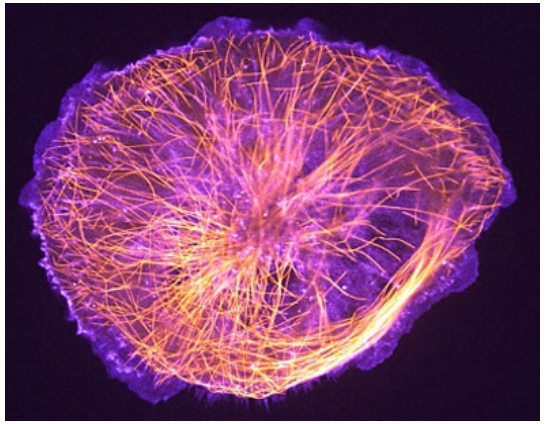
Proteins MUST be the correct 3D shape to be able to do their job in the cell

- Proteins lose their shape if the temperature or pH is too high or low, or if they are exposed to toxic chemicals
- If a protein permanently loses its 3D shape, it is **denatured**
- Denatured proteins CANNOT perform their functions

MACROMOLECULE:
Proteins

Functions of Proteins

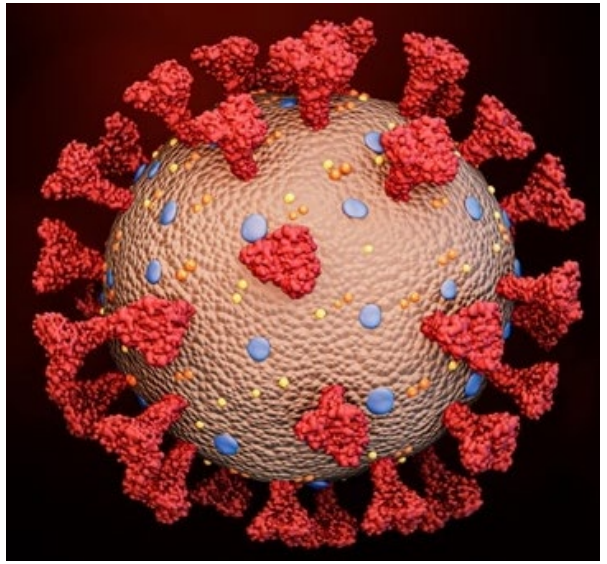
Proteins perform many different functions in cells



Cytoskeleton proteins give cells their 3D shape

Enzymes speed up chemical reactions

- Some reactions (**anabolic** reactions) build things
- Some reactions (**catabolic** reactions) break things



Glycoproteins act like a name tag for cells (or viruses, like the one that causes COVID-19)

Transport proteins move molecules across the plasma membrane of cells

Stop & Think It Through!

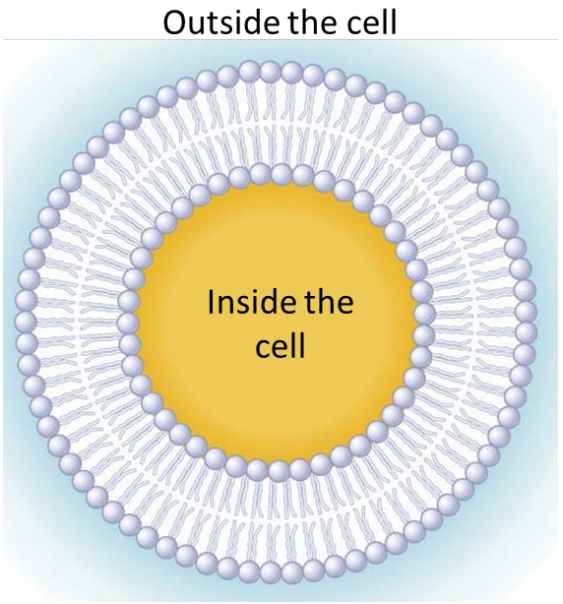
Some antibiotics inactivate the ribosomes of bacterial cells.

What ***effect*** would this have on bacterial cells?

Why would this kind of antibiotic be a good way to treat a bacterial infection?

MACROMOLECULE:
Lipids

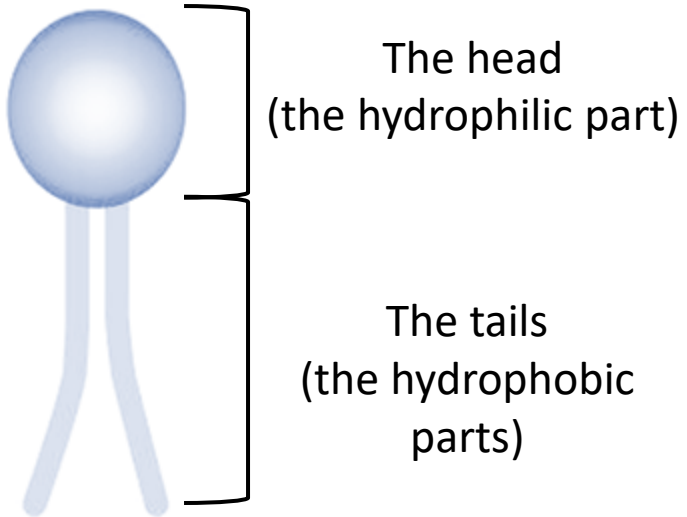
All Cells Have:
A Plasma Membrane



The cell's plasma membrane is also known as its <u>phospholipid</u> bilayer

Phospholipid molecules have two regions

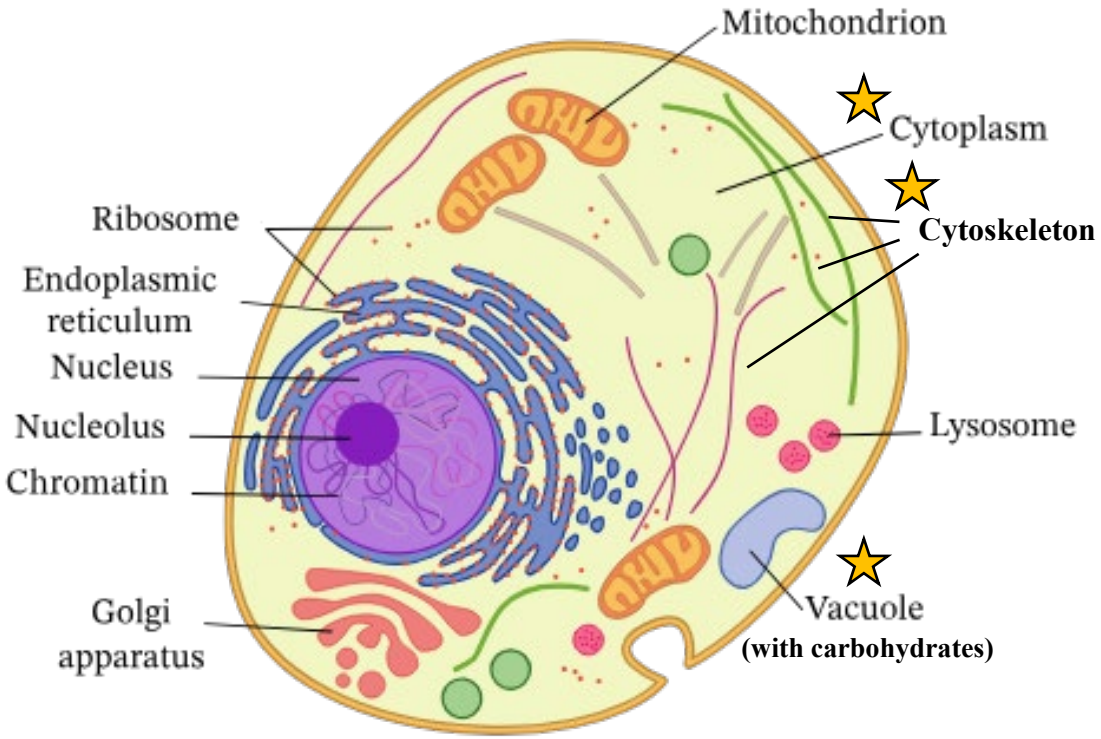
- Their head group, which loves water (making it hydro**philic**)
- Their fatty acid tails, which hate water (making them hydro**phobic**)



The bilayer structure of the plasma membrane protects the phospholipid's tails from water

- It also makes it semipermeable (a.k.a. "picky" about what can & cannot cross it)

All Cells Have: **Cytoplasm**



Cytoplasm is the soupy solution inside a cell's plasma membrane

- 80% of this is water
- It includes all of cell's organelles
- It also includes dissolved salts & macromolecules

Macromolecules in the cytoplasm

- Cytoskeleton **proteins**, giving the cell its shape
- **Enzymes**, speed up chemical reactions
- **Carbohydrates**, providing energy to the cell

MACROMOLECULE:
Carbohydrates

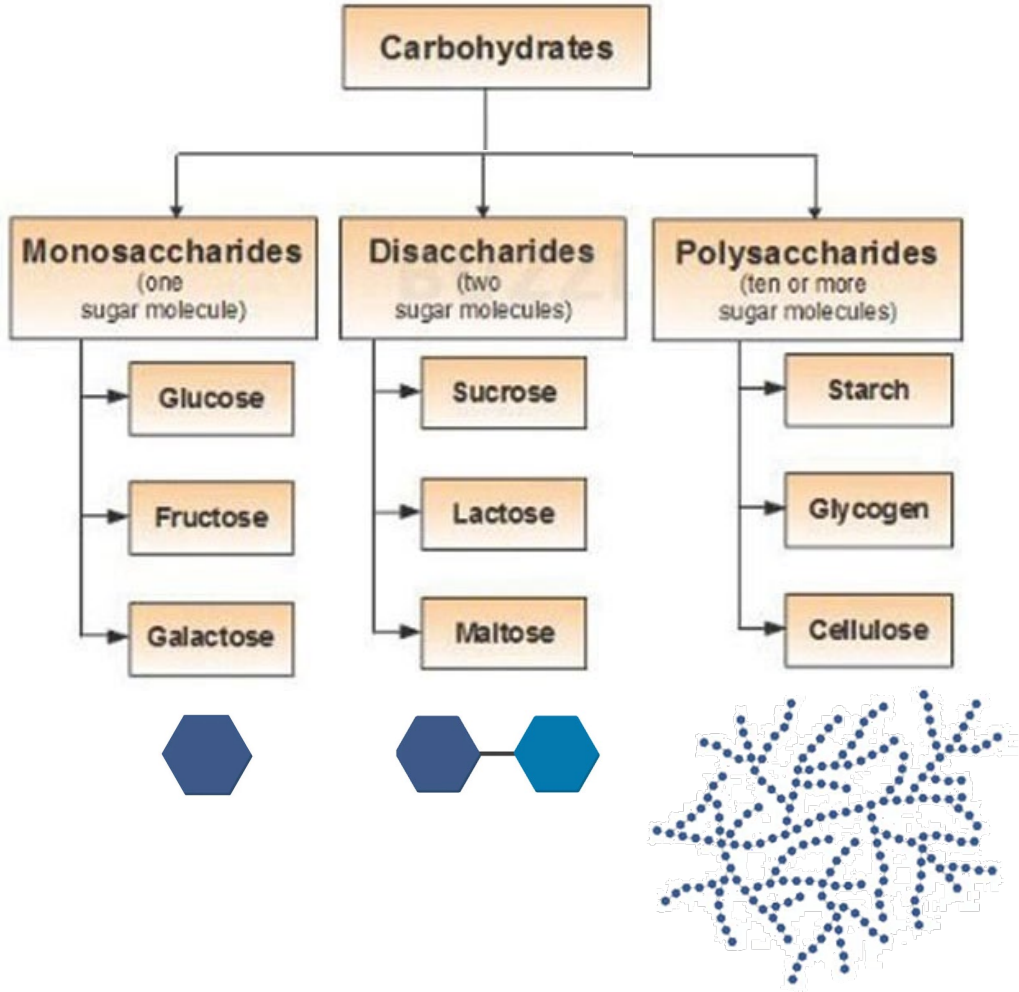
Carbohydrates

Carbohydrates are a cell's "favorite food"

- The energy stored in carbohydrates are released through **catabolic** (a.k.a. breaking) reactions

Carbohydrates are classified by size

- Monosaccharides (like glucose) are made of one sugar molecule
- Disaccharides (like sucrose) are made of two sugar molecules
- Polysaccharides (like starch) are made of many sugar molecules



Carbohydrates

MACROMOLECULE: Carbohydrates

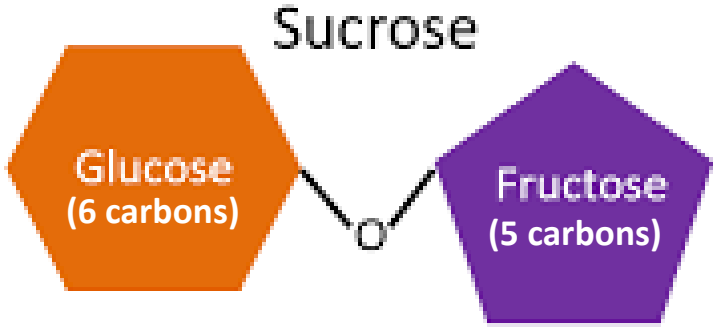
Not all carbohydrates are the same

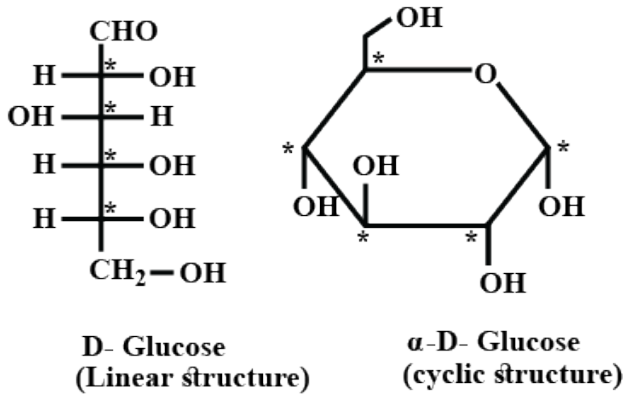
- Some carbohydrates (pentoses) have 5 carbons while others (hexoses) have 6 carbons
- Some carbohydrates are linear while others form rings

Monosaccharides & disaccharides provide energy **quickly**

Polysaccharides **store** energy

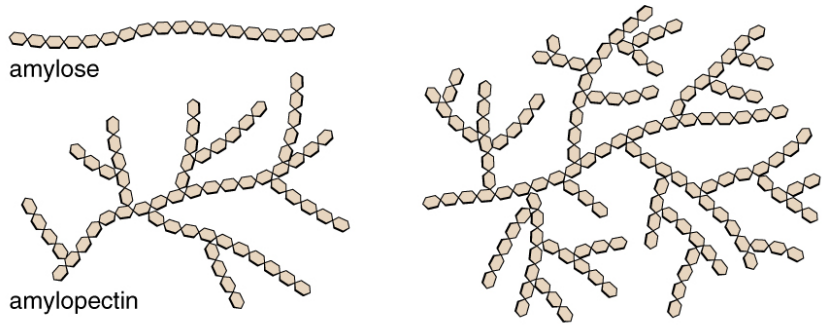
- Glycogen is used by animal cells for short-term energy storage
- Starches are used by plant cells for short-term energy storage





D- Glucose (Linear structure)

α-D- Glucose (cyclic structure)



starch

glycogen

MACROMOLECULE:
Lipids

Fats

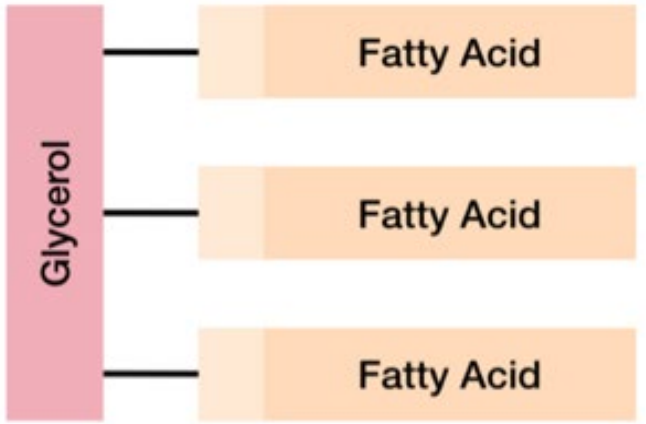
Fats are used for <u>long-term</u> energy storage

The most common fat in animal cells is **triglycerides**

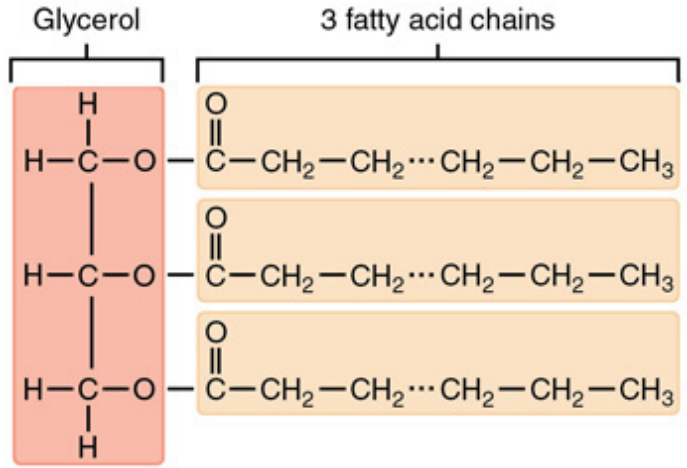
Triglycerides are made of a glycerol head & three fatty acid tails

- The energy of fats is stored in the chemical bonds (connections) in the fatty acid tails
- The longer the fatty acid tail, the more energy that is stored in it

<u>Simplified triglyceride structure</u>



<u>Detailed triglyceride structure</u>



MACROMOLECULE:
Lipids

Fats

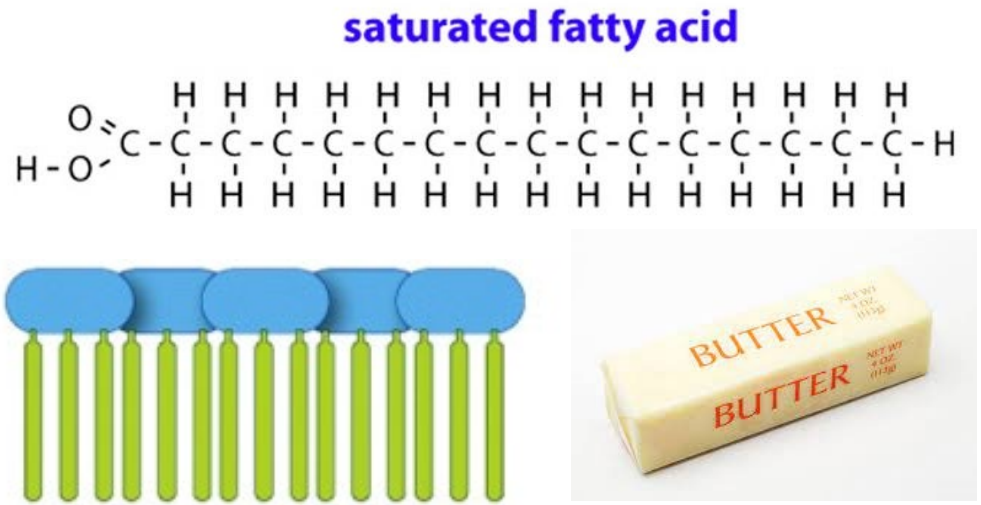
Fatty acid tails can be saturated or unsaturated

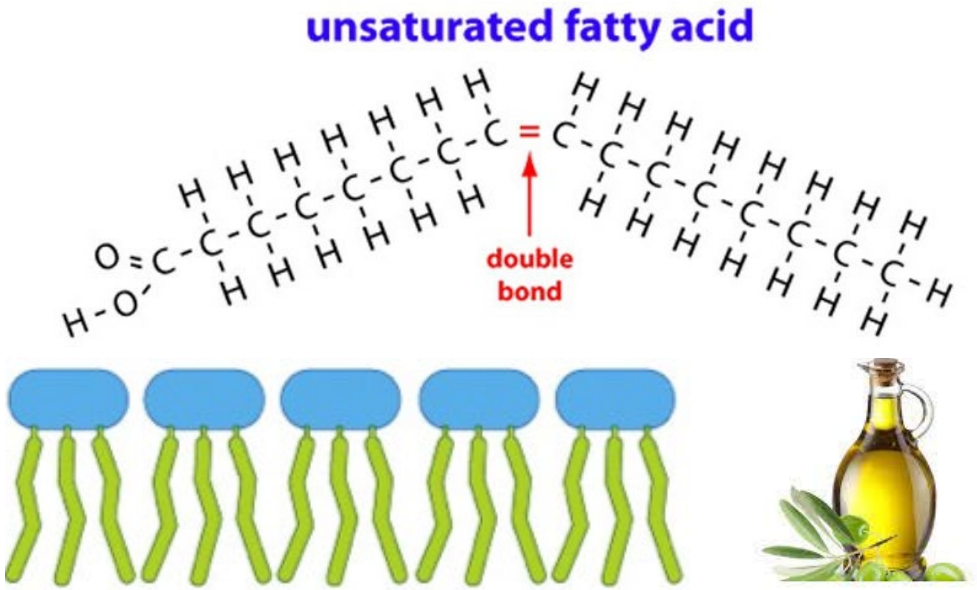
Saturated fatty acids have carbons attached to as many hydrogens as possible

- This creates straight fatty acid tails that can pack together closely
- This kind of fat is solid at room temperature

Unsaturated fatty acids have double bonds (extra connections) between carbons

- This creates bent fatty acid tails that can't squeeze as closely together
- This kind of fat is liquid at room temperature





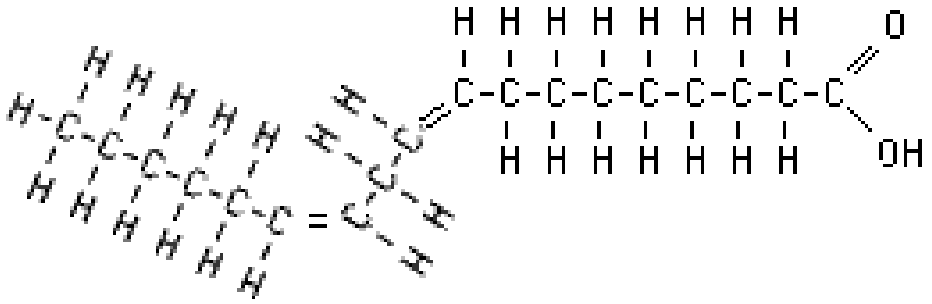
Stop & Think It Through!

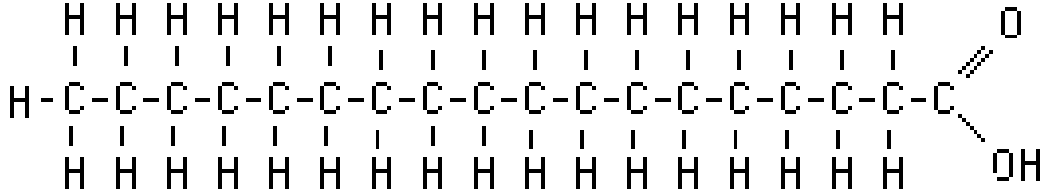
Why is it good for human skeletal muscle cells to store extra energy in the form of ***glycogen***, not ***triglycerides***?

Let's Practice!

Omega-6 fatty acids are a type of **unsaturated** fatty acid used by the human body to grow. (Interestingly, our bodies cannot make them!)

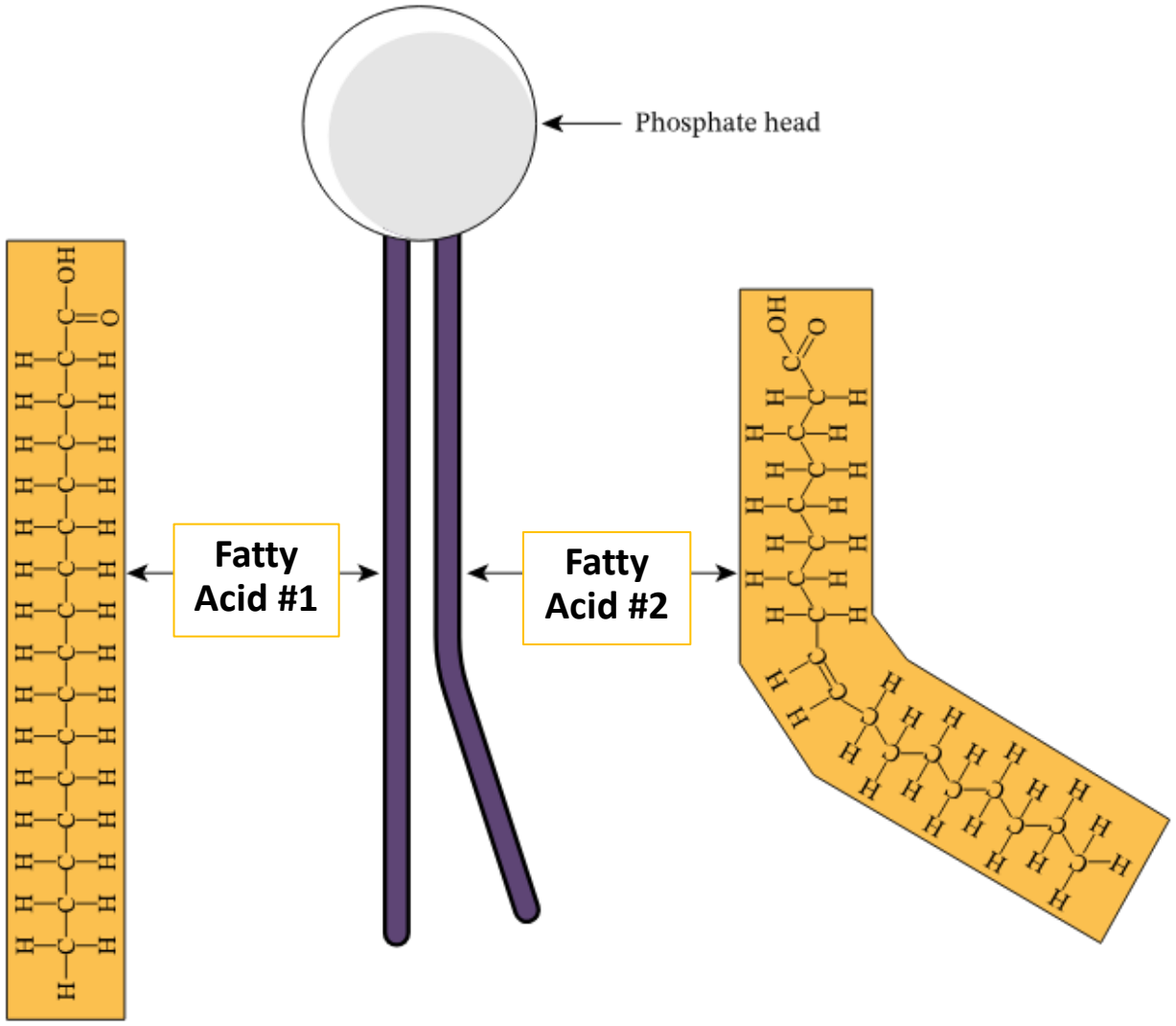
Which chemical structure is MOST LIKELY to represent an omega-6 fatty acid?





How do you know?

Let's Practice!



Phospholipids are the type of lipid used to build a cell's plasma membrane.

Each phospholipid has 2 fatty acid tails.

Fatty Acid #1 is a:

saturated / unsaturated

fatty acid.

Fatty Acid #2 is a:

saturated / unsaturated

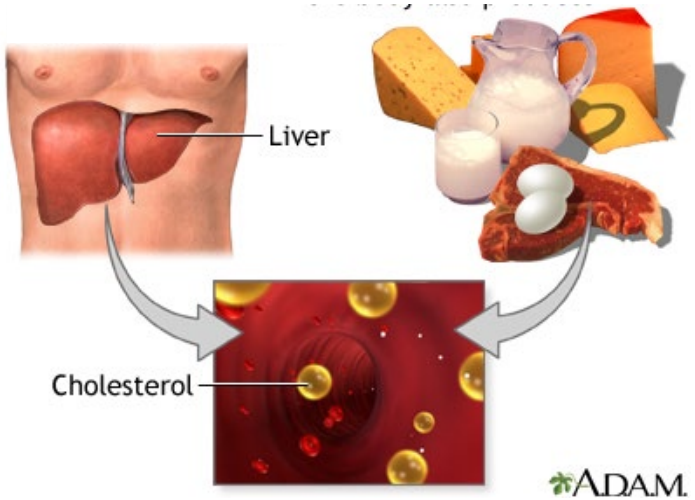
fatty acid

MACROMOLECULE:
Lipids

Cholesterol

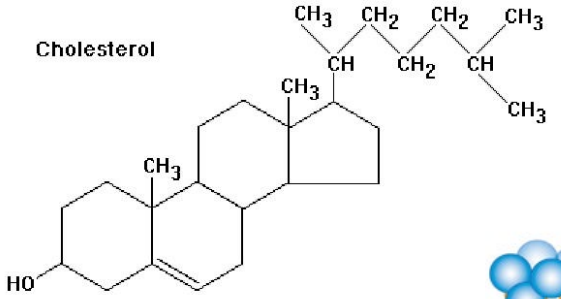
Cholesterol is a lipid made of 4 attached carbon rings

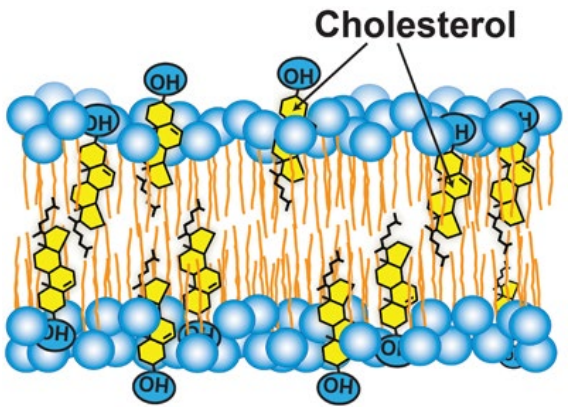
- Cholesterol can be obtained through diet
- Cholesterol is also made by the liver when it metabolizes saturated fatty acids



Excessive cholesterol can clog blood vessels, but the human body requires a moderate level of it

- Cholesterol maintains the stability of the plasma membrane
- Cholesterol is used to make sterol hormones (like testosterone, estrogen, and cortisol)





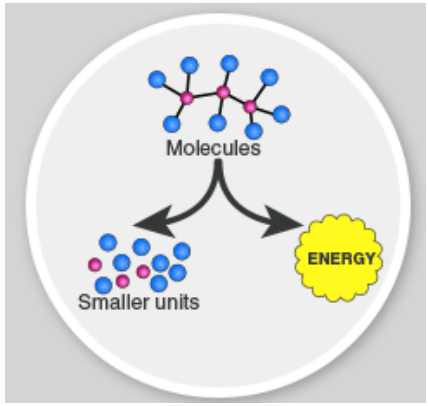
Types of Chemical Reactions

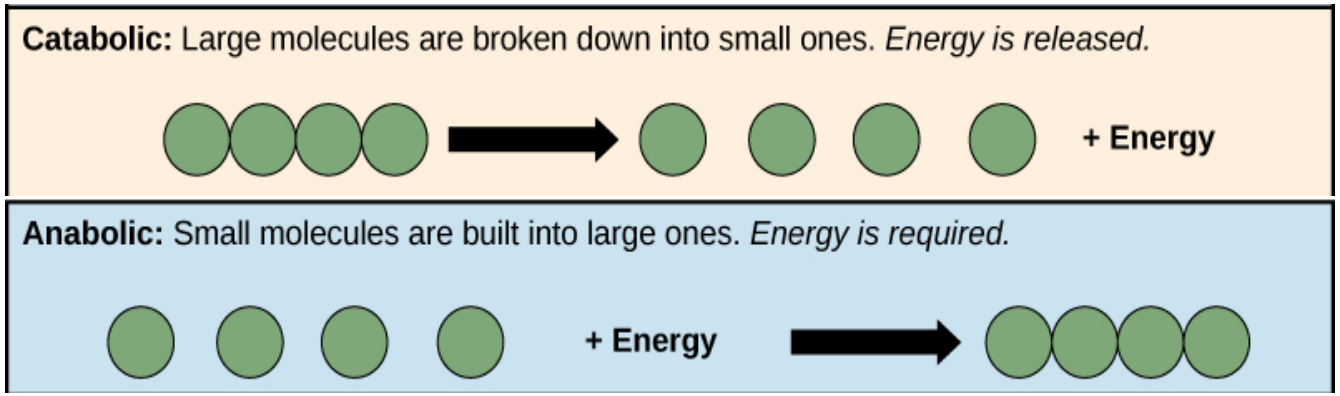
Catabolic reactions occur when large molecules (like lipids) are broken down into smaller pieces

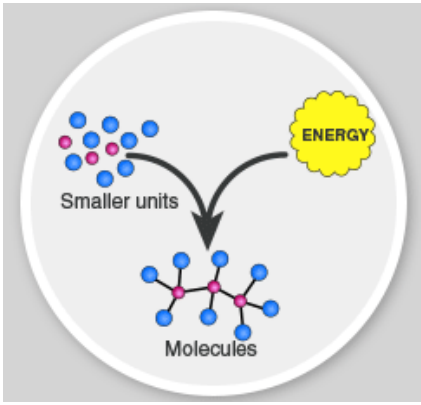
- Large molecules store energy in their chemical bonds (a.k.a. connections) between smaller pieces
- Catabolic reactions **release** the stored energy for a cell to use

Anabolic reactions occur when smaller pieces are used to build a large molecule

- Building new connections between smaller pieces **requires** energy
- Cells use anabolic reactions to store energy for later use







Cortisol

Terminology:

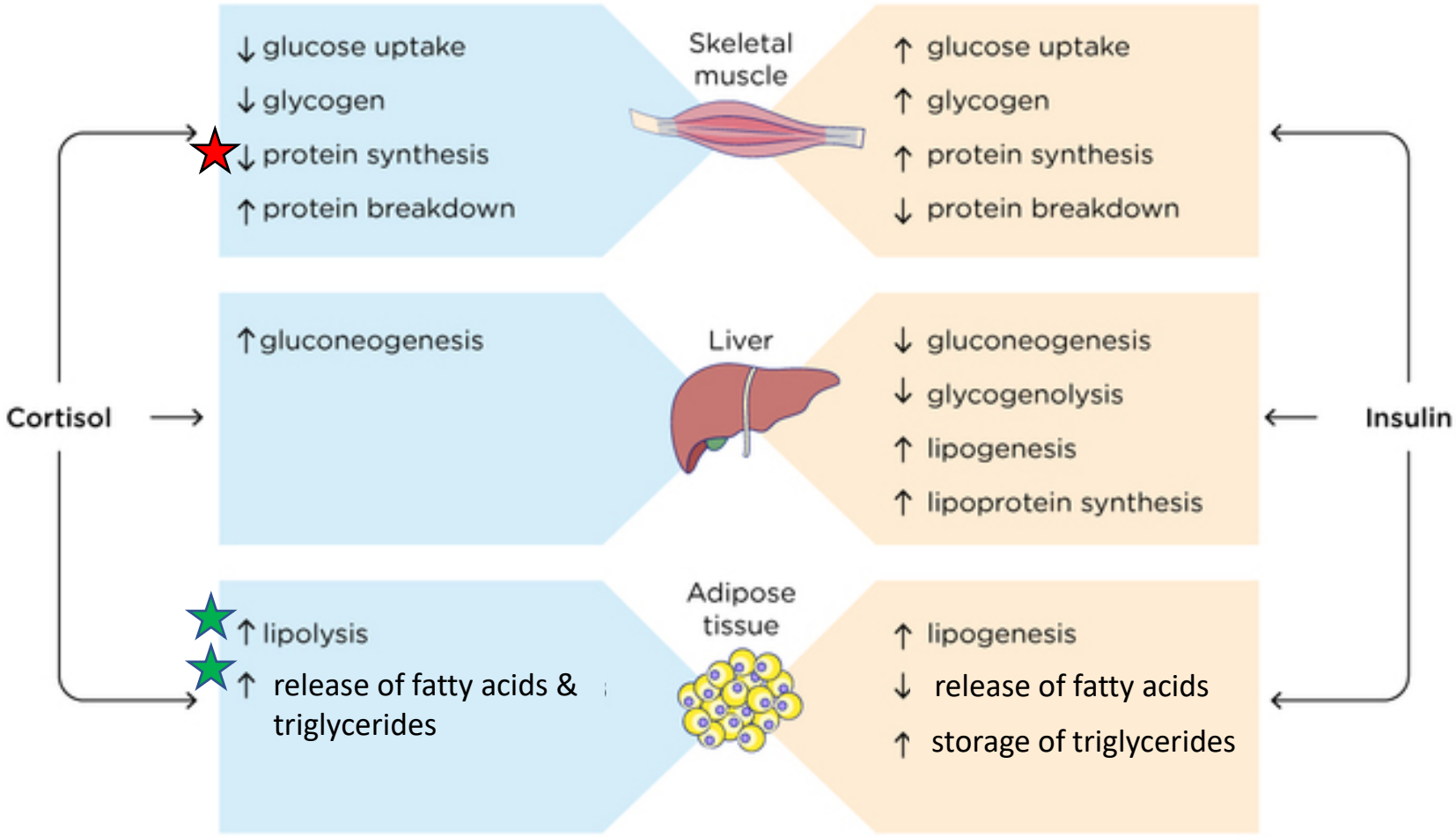
Synthesis / genesis = building

Lysis / release = breaking

Cortisol is a sterol hormone released by the body during stress

Cortisol changes the metabolic processes (a.k.a. chemical reactions) of the body

- It increases **breakdown** of glycogen **(stored energy)** in the body
- Cortisol decreases the **building** of **new proteins**



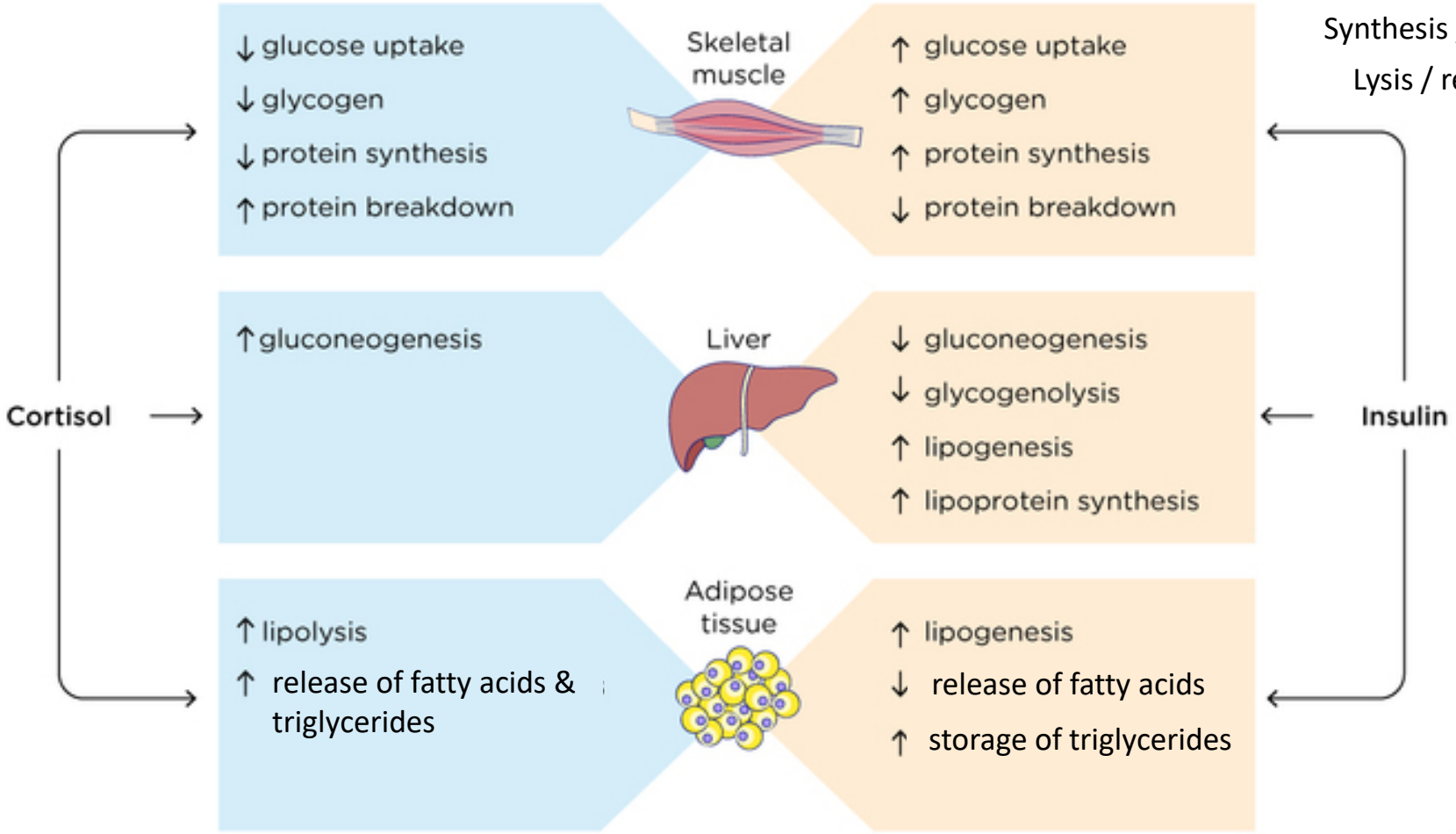
Notice that the effects of <u>cortisol</u> on metabolism are **opposite** of the effects of <u>insulin</u> on metabolism

Let's Apply It!

Terminology:

Synthesis / genesis = building

Lysis / release = breaking

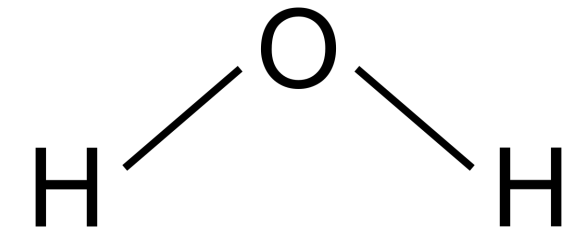


Based on its effects in the body, would **cortisol** be an <u>anabolic</u> hormone or a <u>catabolic</u> hormone?

Based on its effects in the body, would **insulin** be an <u>anabolic</u> hormone or a <u>catabolic</u> hormone?

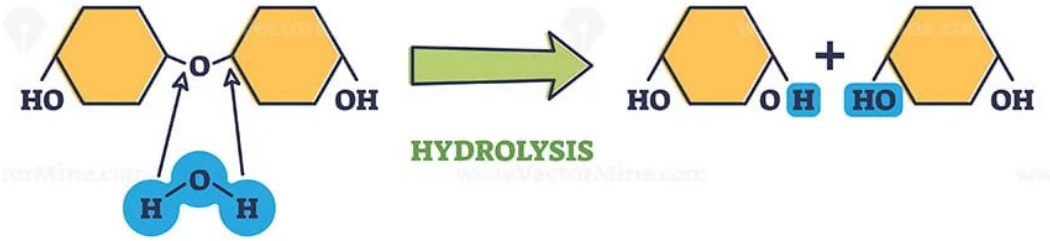
Water & Chemical Reactions

Water (H_2O) is often involved in the breaking & building of chemical bonds



In **hydrolysis**, water is used to <u>break</u> a chemical bond

- A water molecule is split into H & OH, each part attaching to a different side of the chemical bond
  - Result: the monomers detach from one another
- Hydrolysis is a type of ***catabolic*** reaction



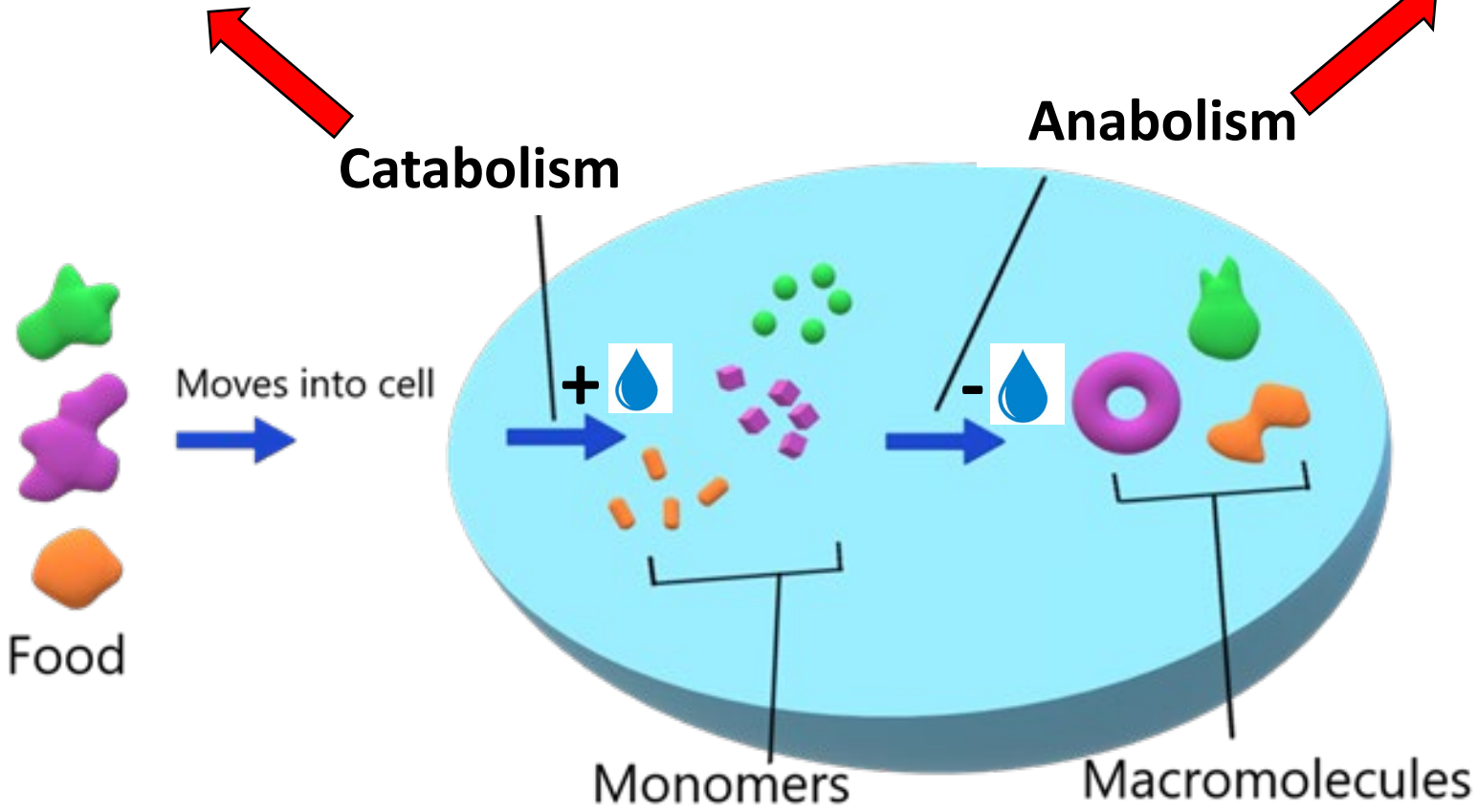
In **dehydration synthesis**, water is <u>made</u> (along with a new chemical bond)

- H & OH are removed from the monomers
  - Result: a chemical bond forms between them
- Dehydration synthesis is a type of ***anabolic*** reaction

So… What Happens When You Eat?

The **macromolecules** in the food you eat are broken into **monomers** through the process of hydrolysis.

The **monomers** from your food are used to build **macromolecules** using dehydration synthesis.



Let's Practice!
The Macromolecules: A Summary

Type of Macromolecule	Function	Examples
Lipids		

To Prepare for Next Class…

- ❑ Review your class notes
  - Use the eTextbook & Other Helpful Resources to supplement your lecture notes
- ❑ Complete the homework assignment
  - Review what you didn't understand and make another attempt. You can complete the homework as many times as you want!
- ❑ Print the slides for Lesson #2 – The Great Divide
- ❑ Take some deep breaths… this moves oxygen directly into your cells and reduces stress!