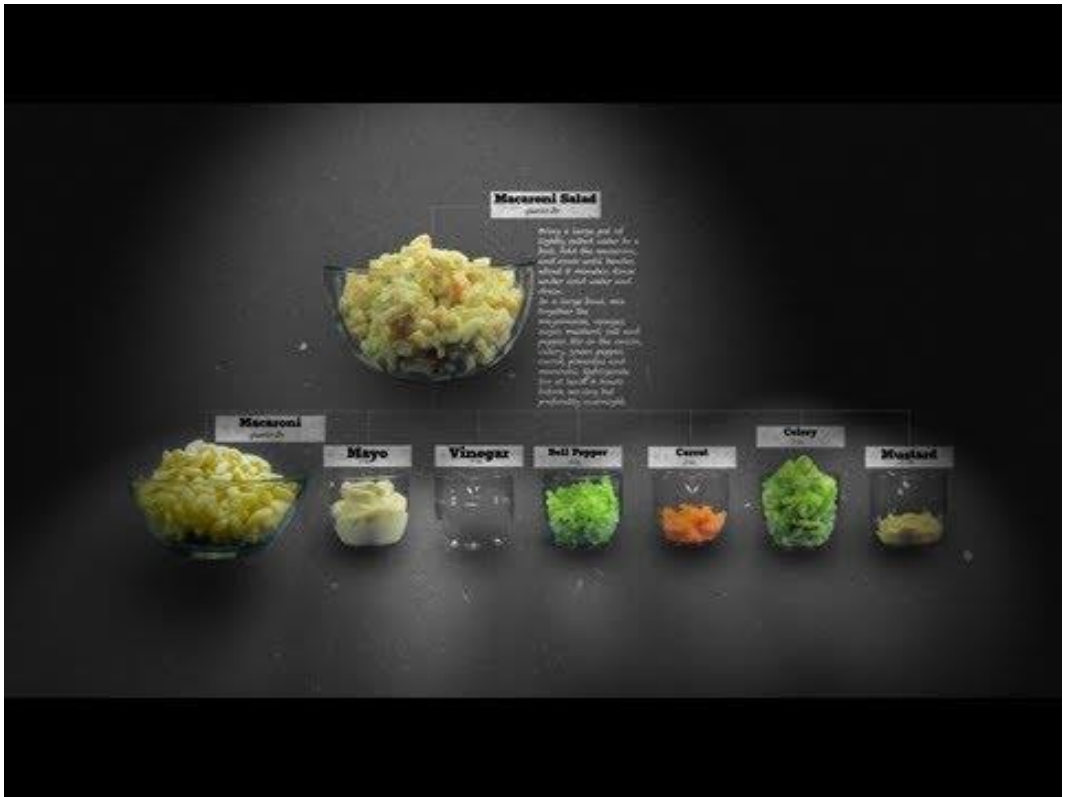
Introduction to Organic Chemistry

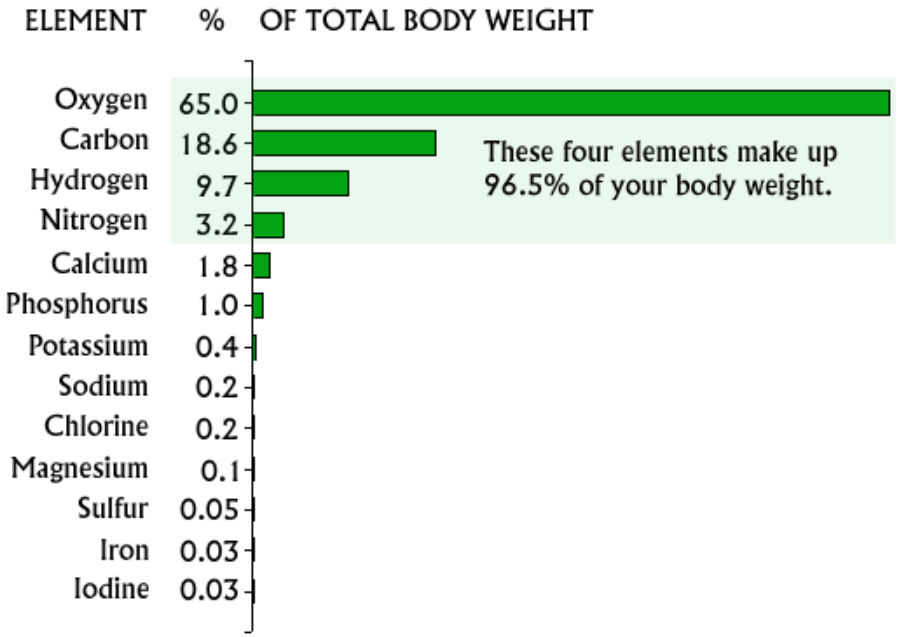
Composition of Living Things

- What makes up living things?
- How do we get these building blocks?



Composition of Living Things

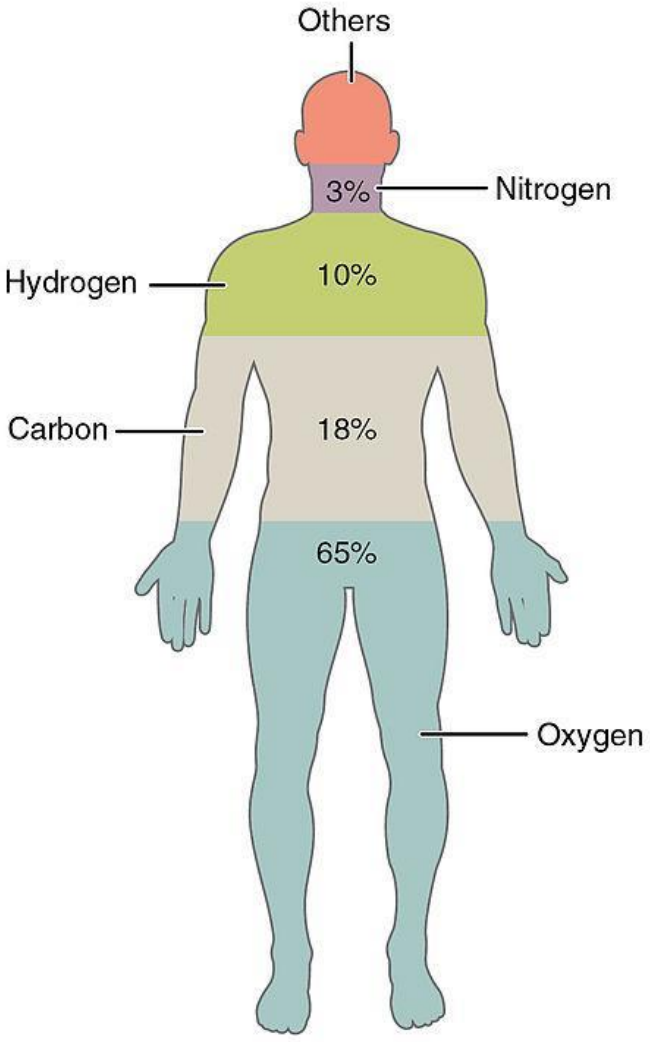
- Which atoms make up living organisms?
  - Of the 92 elements that naturally occur on Earth, about 25 are found in organisms
  - Just 4 make up about **96**% of a human body's mass
    - Carbon (**C**)
    - Hydrogen (**H**)
    - Oxygen (**O**)
    - Nitrogen (**N**)



https://askabiologist.asu.edu/content/atoms-life

CHOPKINS CaFe Mg

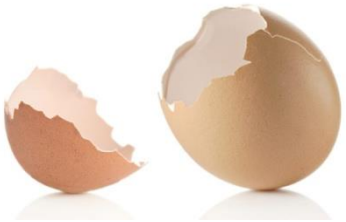
This sounds like an excellent small restaurant…say it out loud.



Element	Symbol	Percentage in Body
Oxygen	O	65.0
Carbon	C	18.5
Hydrogen	H	9.5
Nitrogen	N	3.2
Calcium	Ca	1.5
Phosphorus	P	1.0
Potassium	K	0.4
Sulfur	S	0.3
Sodium	Na	0.2
Chlorine	Cl	0.2
Magnesium	Mg	0.1
Trace elements include boron (B), chromium (Cr), cobalt (Co), copper (Cu), fluorine (F), iodine (I), iron (Fe), manganese (Mn), molybdenum (Mo), selenium (Se), silicon (Si), tin (Sn), vanadium (V), and zinc (Zn).		less than 1.0

http://cnx.org/content/m45998/latest/?collection=col11496/1.6

Organic vs. Inorganic Compounds



- Historically, compounds isolated from plants and animals were deemed *organic* while those traced back to minerals were *inorganic*.
  - **Organic compounds typically had carbon (C)**

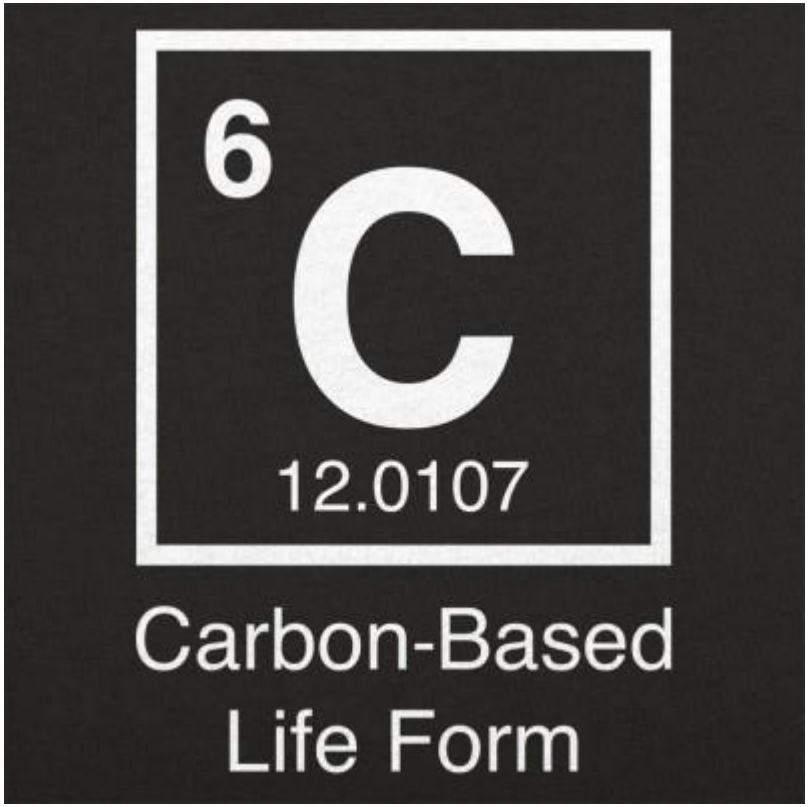
- However, some molecules contain C, such as calcium carbonate ($CaCO_3$) and elemental forms of carbon (diamond and graphite), that are clearly *in*organic.

Organic vs. Inorganic Compounds

Organic	Inorganic
Substance that contains **BOTH** carbon and hydrogen	Substance that does NOT contain BOTH carbon and hydrogen
*General rule is that they contain carbon	*Inorganic Examples with C: **Carbon Monoxide (CO), Carbon Dioxide (CO_2), Cyanides**
Types Essential to Life: Carbohydrates ($C_6H_{12}O_6$) Lipids Nucleic Acids Proteins	**Types Essential to Life:** Water (H_2O) Salts (NaCl) Acids (HCl)

Organic vs. Inorganic Compounds

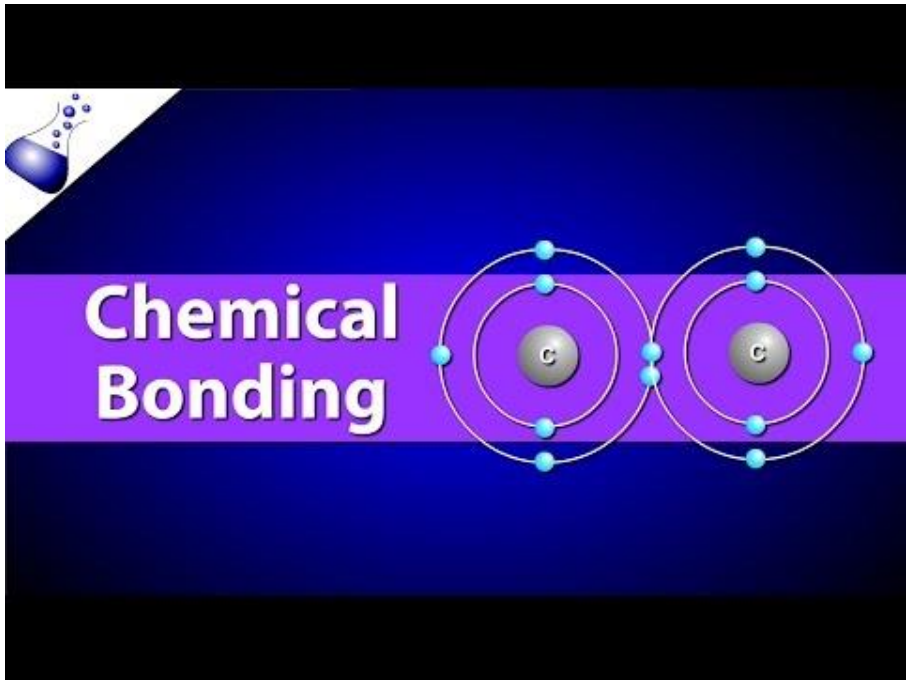
- Carbon-based molecules form the **structure** of living things and carry out most of the processes that keep organisms **alive**.



Chemical Bonds

- Elements attach to other elements by forming chemical bonds.

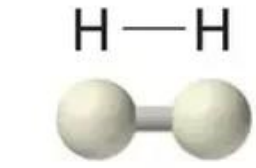
- Bonds can be ionic or covalent, but we will focus on covalent bonds when talking about organic compounds.



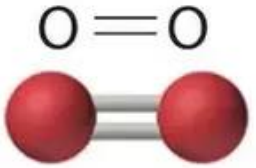
Chemical Bonds

- Covalent bonds are shown as solid lines between atoms in a molecule.

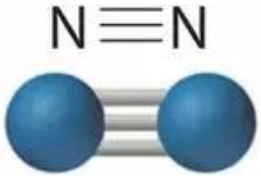
- There can be single, double and triple covalent bonds.



Single bond



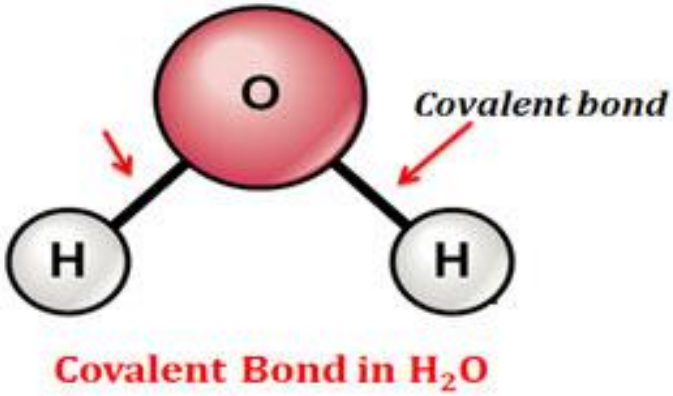
Double bond

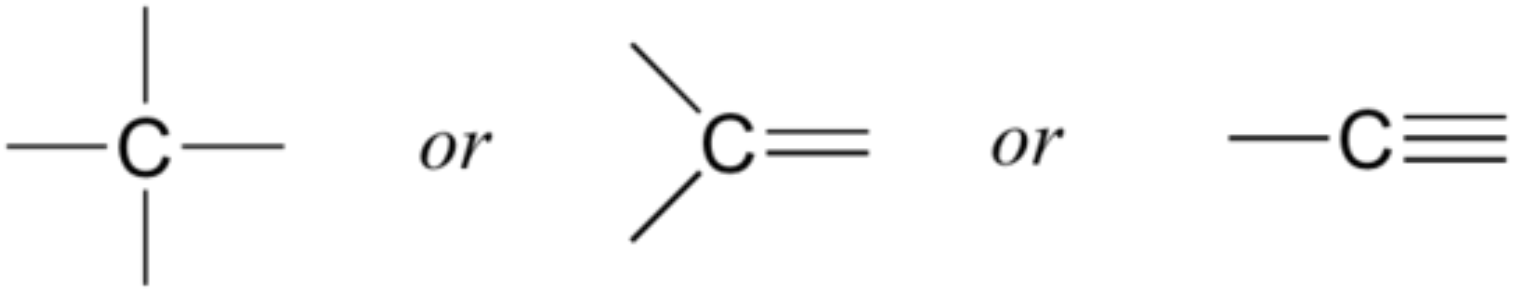


Triple bond

Chemical Bonds

- Carbon can make 4 bonds
- Hydrogen can make 1 bond
- Oxygen can make 2 bonds





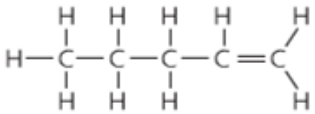
carbon usually has 4 bonds

Fundamental Structures of Carbon-Based Molecules

- Three fundamental structures:
  - Straight Chains
  - Branched
  - Rings

FIGURE 2.10 CARBON CHAINS AND RINGS

Straight chain

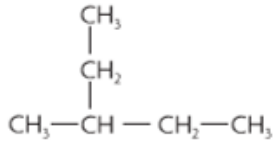


A simplified structure can also be shown as:

$CH_3—CH_2—CH_2—CH=CH_2$

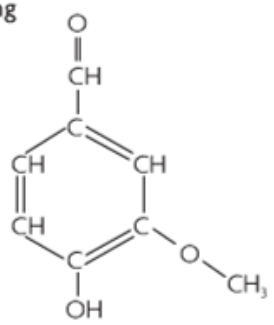
Pentene

Branched chain



Hexane

Ring



Vanillin

Share with your partner the different configurations above (relate the name to their structure) and how they show that carbon is forming 4 bonds.

Open up your Molecule Kits!

Can you figure out which color represents each of the following elements:

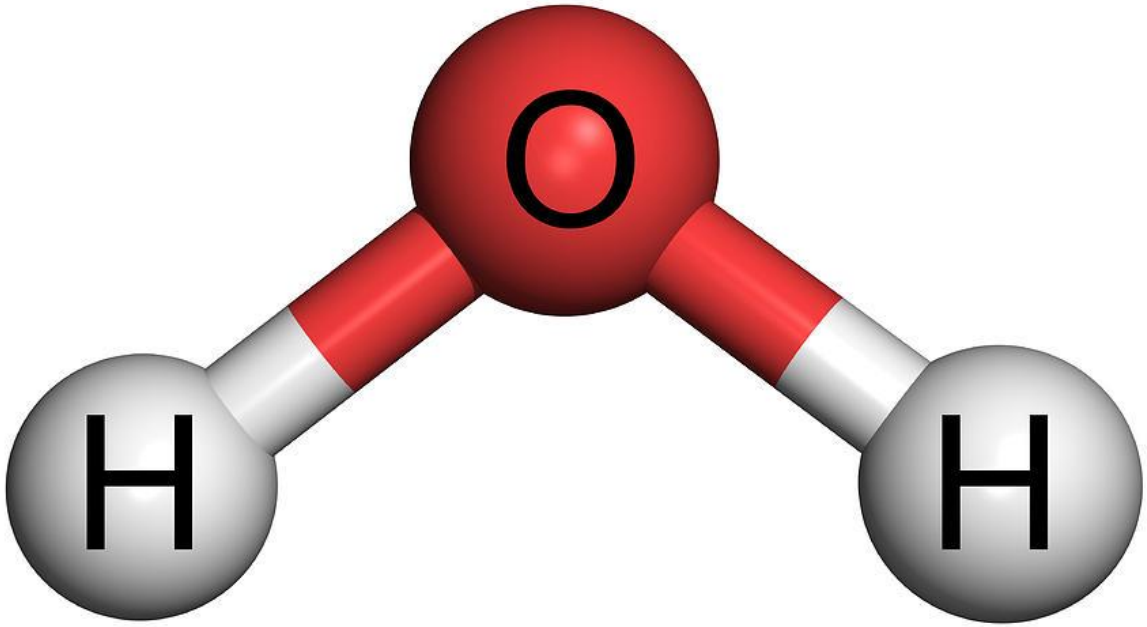
Carbon: **Black**

Hydrogen: **White**

Oxygen: **Red**

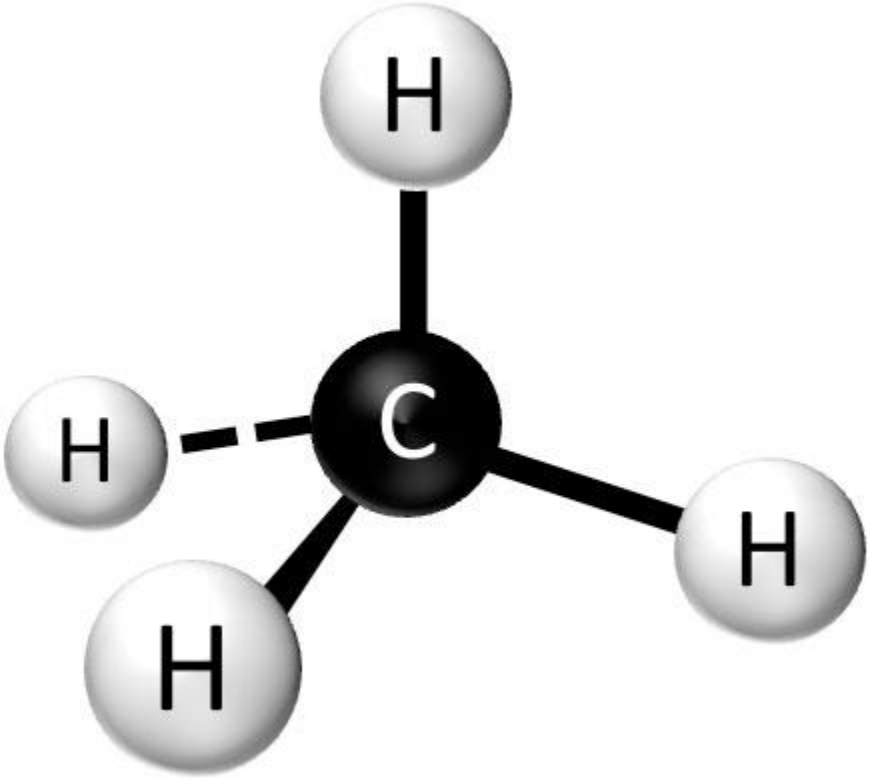
Let's make Water!

H_2O



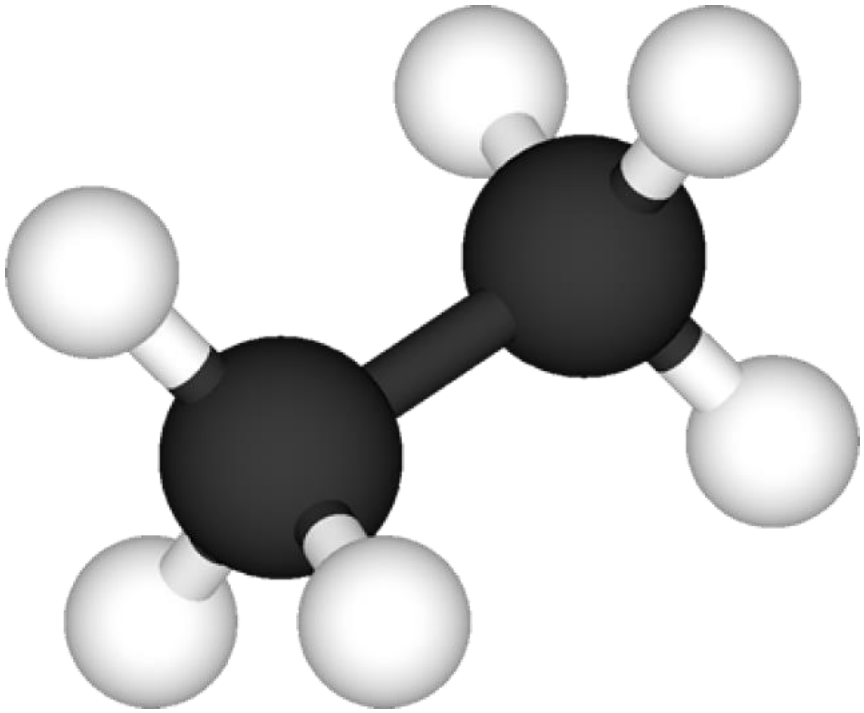
Let's make Methane!

CH_4



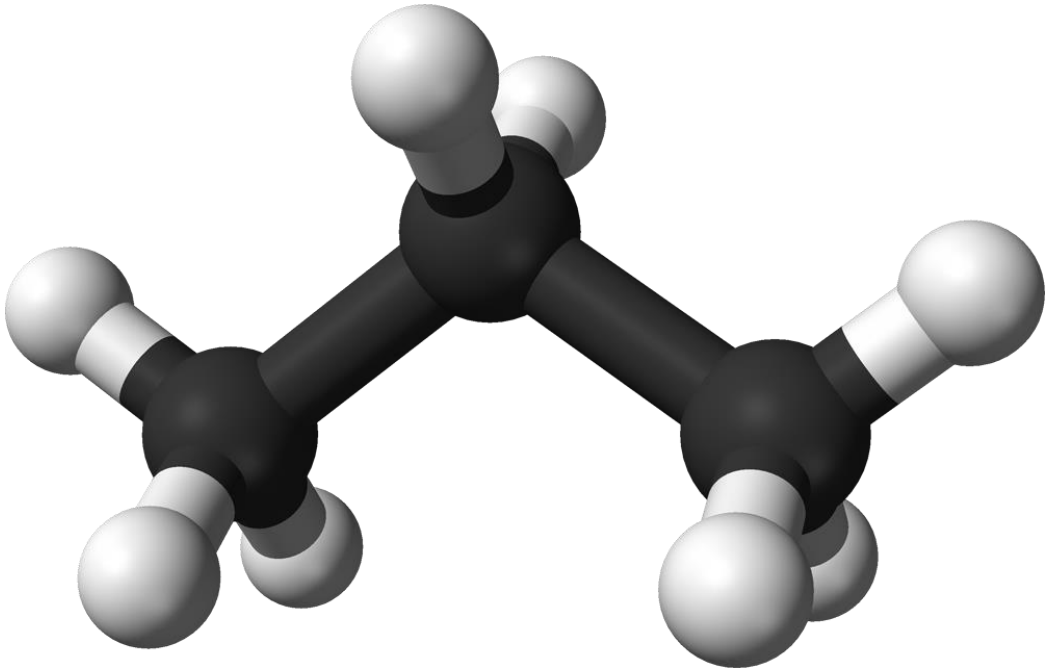
How about Ethane?

C_2H_6



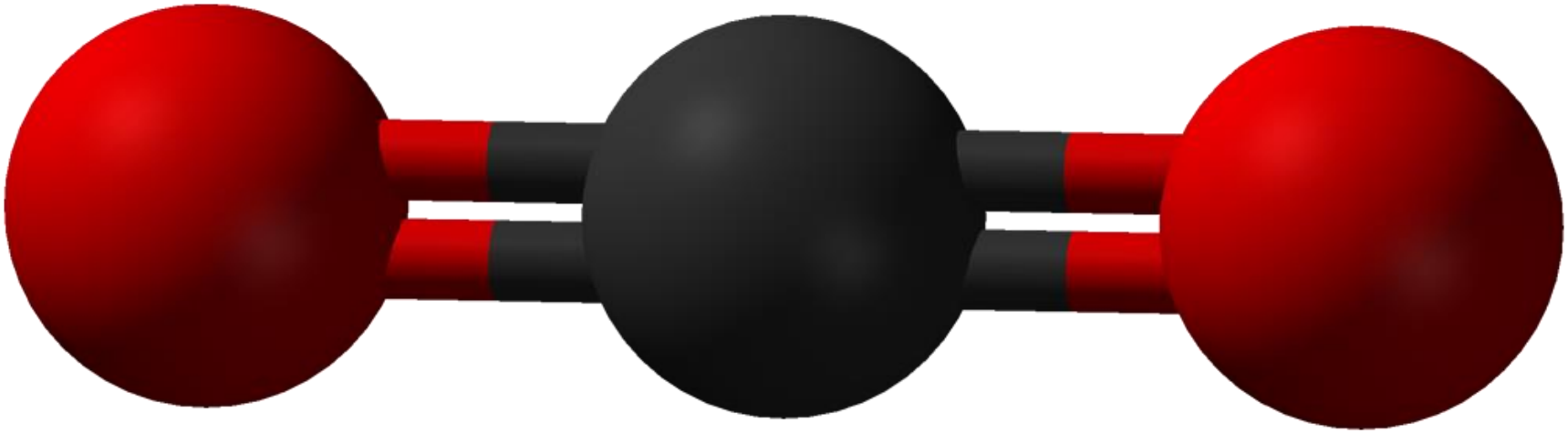
Can you figure out how to put together Propane?

C_3H_8



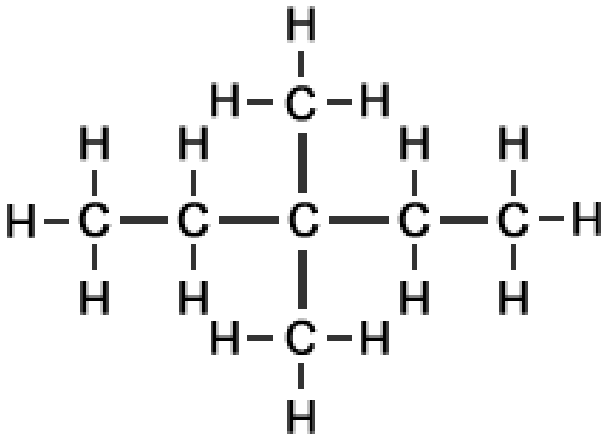
Can you make Carbon Dioxide?

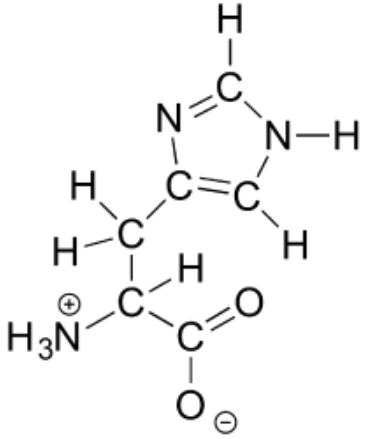
This one is tricky!



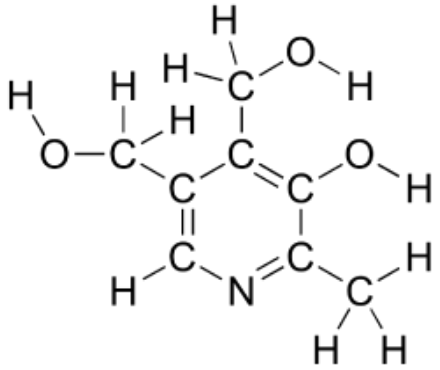
Drawing Organic Molecules

Full Display: Shows every atom and bond





histidine

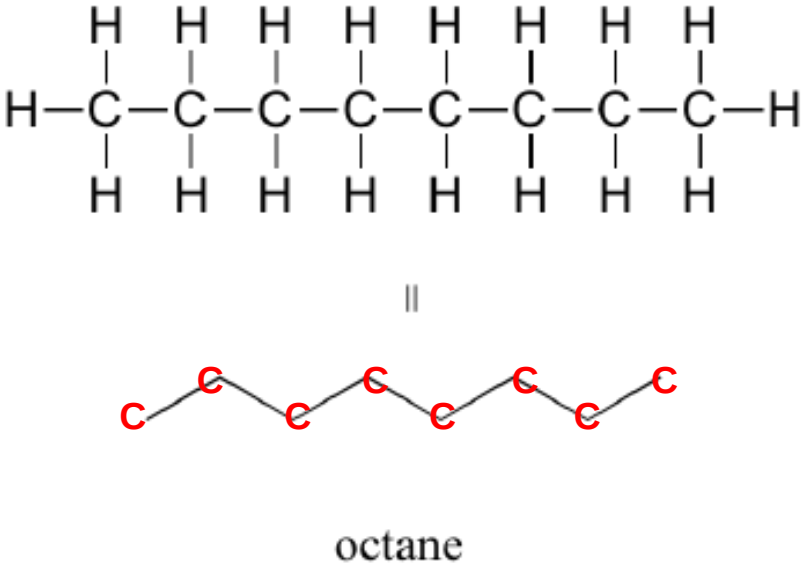


pyridoxine
(Vitamin B_6)

This can be time consuming to draw out, especially with really big molecules

Drawing Organic Molecules

Skeletal: Only shows bonds between carbons.



octane

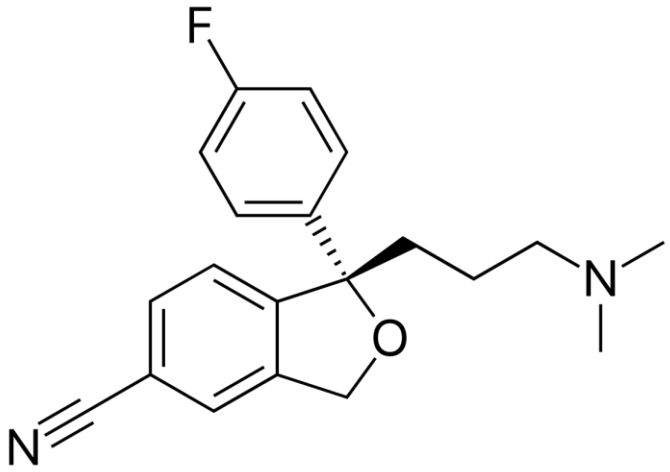
Each carbon is represented by a bend or end.

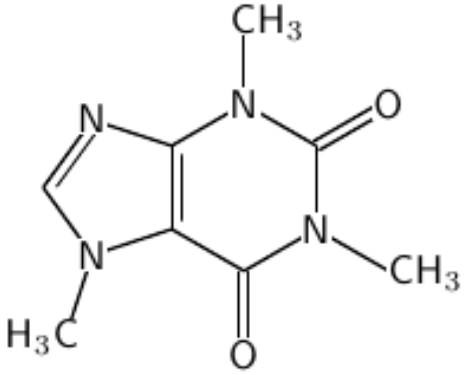
Bonds between carbons and hydrogens are not shown.

We can deduce how many hydrogens are present, since we know carbon makes 4 bonds.

Drawing Organic Molecules

Skeletal: Only shows bonds between carbons.





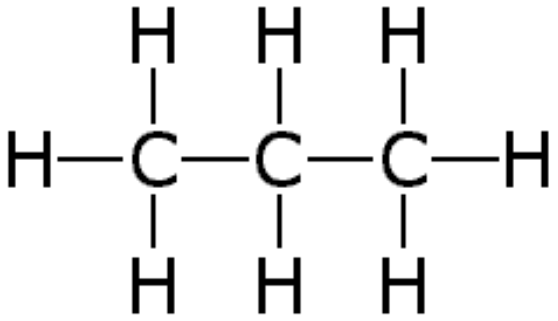
Elements that are not carbon and hydrogen are still shown.

Hydrogens attached to elements other than carbon are still shown.

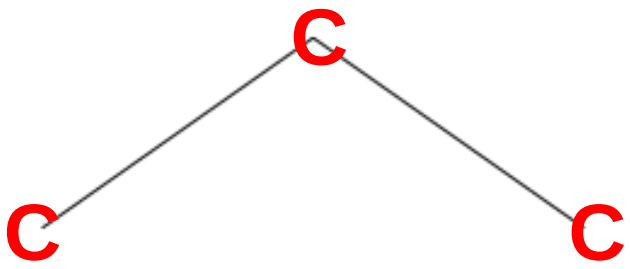
Bonds between carbon and elements other than hydrogen are still shown.

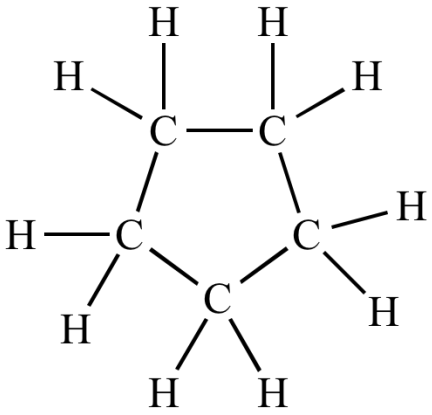
Drawing Organic Molecules

Let's practice

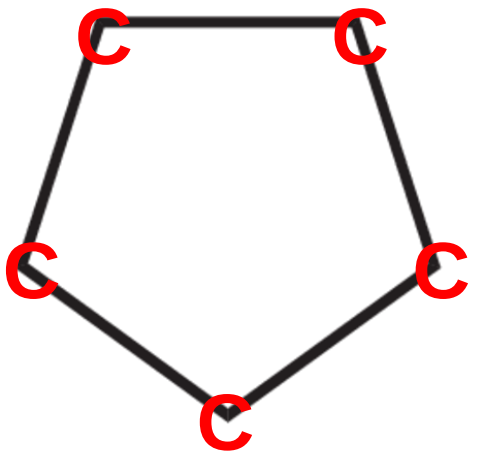


Propane



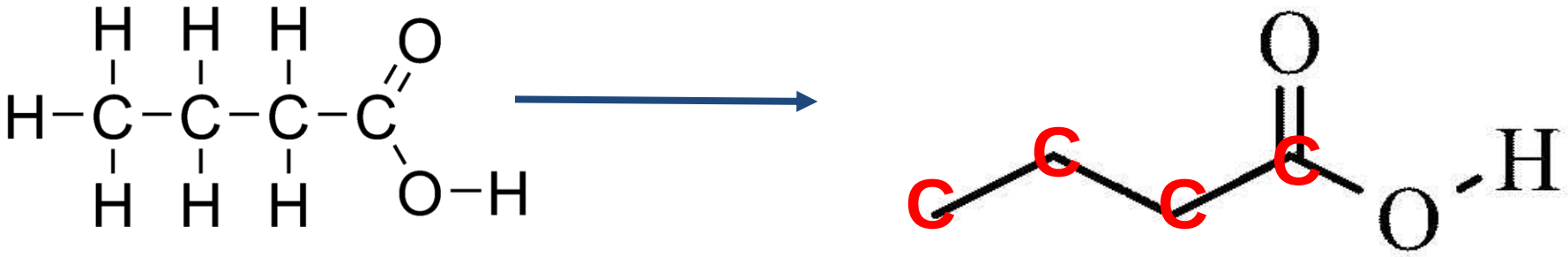


Cyclopentane



Drawing Organic Molecules

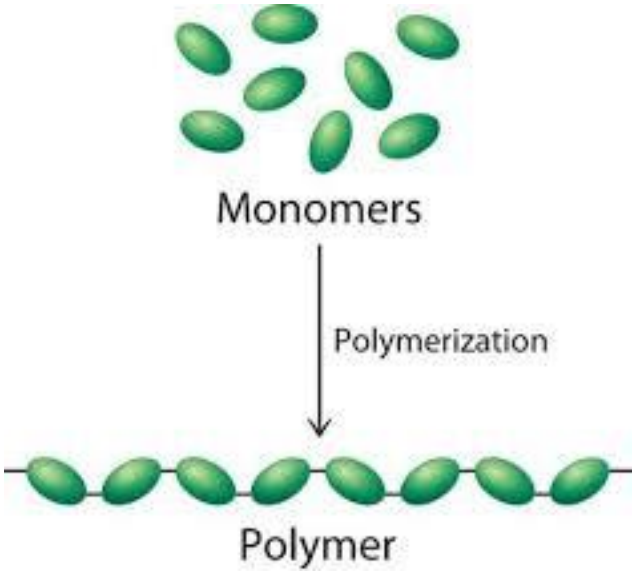
Let's practice



Butyric Acid

Monomer vs. Polymer

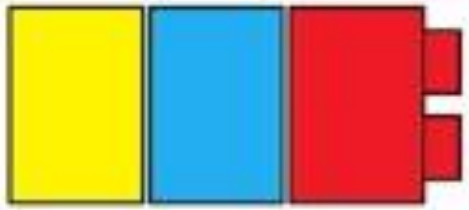
- Small molecules act as subunits of the entire molecule.
  - **Monomer**: each subunit in a complete molecule
  - **Polymer**: a large molecule, or macromolecule, made of many monomers bonded together.



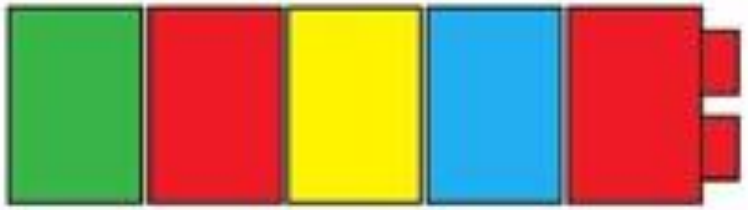
- All of the monomers can be the **same** (i.e. carbohydrates) or different (i.e. proteins).

Monomer vs. Polymer

Monomers



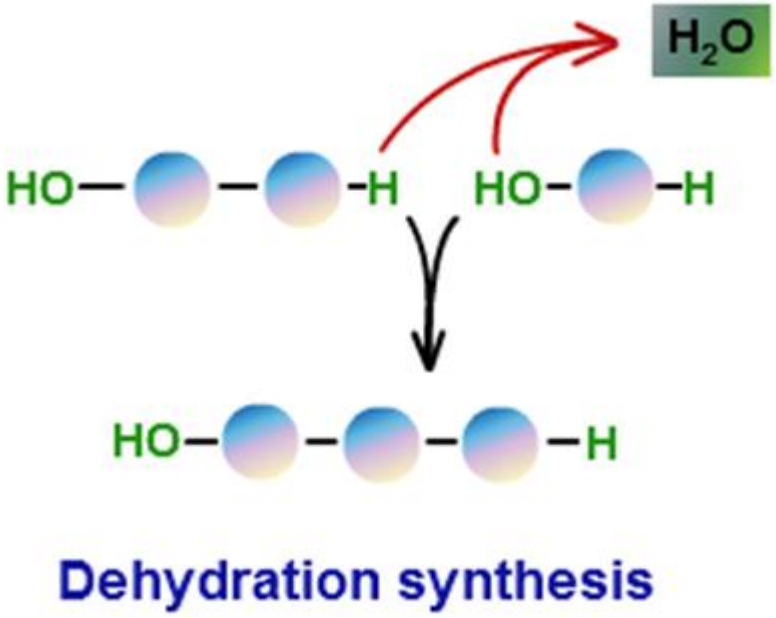
Polymer of three monomers



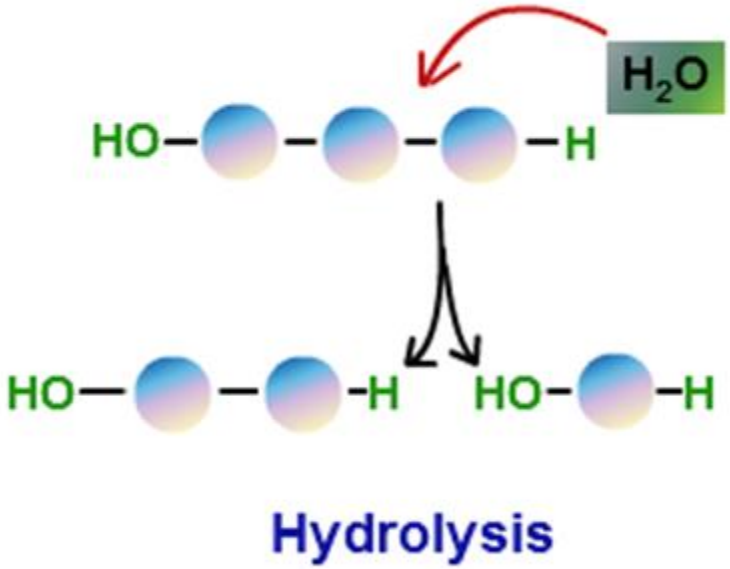
Polymer of five monomers

Building Up and Breaking Down Molecules

Forming larger molecules	Breaking bigger molecules into smaller ones
Dehydration Synthesis	Hydrolysis



Dehydration synthesis



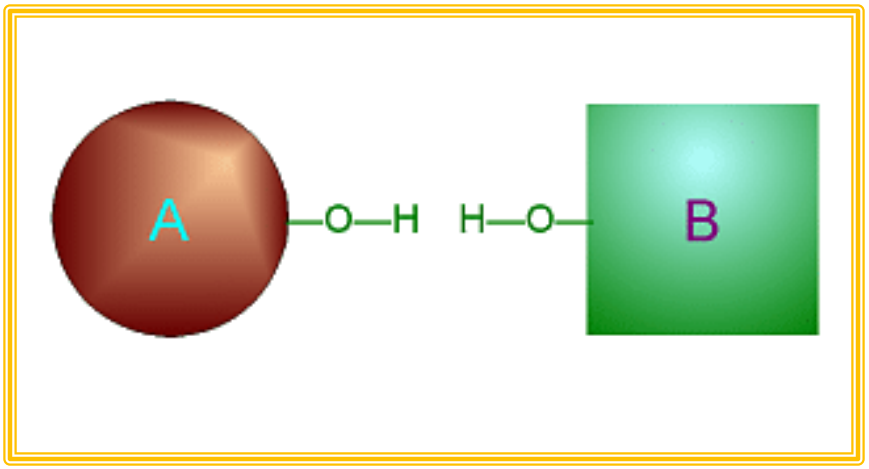
Hydrolysis

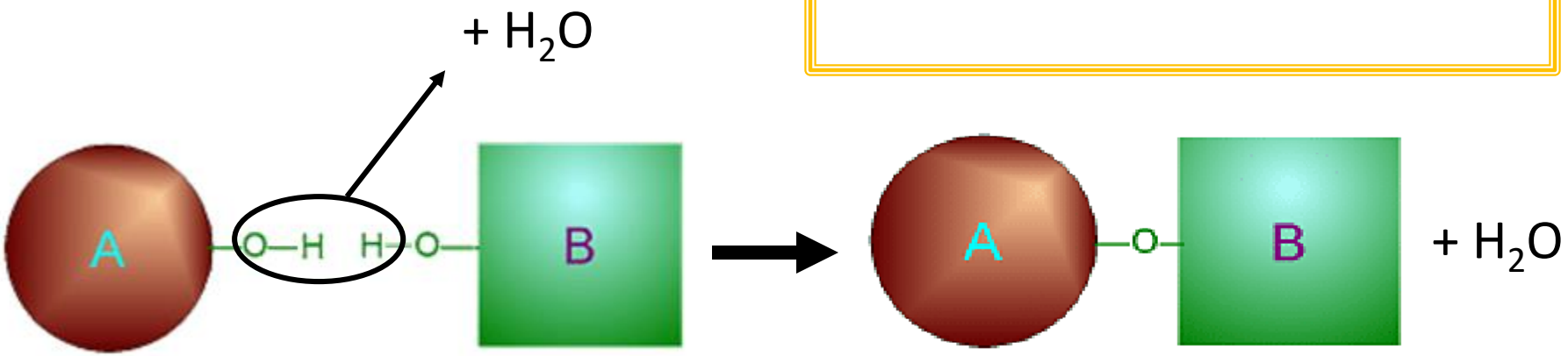
Sketch a simple drawing in your notes

Dehydration Synthesis – Build Up

- Synthesis
  - to create (to put together, to make bigger)

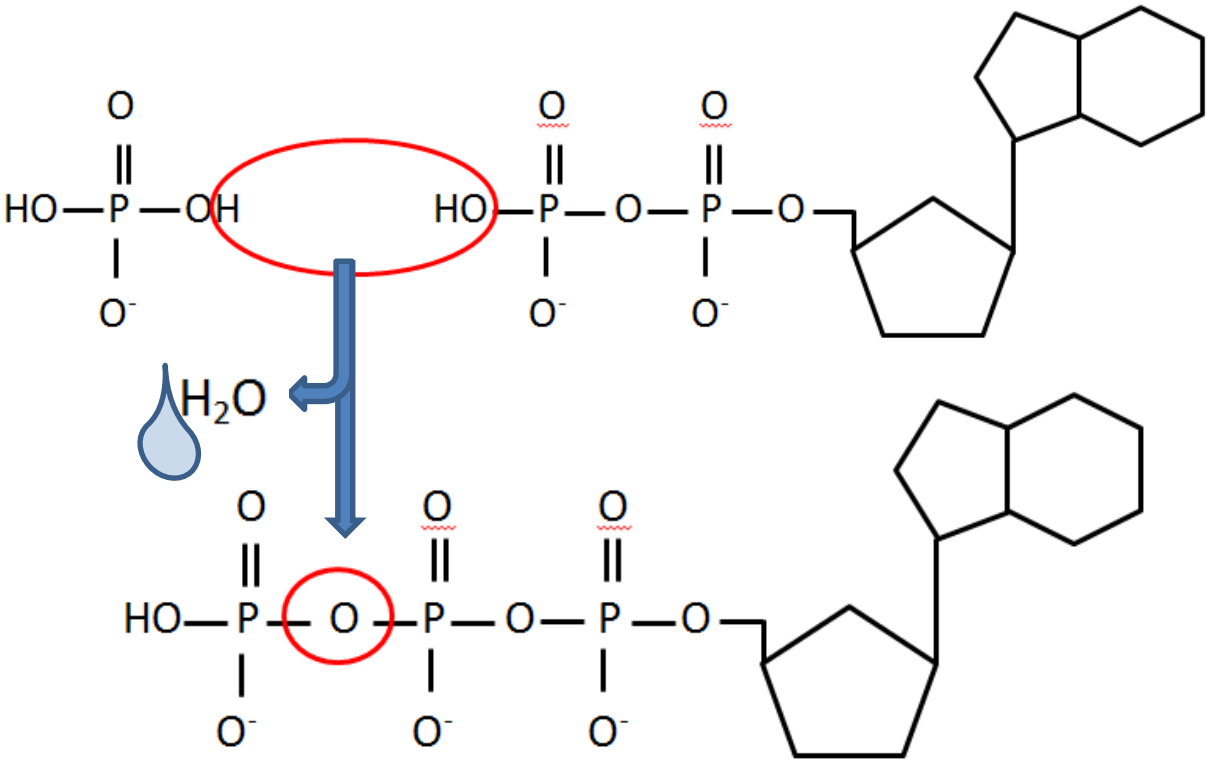
- Dehydration
  - to take out water





Ex: Dehydration Synthesis of ATP

**ATP is a molecule that stores readily usable energy for cells.



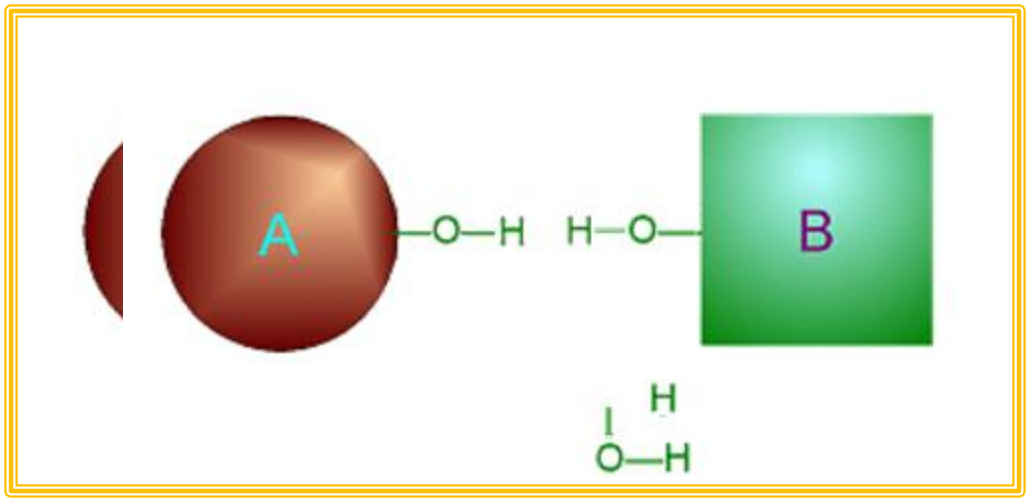
A phosphate group is added to the end.

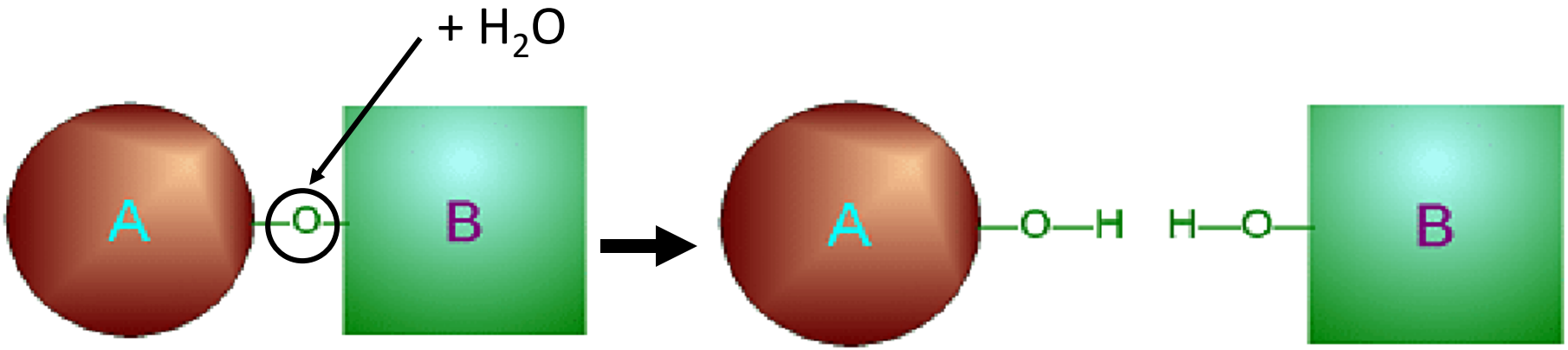
In doing so, energy is stored to be used by the cell.

This is a VERY important molecule in biology!

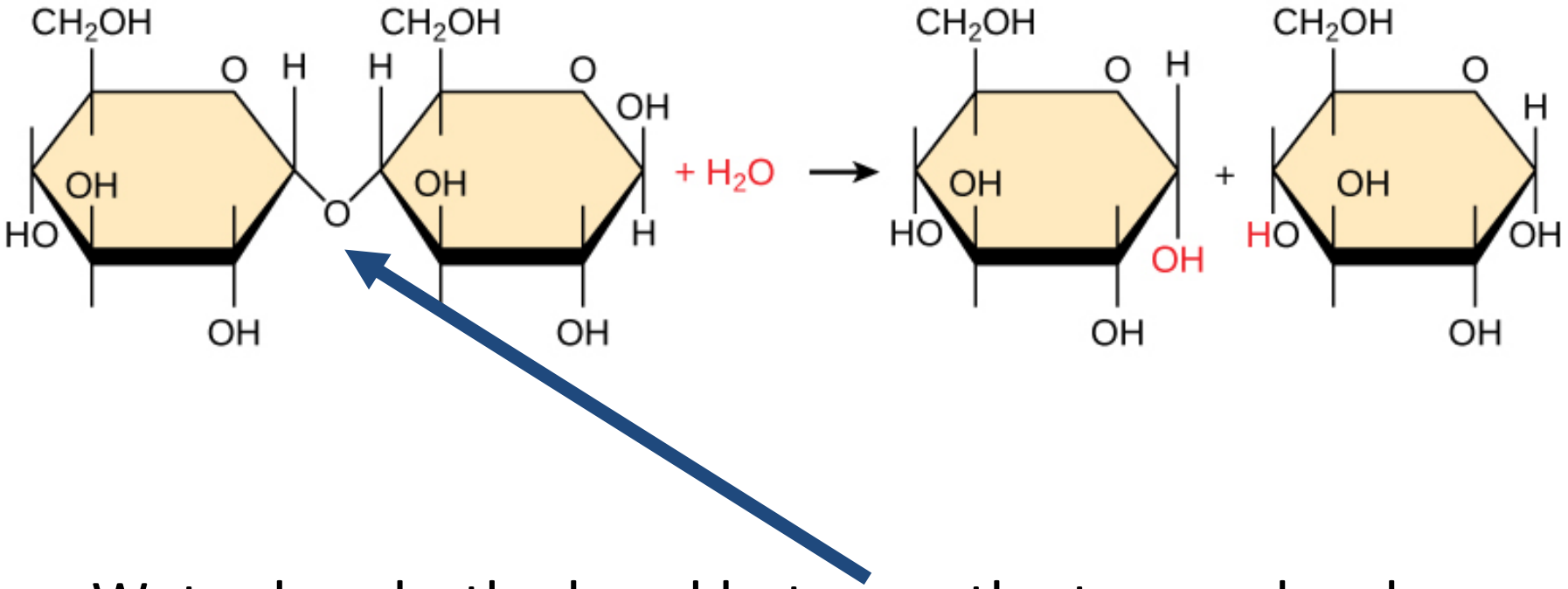
Hydrolysis – Break Down

- Lysis
  - to **split**
- Hydro
  - water (H_2O)





Ex: Hydrolysis of Starch

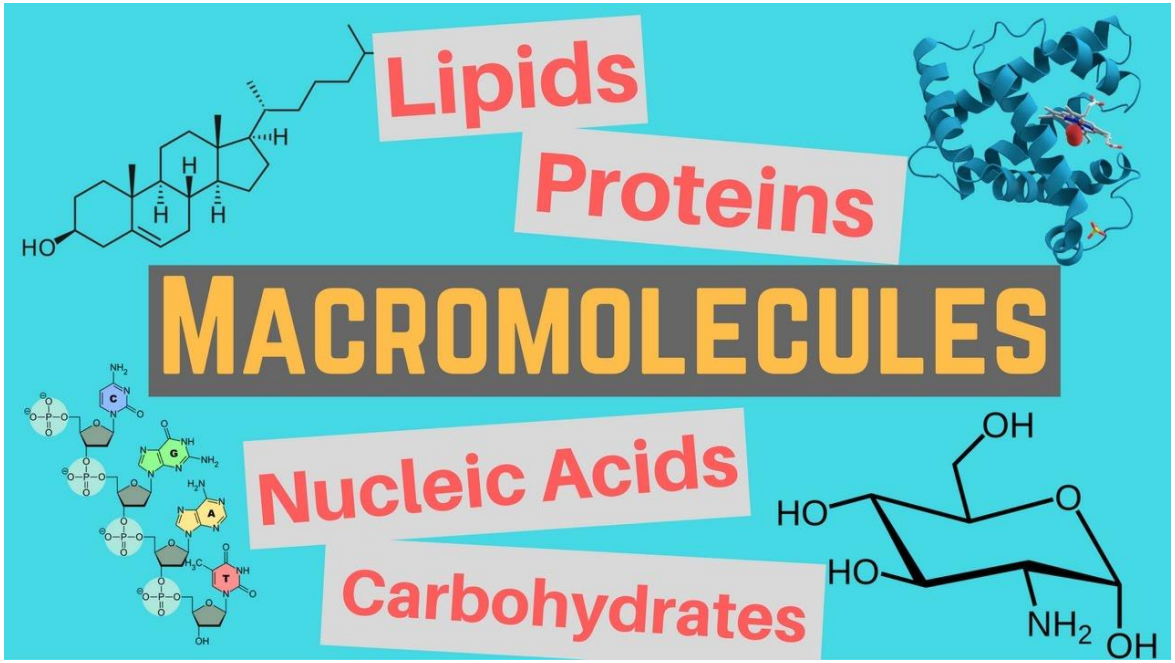


Water breaks the bond between the two molecules.

http://dm.ncl.ac.uk/helencollard/files/2009/04/atp.gif

Four Main Classes of Organic **Macromolecules**

Each of these molecules are made up of smaller parts. Understanding what they are made of helps you understand their function.



Macromolecule Table

We will come back to this table after each macromolecule we cover. It may be a good idea to tab this page with something like a sticky note.

Macromolecule	Lipids	Carbohydrates	Nucleic Acids	Proteins
Types of Atoms				
Monomers made of	X			
Function(s)				
Examples				
Sketch				