Macromolecules:

Carbohydrates, Lipids, Proteins, Nucleic Acids

I. Organic Compounds

A. What are organic compounds?

1. Contain carbon covalently bonded to another carbon
2. Found in all living things
3. Cells are made up almost entirely of H_2O & organic compounds

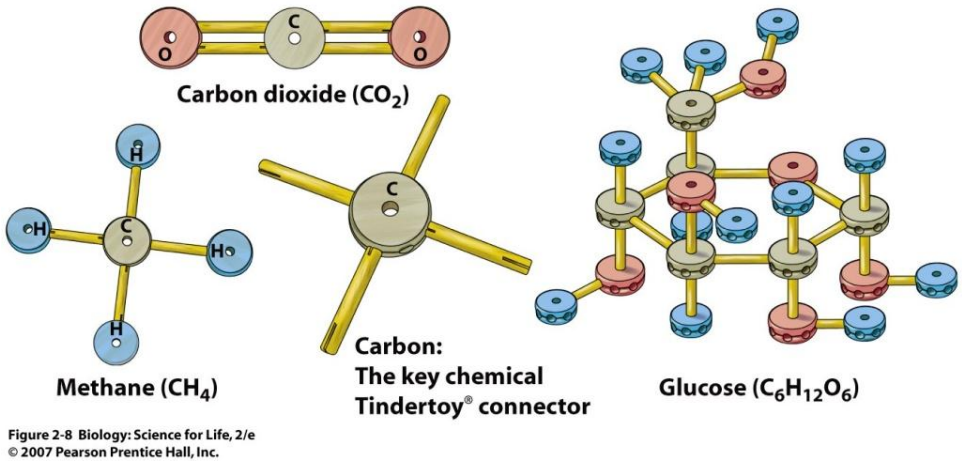
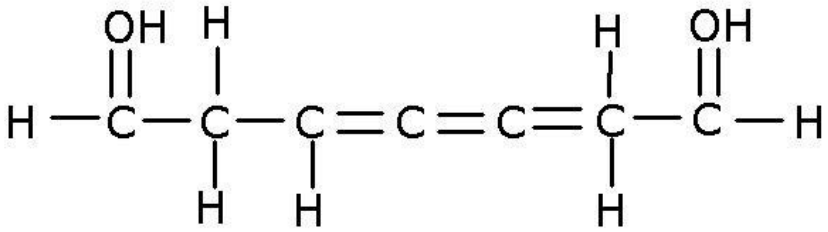


Figure 2-8 Biology: Science for Life, 2/e

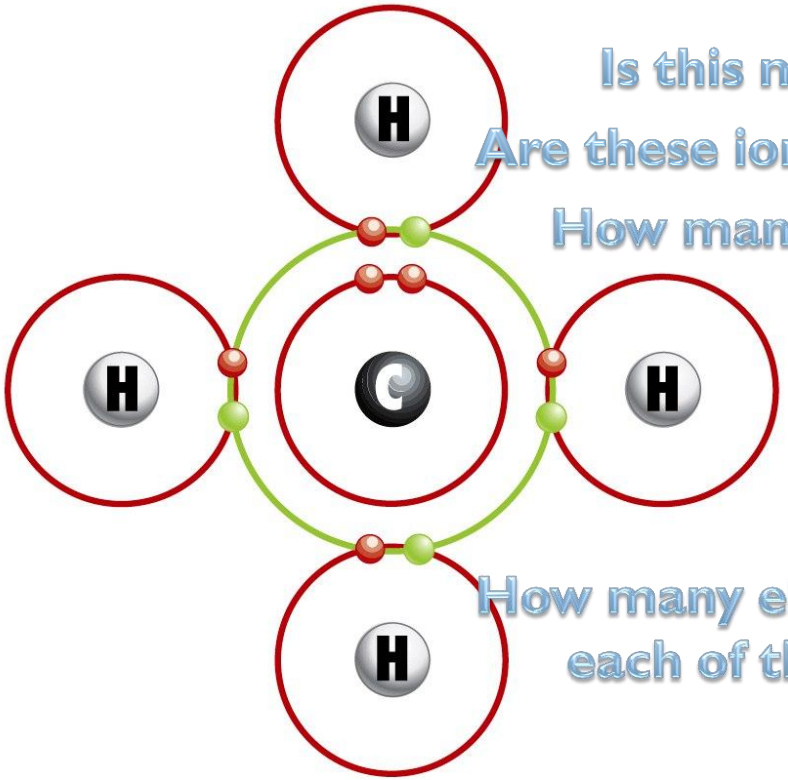
I. Organic Compounds

B. What makes carbon such an important element?

1. It forms 4 bonds
2. It forms long chains with itself
3. It can form single, double, & triple bonds



I. Organic Compounds



Methane (CH_4)

Figure 2-9b Biology: Science for Life, 2/e

Is this molecule organic?

Are these ionic or covalent bonds?

How many bonds has carbon formed?

How many electrons are shared in each of these single bonds?

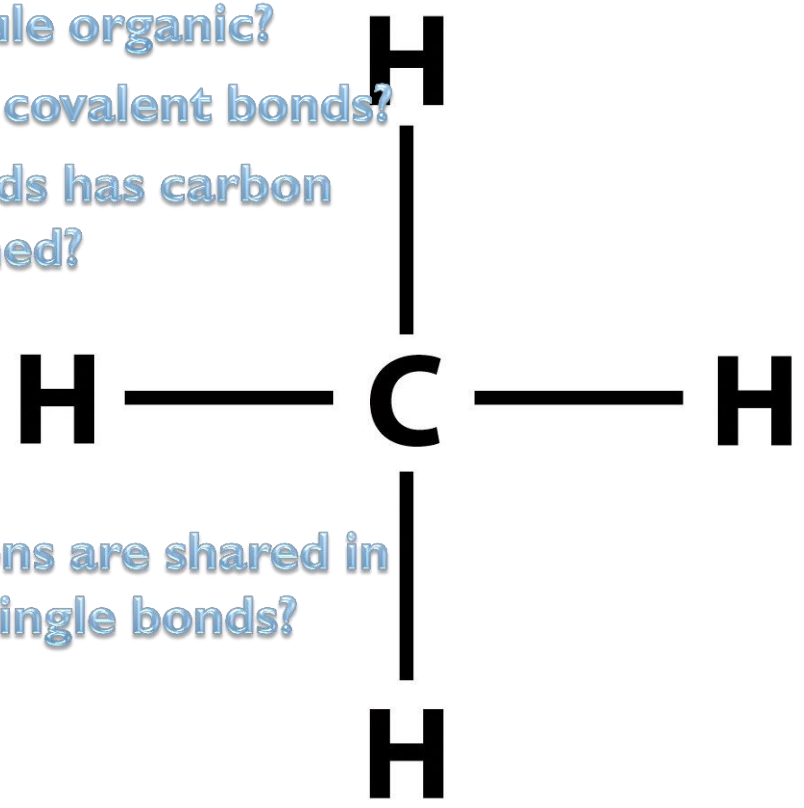


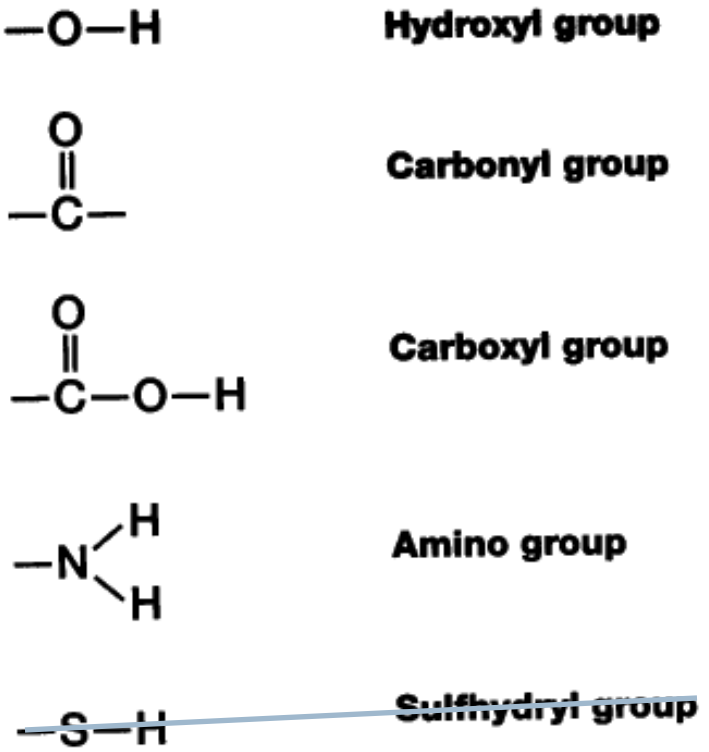
Figure 2-9c Biology: Science for Life, 2/e

I. Organic Compounds

D. Functional groups

1. Special groups of atoms attached to organic compounds

2. Used to identify organic compounds



Macromolecules

- Many molecules in living things are HUGE (…relatively)
- These huge molecules are called:

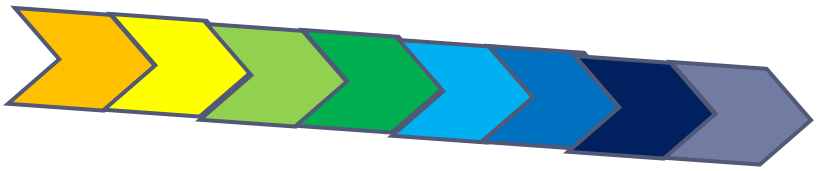
Macromolecules

- "Macro" – giant
- "Molecule" – two or more atoms put together

- Macromolecules are the **building blocks** of living things

Macromolecules

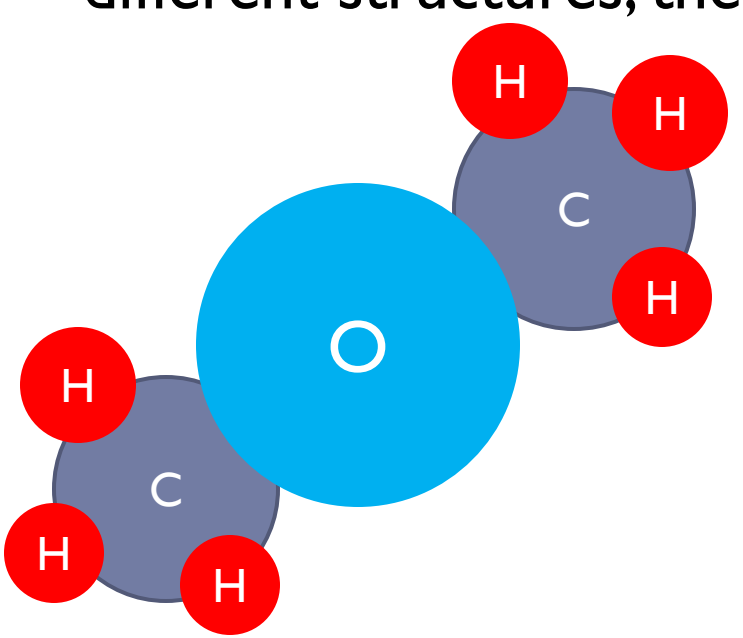
- Macromolecules are made up of smaller pieces
  - One of these pieces by itself is called a **monomer**
    - "Mono" - one
    - Monomer – one unit/building block of a macromolecule
  - Putting many monomers together results in a **polymer**
    - "Poly" – many
    - Polymer – many units/building blocks hooked together



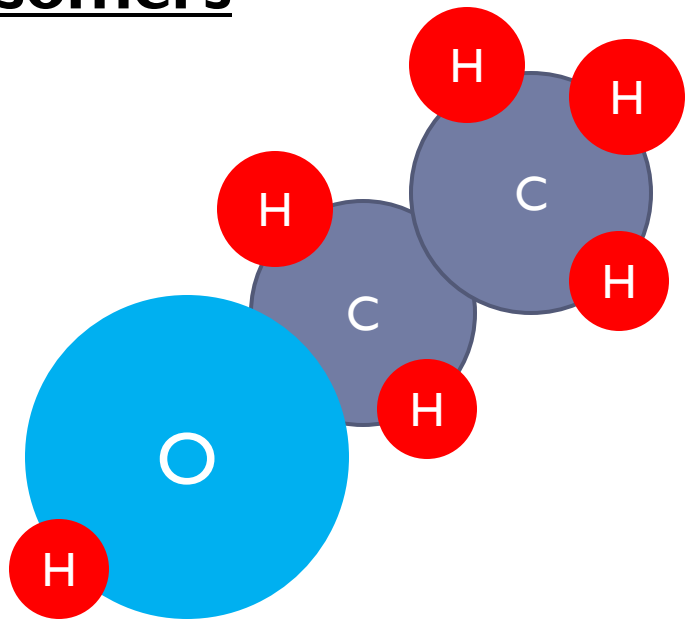
Polymer example

Macromolecules

- If 2 molecules have the same chemical formula, but different structures, then they are **isomers**



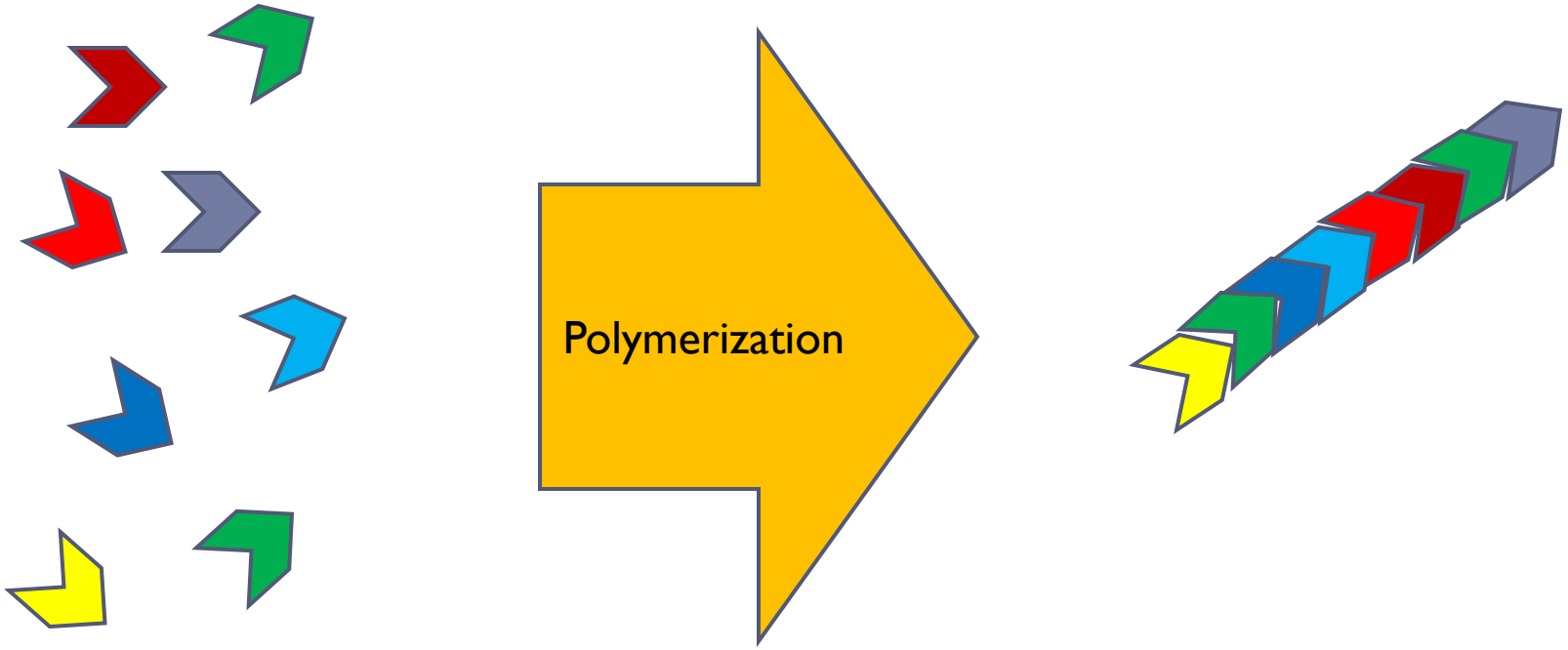
C_2H_6O



- **Isomer** – a molecule with the same chemical formula but different structure as another molecule

Macromolecules

- The process of monomers coming together to form polymers is called **polymerization**



Macromolecules

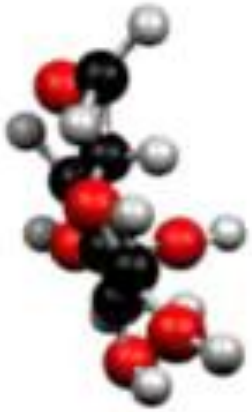
- Putting two or more monomers together is done through a process called **dehydration synthesis** or **condensation**

- Let's break that one down…
  - De – "removal of"
  - Hydration – "water"
  - Synthesis – "put together"

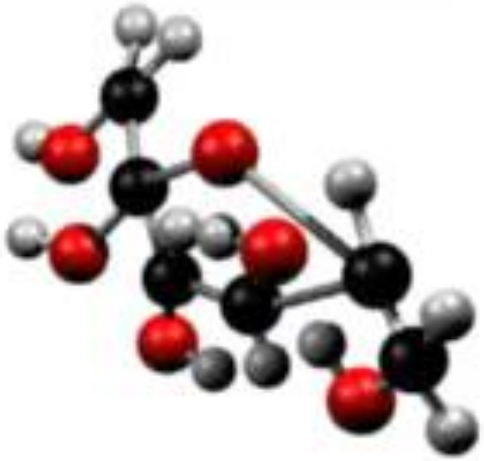
- So, dehydration synthesis means:
  - The removal of a water molecule to form a new bond

Carbohydrates

Glucose



Fructose



Carbohydrates

- The reverse of a dehydration synthesis reaction is called a **hydrolysis**, where water is used to break the bond between monomers

Kinds of Macromolecules

- 4 groups of macromolecules found in living things (organic compounds) are:
  - **Carbohydrates**
  - **Lipids**
  - **Proteins**
  - **Nucleic Acids**

Carbohydrates

Carbohydrates

- Main ideas for carbohydrates:
  - Uses for carbohydrates
  - How to identify a carbohydrate
  - Examples of carbohydrates
  - Chemical tests for carbohydrates

Carbohydrates

- A **carbohydrate** is a molecule made up of carbon, hydrogen, and oxygen atoms

- A carbohydrate will have twice as many hydrogen atoms as oxygen atoms
  - H:O = 2:1

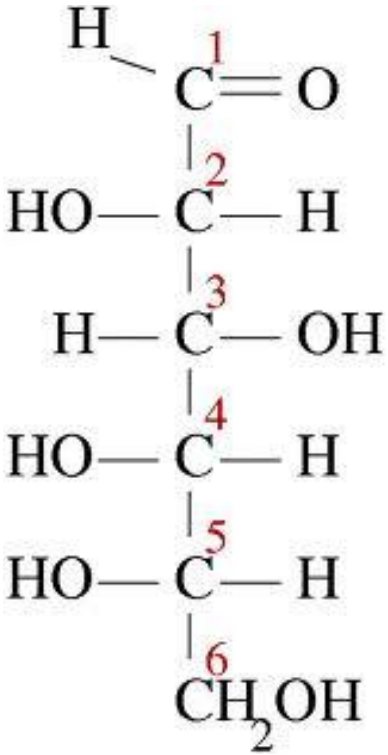
Carbohydrates

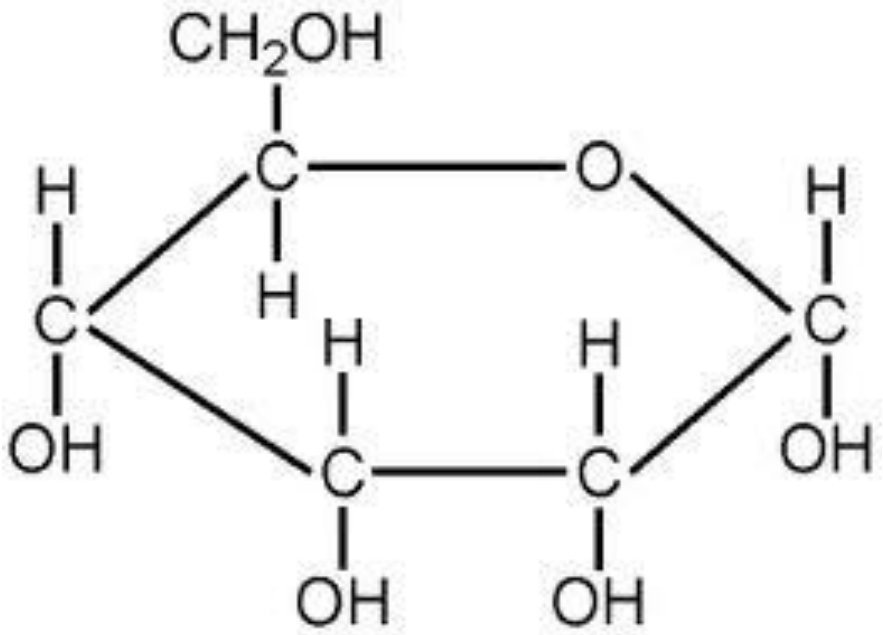
- Made up of 3 major groups:
  - Monosaccharides
  - Disaccharides
  - Polysaccharides

- The word **saccharide** means "sugar." What do you think the words, **mono-**, **di-**, and **polysaccharide** mean?

Carbohydrates

- **<u>Monosaccharides</u>** are single sugar molecules
  - Examples:
    - Fructose (fruit sugar), Galactose (milk sugar), Glucose (blood sugar):



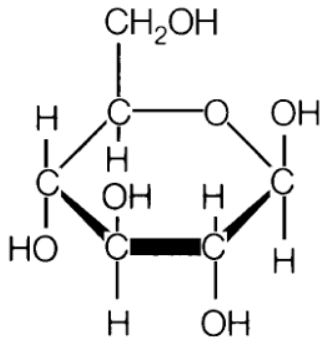


III. Carbohydrates

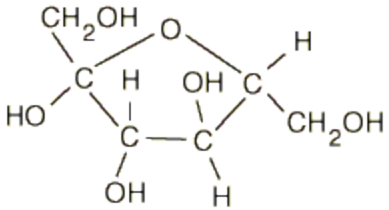
ISOMERS

A. Monosaccharides

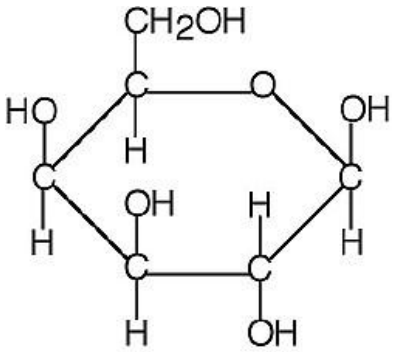
1. Simplest Carbohydrates
2. Monomers used to build larger carbohydrates
3. Used for quick energy
4. Ratio of C:H:O = 1:2:1
   = CH_2O
5. $C_6H_{12}O_6$



Glucose



Fructose



Galactose

Carbohydrates

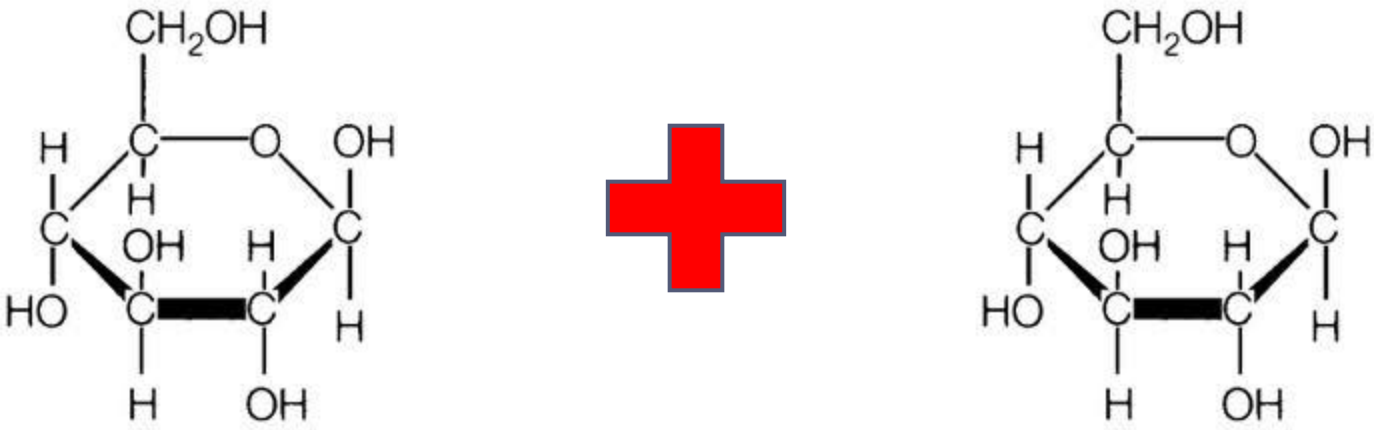
- Putting two or more monosaccharides together is done through a process called **dehydration synthesis** or **condensation**

- Let's break that one down…
  - De – "removal of"
  - Hydration – "water"
  - Synthesis – "put together"

- So, dehydration synthesis means:
  - The removal of a water molecule to form a new bond

Carbohydrates

- Dehydration synthesis
  - Practice trying to put these two monosaccharides together:



Carbohydrates

- Dehydration synthesis
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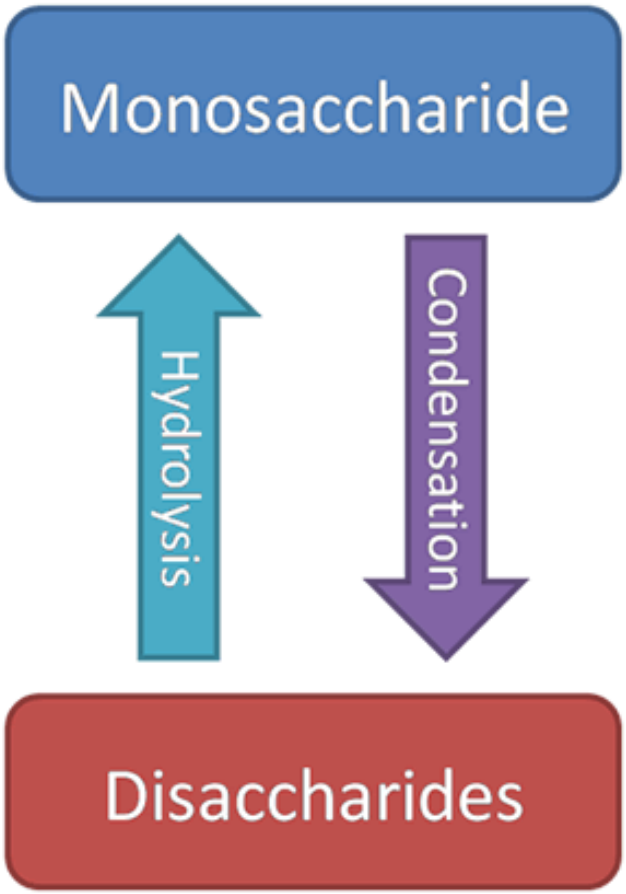
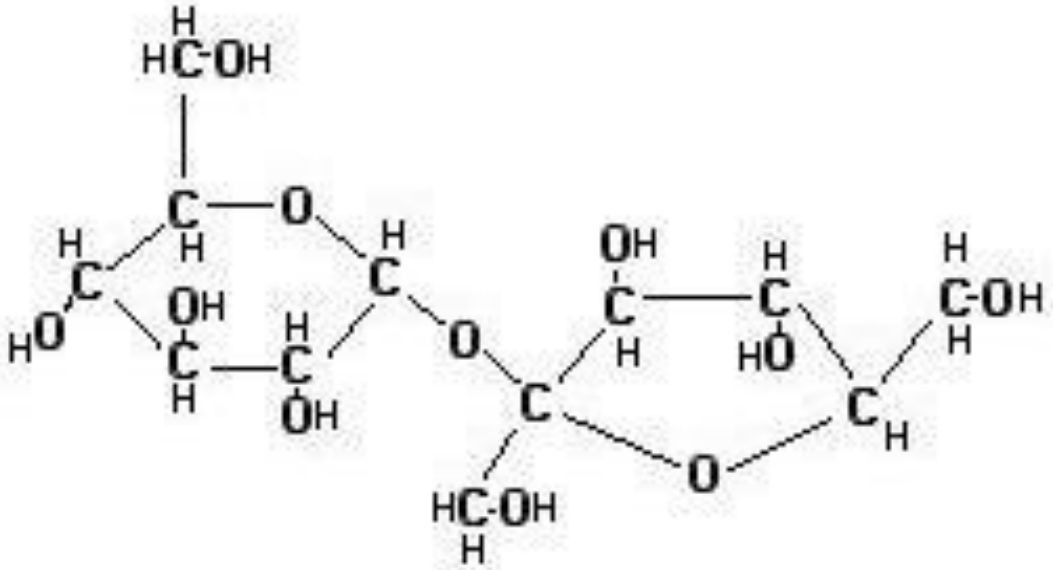

Monosaccharide
Hydrolysis
Condensation
Disaccharides

Carbohydrates

- **<u>Disaccharides</u>** are two sugar molecules put together
  - Examples:
    - Sucrose (table sugar – pictured), Lactose (milk sugar), Maltose



Carbohydrates

- Dehydration synthesis occurs between two glucose molecules. You know that glucose has a chemical formula of $\mathbf{C_6H_{12}O_6}$. How could you figure out the chemical formula for the new disaccharide formed?

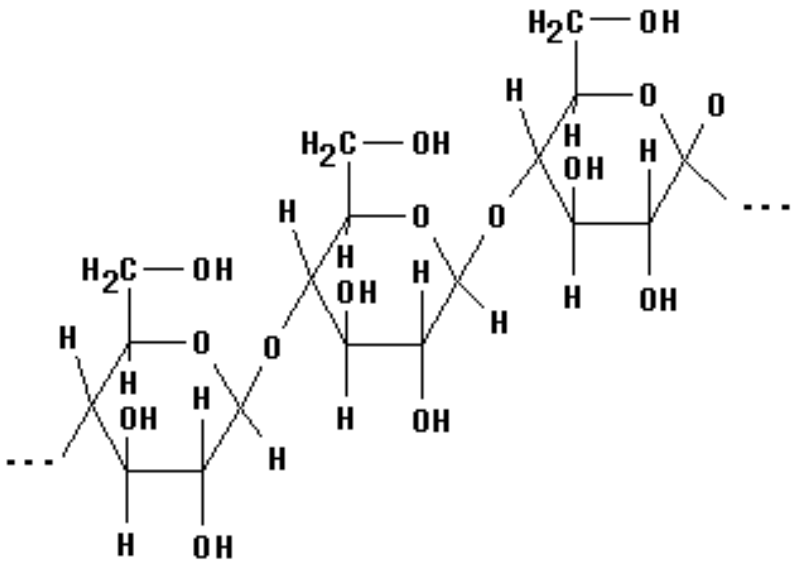
Carbohydrates

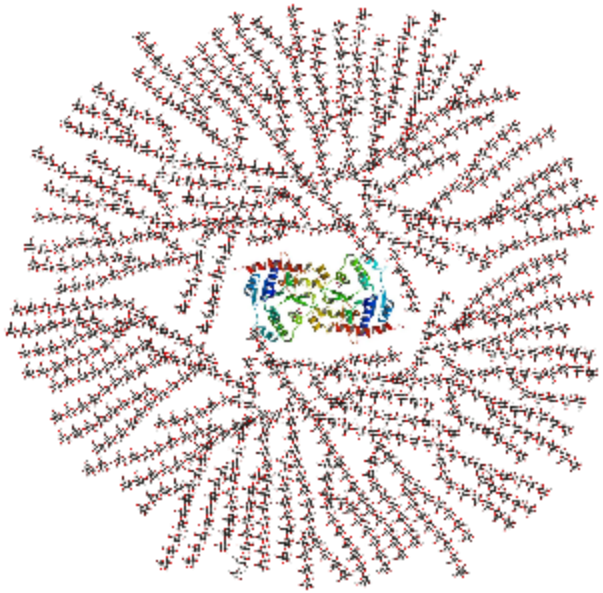
- Dehydration synthesis occurs between two glucose molecules. You know that glucose has a chemical formula of $C_6H_{12}O_6$. How could you figure out the chemical formula for the new disaccharide formed?

- $C_6H_{12}O_6 + C_6H_{12}O_6 - H_2O = C_{12}H_{22}O_{11}$

Carbohydrates

- **Polysaccharides** are 3 or more monosaccharides put together

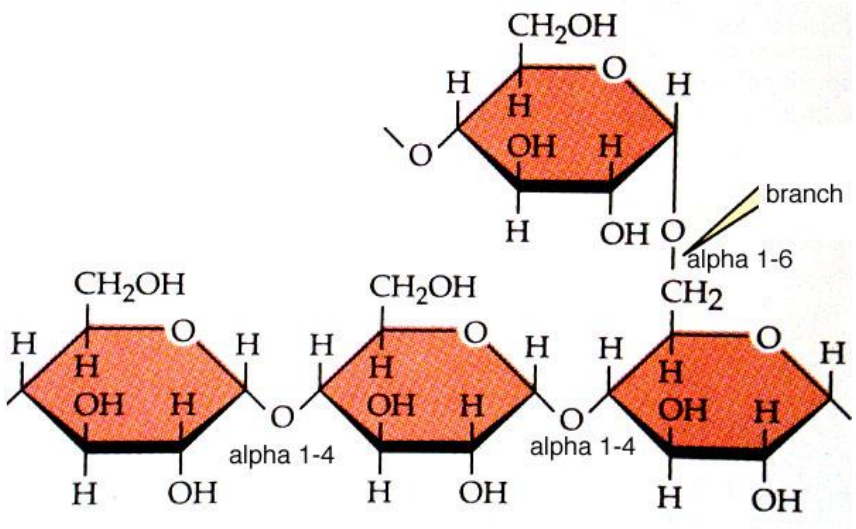




III. Carbohydrates

C. Polysaccharides

1. No formula, but ratio of H:O always = 2:1
2. Used for energy storage
   a. Starch – plant storage
   b. Glycogen – animal storage
3. Examples
   a. Cellulose – plant cell walls
   b. Chitin – insect exoskeletons, cell walls of fungi



Carbohydrates

- What about uses for carbohydrates?

- Living things use these carbohydrate molecules as their **primary source of energy**

  - The breakdown of sugars supplies immediate energy for all cell activities

Carbohydrates

- Some foods are high in "carbs."
  - Have you ever heard of someone trying to "carbo-load" before?
  - What type of person would most likely want to carbo-load?
  - Why would they?

Carbohydrates

- Testing for carbohydrates
  - How could you find out what carbohydrates are present in a sample?
  - **Benedict's Test (blue)**
    - If it turns orange you have a monosaccharide, if it turns blue you have a disaccharide, if it turns blue you have a polysaccharide
  - **Iodine Test (yellow)**
    - If it turns yellow you have a monosaccharide, if it turns yellow you have a disaccharide, if it turns purple you have a polysaccharide

What are the only 3 elements all carbohydrates are made of?

What is the ratio of H:O in carbohydrates?

What type of carbohydrate is glycogen?

What molecule do animals use to store energy?

What is the molecular formula for all monosaccharides?

Which carbohydrate is found in plant cell walls?

Proteins

Proteins

- Main ideas for proteins:
  - What makes up a protein?
  - What are the key parts of an amino acid?
  - How are proteins assembled?
  - What do proteins do?
  - How can we test for proteins?

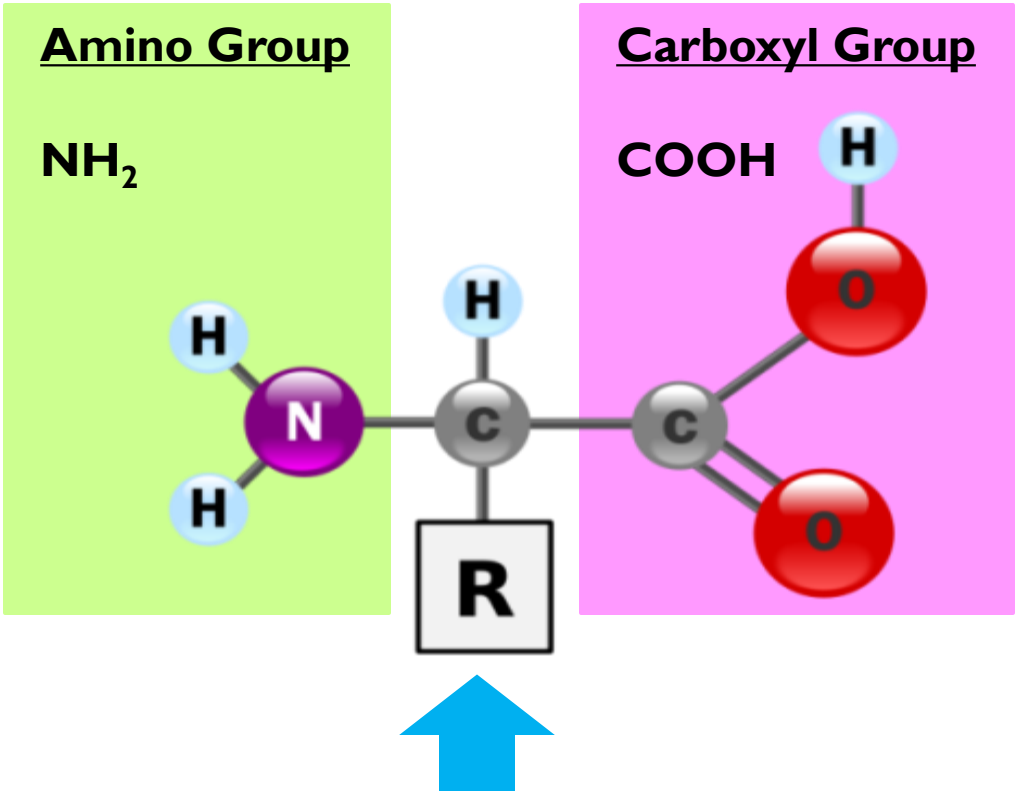
Proteins

- What is a protein?
  - A **protein** is a macromolecule made up of nitrogen, carbon, hydrogen, and oxygen

Proteins

- **Amino acids**
  - Monomers of proteins
  - Compounds of nitrogen atoms, oxygen atoms, carbon atoms, and hydrogen atoms
  - Have an **amino group** and a **carboxyl group**

  - Let's see what they look like…

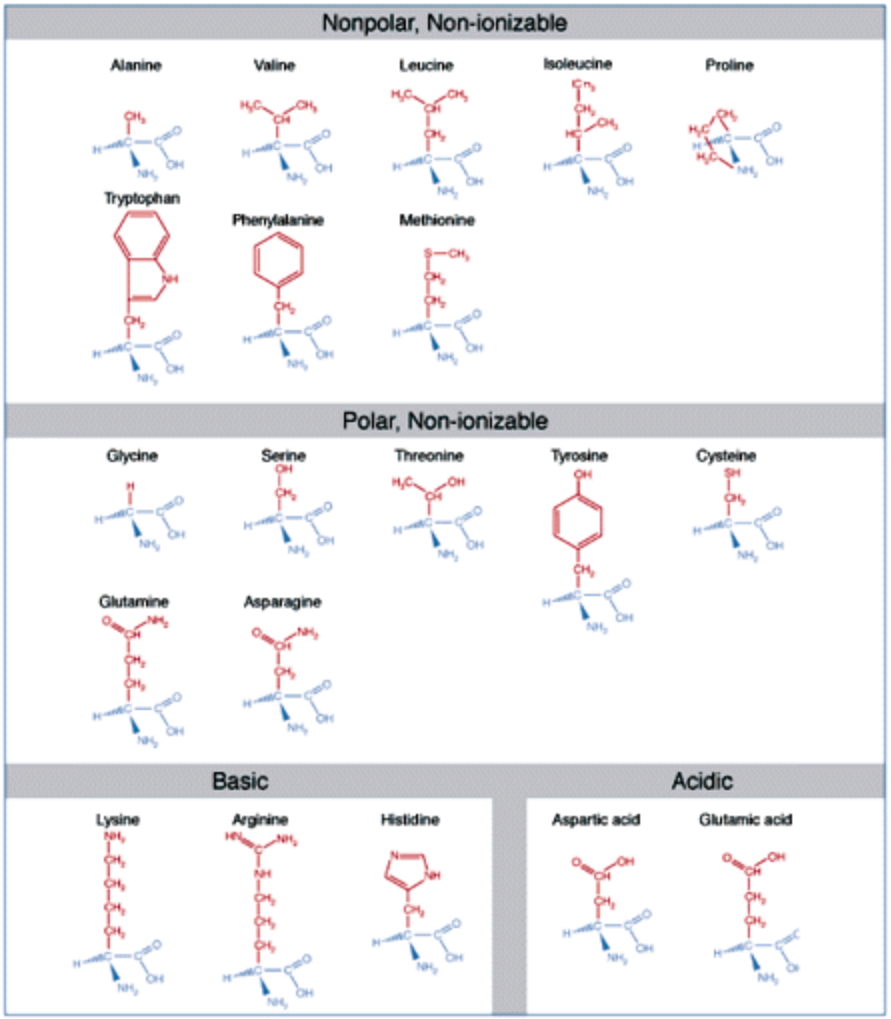


The **R Group** refers to the "rest of" the molecule.
Amino acids will always look the same except for the R group.
There are MANY different R groups.

Proteins are Diverse!

- To the right, you see many different amino acids…the red part is the R group

- With MANY different R groups, there are MANY different possible combinations of amino acids, which means there are MANY different proteins

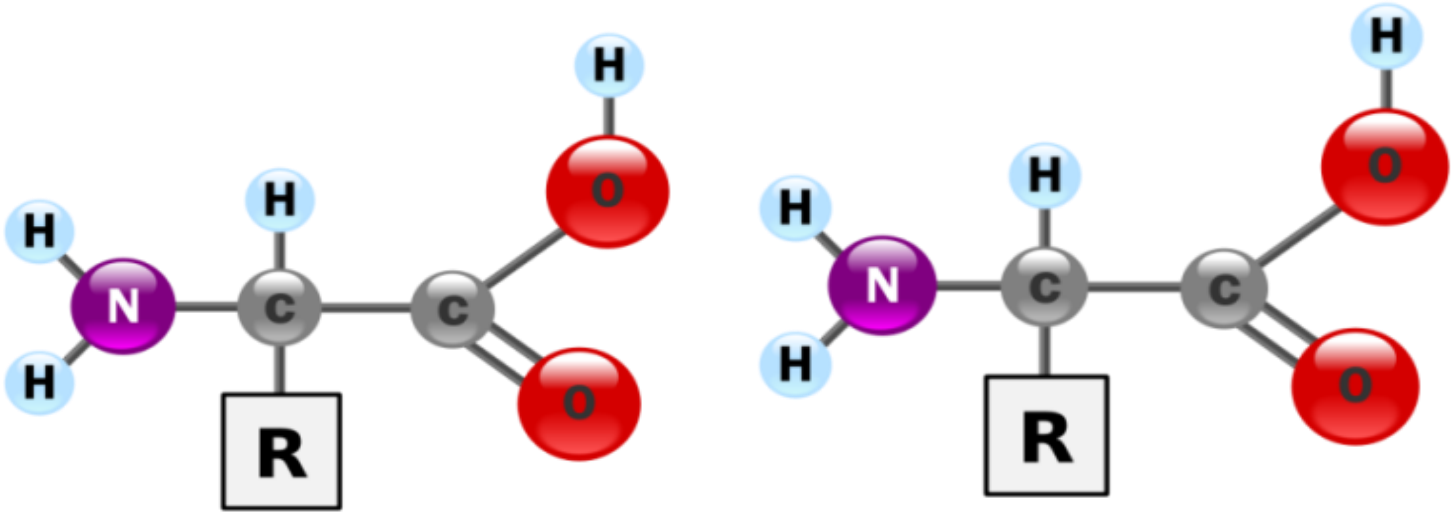


Proteins

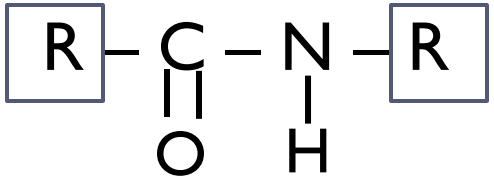
- How do amino acid monomers polymerize to form protein polymers? In other words, how are proteins put together?
  - **Dehydration synthesis!**

Proteins

- Combining amino acids with dehydration synthesis:



- Amino Group always bonds with the Carboxyl Group
- Peptide bond: Covalent bond formed between two amino acids when H2O is removed



Proteins

- Proteins are called macromolecules for a good reason…
  - THEY ARE GIGANTIC! (relatively)
  - The average size for a protein can be well over 250 amino acids
  - This forms an amino acid chain or a **POLYPEPTIDE**

Protein

- These long chains are neatly organized inside living things:
  - Levels of organization:
    - **Primary Structure** – the chain
    - **Secondary Structure** – the chain curls into an *alpha helix* or folds into a *beta sheet*
    - **Tertiary Structure** – alpha helices and beta sheets fold on each other
    - **Quarternary Structure** – large sections of tertiary structures fold over each other
- Let's see what these looks like:

Proteins Structure

D. Protein Structure
   1. Primary (1°) Structure
      a. Long chain of amino acids
   2. Secondary (2°) Structure
      a. alpha helix
      b. beta-pleated sheet

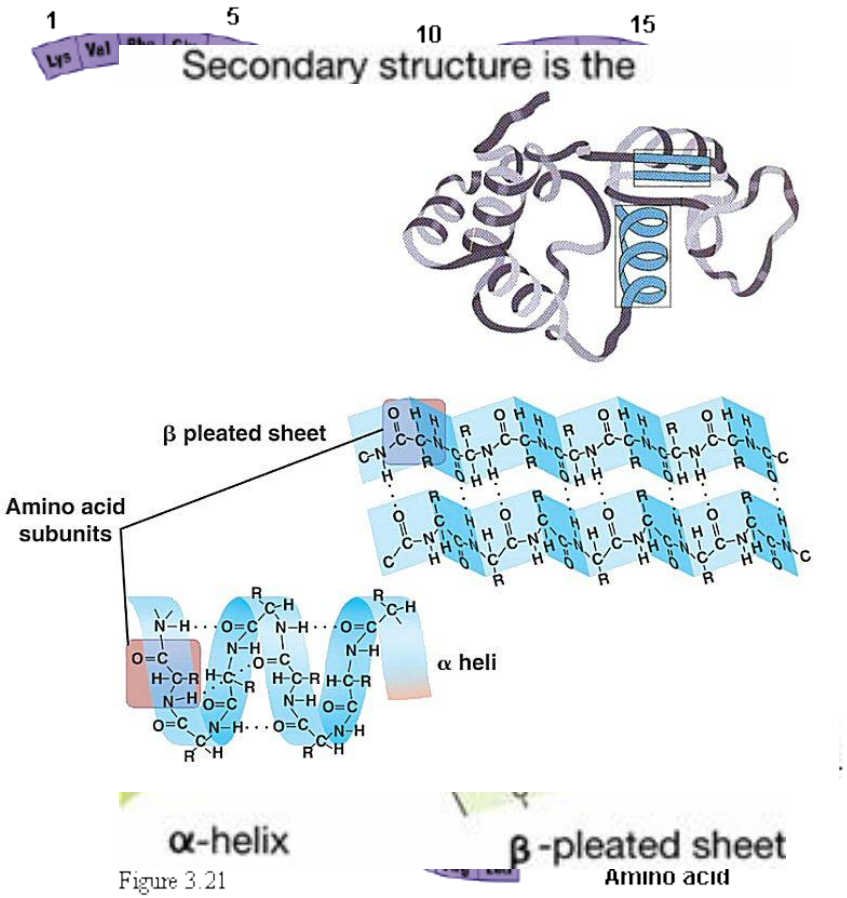
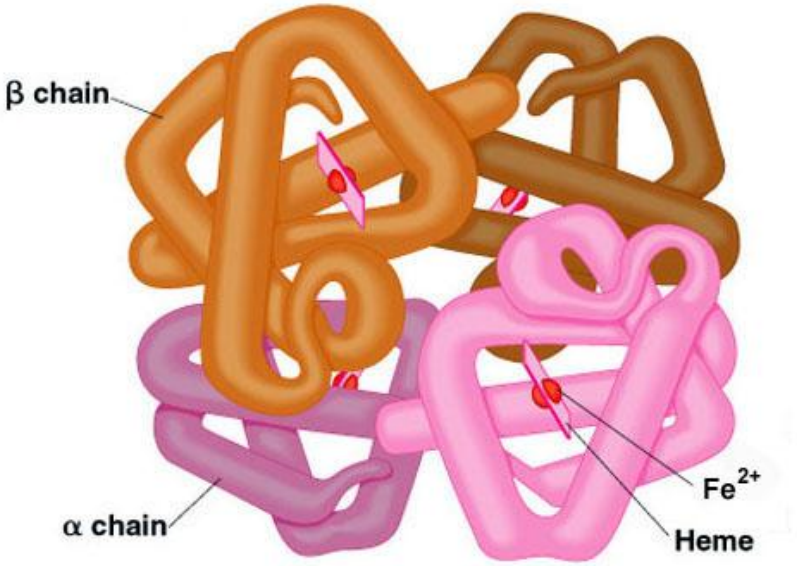
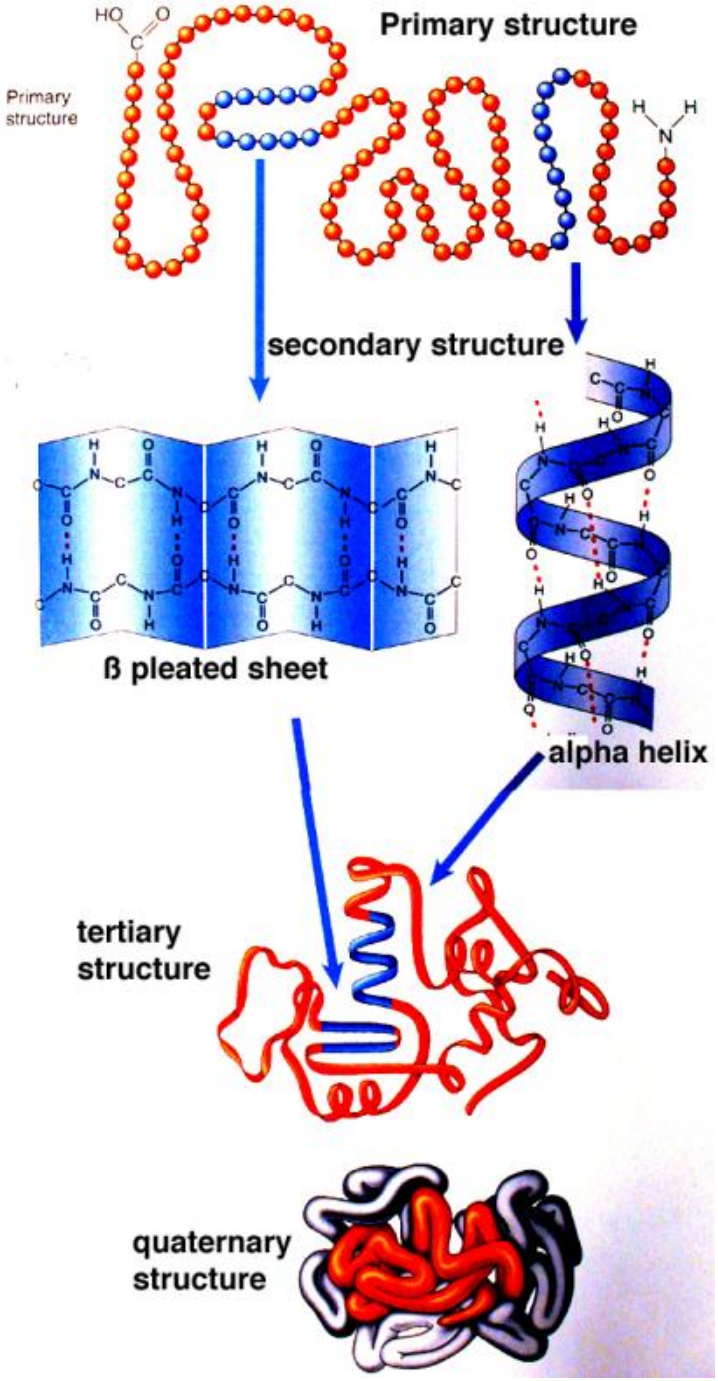


Figure 3.21

III. Proteins

3. Tertiary (3°) Structure
   a. Continued folding of polypeptide beyond secondary structure
   b. Caused by attractions between R groups of amino acids
   c. Can be fibrous or globular
4. Quaternary (4°) Structure
   a. Highest level of protein structure
   b. Made of two or more folded polypeptides joined together
   c. Most (but not all) proteins have a quaternary structure
5. Denaturation
   a. Destruction of a proteins natural shape due to rise in temp or change in pH




Primary structure
Primary structure
secondary structure
ß pleated sheet
alpha helix
tertiary structure
quaternary structure

Proteins

- Remember: with many different R groups, there are many combinations of amino acids, meaning that there are many different proteins

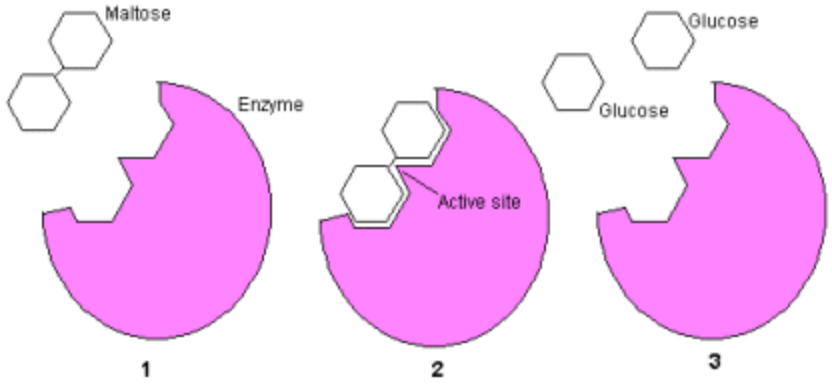
- Each type has a specific role!

Proteins

- What do proteins do?
- **Structural**
  - Support
  - EX:
    - Keratin – hair, nails, rhino horns, turtle shells
    - Collagen – bone, tendons, ligaments – most abundant in our bodies

Proteins

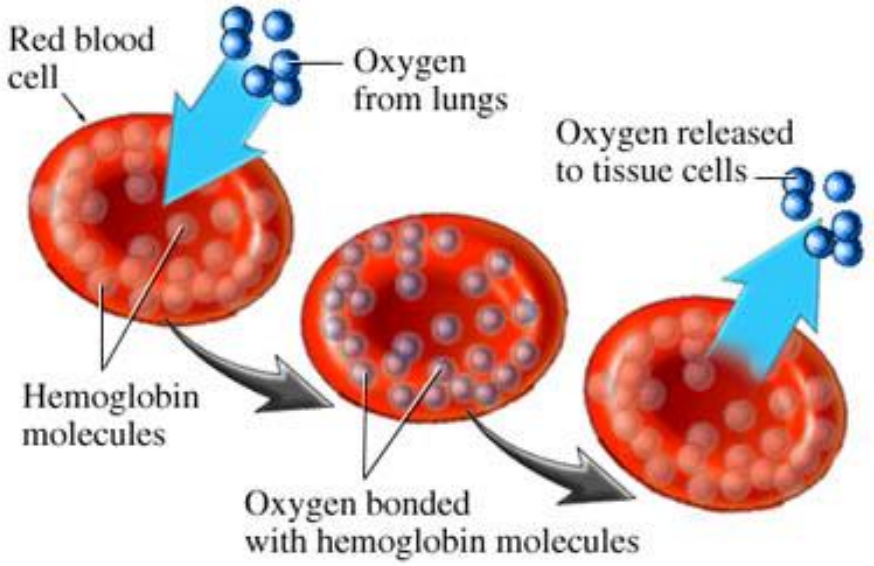
- What do proteins do?
- **Enzymes**
  - Speed up chemical reactions (catalysts)
  - EX:
    - Sucrase – breaks down sucrose



Proteins

- What do proteins do?

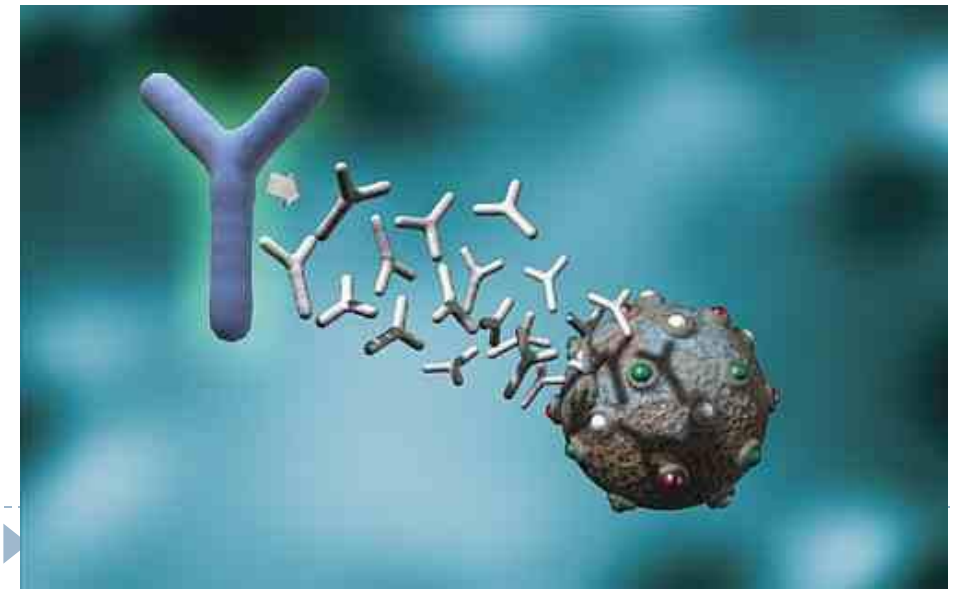
- **<u>Transport</u>**
  - Carry nutrients around body
  - EX:
    - Hemoglobin – carries oxygen around body through bloodstream

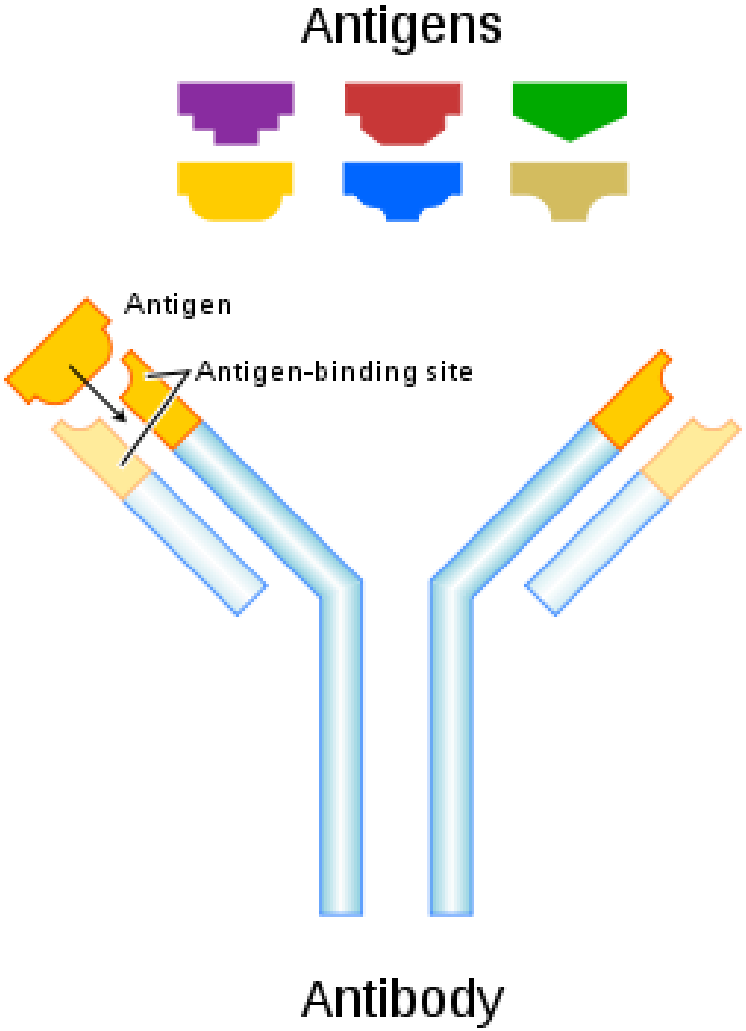


Proteins

- What do proteins do?

- **Defense**
  - Help protect body against disease
  - Anti-bodies

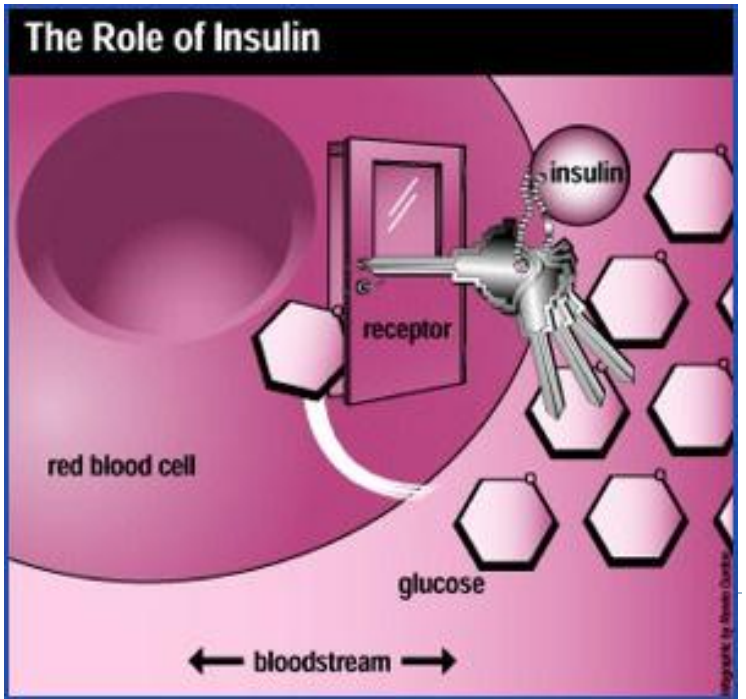




Proteins

- What do proteins do?

- **Hormones**
  - Send signals to cells & organs
    - Insulin – tells cells to take in glucose from blood



Proteins

- Where can you find proteins?

  - They start inside our cells (where they are made)
  - Hair
  - Bone
  - Muscle
  - Meat
  - Eggs
  - Organs
  - LOTS of other locations

Proteins

- How can you test for a protein?
  - **Biuret's Test**
    - Changes to **purple** in the presence of a protein

Lipids

Lipids

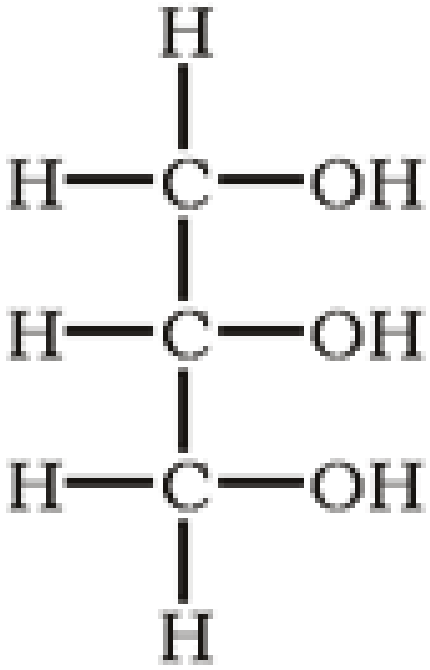
- Main ideas for lipids:
  - What a lipid is made of
  - Uses for lipids
  - Examples of lipids
  - Tests to determine if lipids are present

Lipids

- **Lipids**
  - Molecules made up of mostly carbon and hydrogen atoms (and some oxygen atoms too)
  - Nonpolar covalent bonds
    - Hydrophobic
    - Insoluble in water
  - Can be identified by the 2 key parts of their assembly: one glycerol backbone and 3 long carbon chains (fatty acids)…
  - Far greater than 2:1 H:O ratio

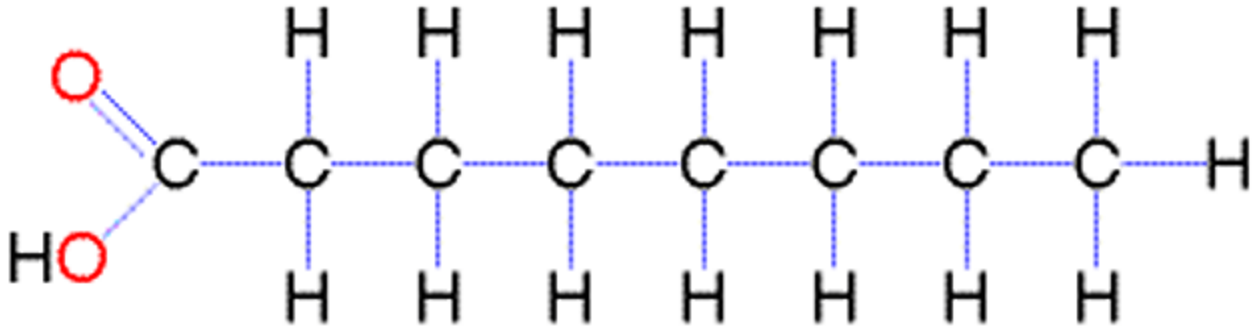
Lipids

- Making a lipid:
  - The first key part to a lipid is a **glycerol**
    - Glycerol serves as the "backbone" of the lipid



Lipids

- Making a lipid
  - The other key parts to a lipid are 3 **fatty acids**
    - Long carbon chains

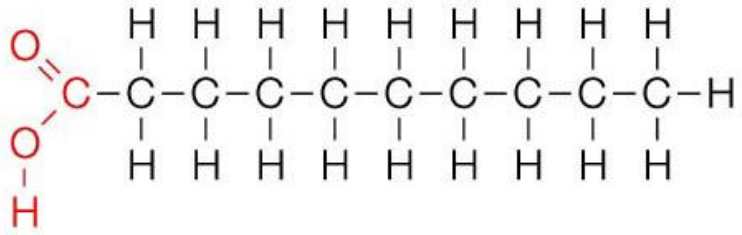


COOH

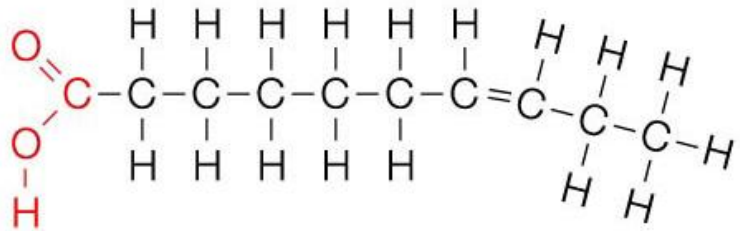
Lipids

- 2 kinds of fatty acids:

  - **Saturated**
    - All single bonds in the carbon chain
    - There are the maximum possible number of hydrogen
    - Generally considered "bad" for you
    - Solid at room temperature
    - Straight



  - **Unsaturated**
    - One or more double bonds in the carbon chain
    - There could be more hydrogen
    - Generally considered "better" for you
    - Liquid at room temperature
    - Kinked (not straight)

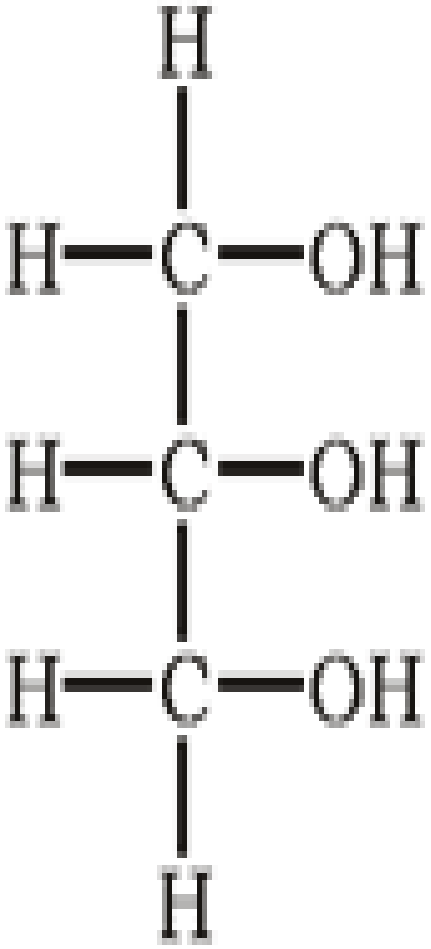


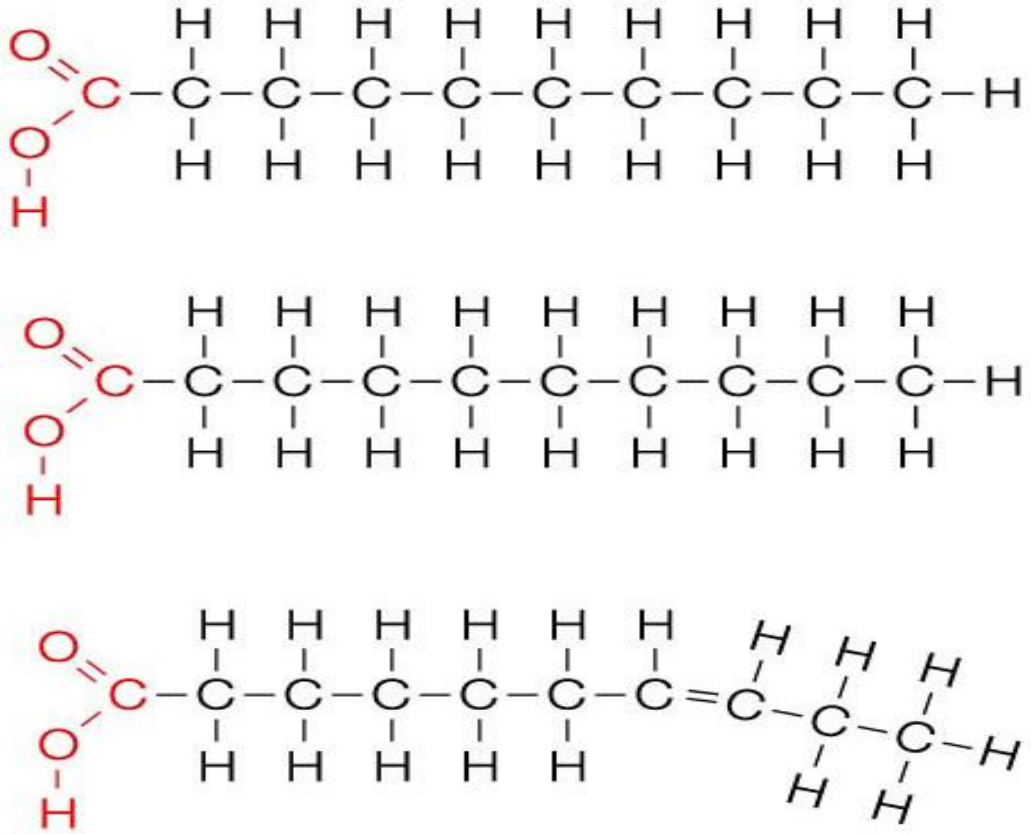
Lipids

- Making a lipid
  - So how do the glycerol and fatty acids come together?
  - **Dehydration synthesis**…

Lipids

- Dehydration synthesis





Lipids

C. Uses in Living Things

1. Long-term Energy Storage
   a. Fats
   b. Oils

1 gram of fat = 9 calories

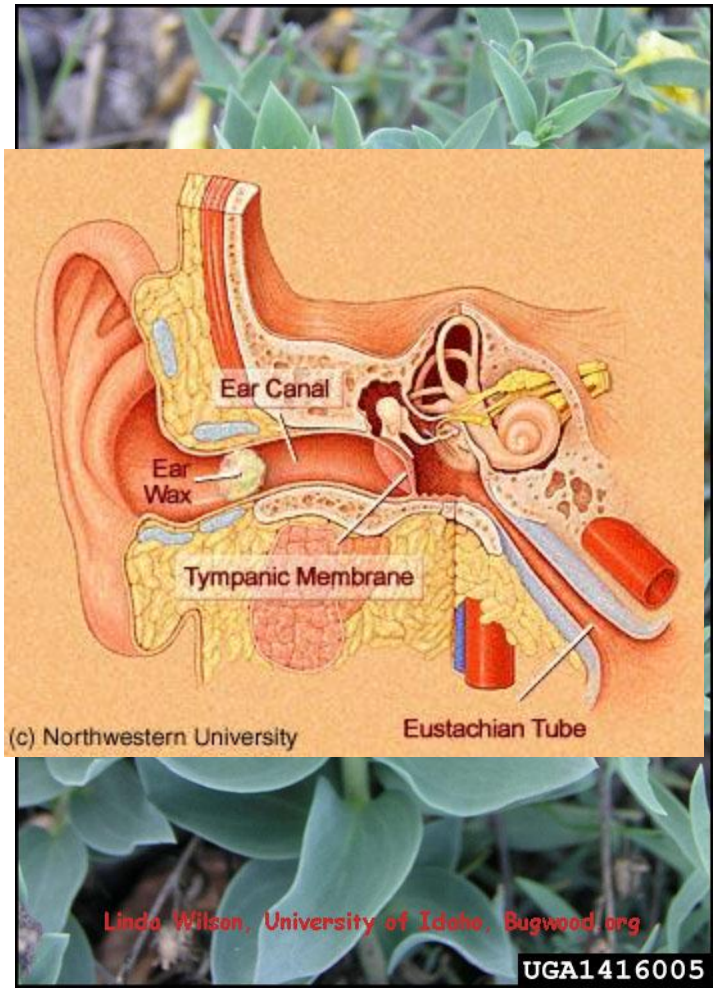
1 gram of protein = 4 calories

1 gram of carbohydrates = 4 calories

Live Fit Blog

Lipids

C. Uses in Living Things
    2. Protection
        a. Plants
        b. Animals



Lipids

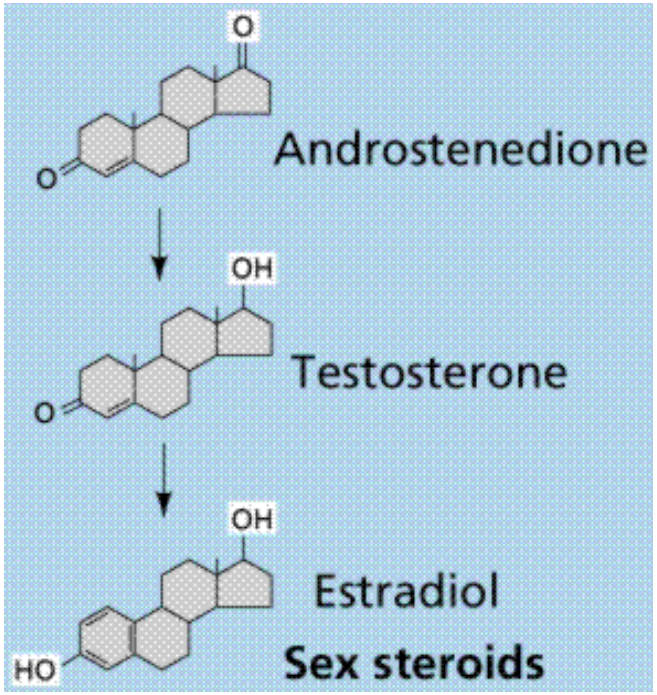
C. Uses in Living Things
    3. Insulation
        a. Blubber (marine mammals)

What do these guys have in common?

Lipids

C. Uses in Living Things

4. Hormones (Steroids)
    a. Testosterone
    b. Estrogen
    c. Cholesterol



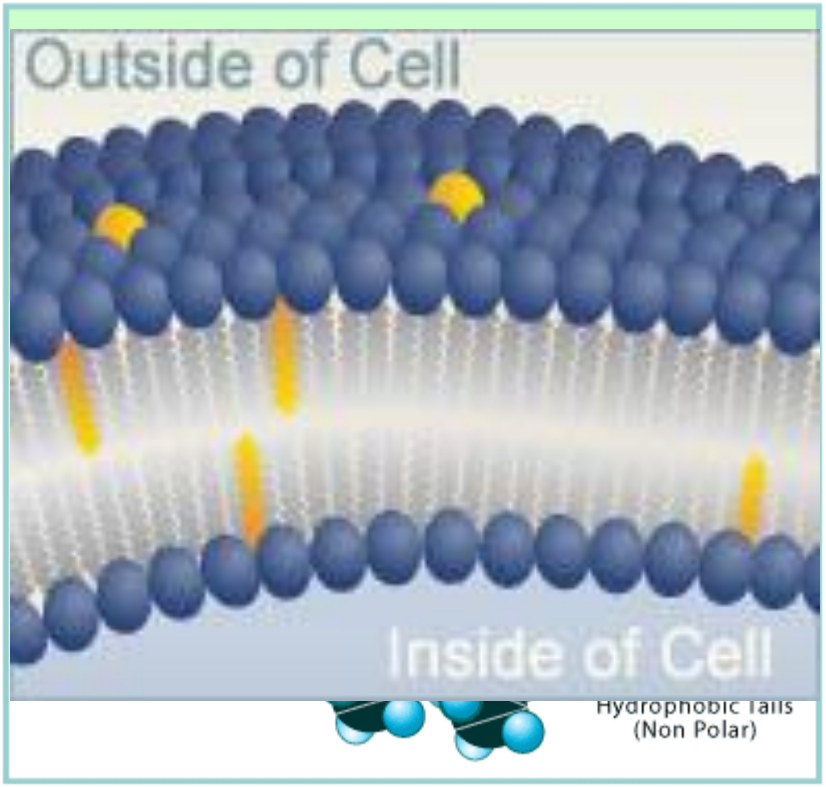
IV. Lipids

C. Uses in Living Things

5. Cell (Plasma) Membranes

a. Phospholipids

b. Polar head, 2 nonpolar tails



Lipids

- Examples of lipids
  - Meat fat
  - Oil
  - Waxes
  - Butter
  - Grease
  - Mayo

Lipids

- Tests to run:
  - The water solubility test
    - Lipids *do not* mix in water – non lipids *do*
  - The brown paper bag test
    - If you put a substance on a paper bag and the bag *dried well* over time, the substance was a non-lipid. If the bag *never looks dry* and *light can get through it*, the substance was a lipid