

# Chapter 3

## Part 1

# The Molecules of Cells



PowerPoint Lectures for  
***Biology: Concepts & Connections, Sixth Edition***  
***Campbell, Reece, Taylor, Simon, and Dickey***

**Lecture by Dr. Fernando Prince**

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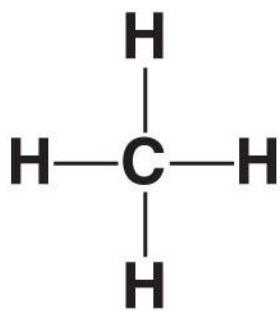
# INTRODUCTION TO ORGANIC COMPOUNDS

## 3.1 Life's molecular diversity is based on the properties of carbon

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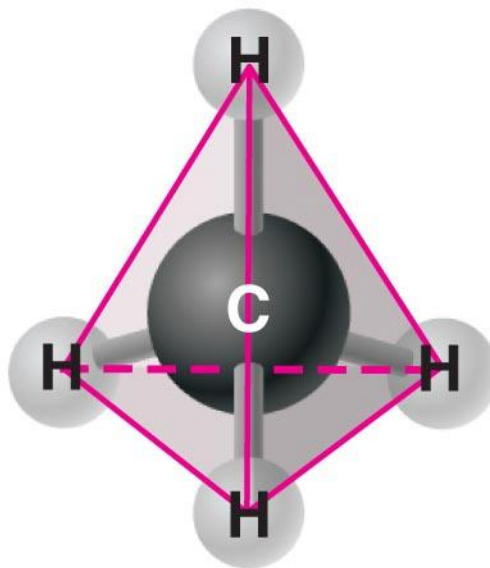
- Diverse molecules found in cells are composed of carbon bonded to other elements
  - Carbon-based molecules are called **organic compounds**
  - By sharing electrons, carbon can bond to four other atoms
  - By doing so, it can branch in up to four directions

## Structural formula

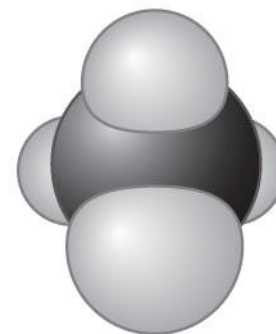


**Methane**

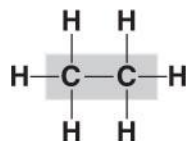
## Ball-and-stick model



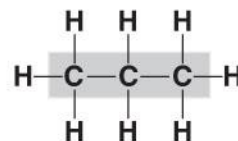
## Space-filling model



**The four single bonds of carbon point to the corners of a tetrahedron.**

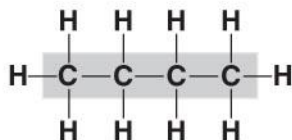


**Ethane**

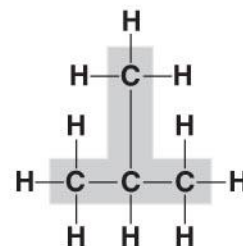


**Propane**

**Length. Carbon skeletons vary in length.**

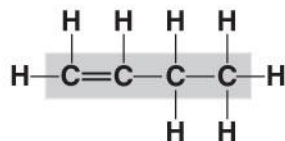


**Butane**

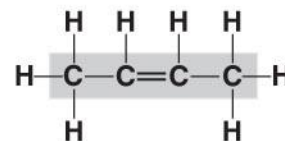


**Isobutane**

**Branching. Skeletons may be unbranched or branched.**

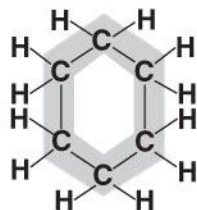


**1-Butene**

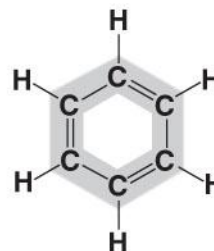


**2-Butene**

**Double bonds. Skeletons may have double bonds, which can vary in location.**



**Cyclohexane**



**Benzene**

**Rings. Skeletons may be arranged in rings.**

## 3.2 Characteristic chemical groups help determine the properties of organic compounds

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- An organic compound has unique properties that depend upon
  - The size and shape of the molecule and
  - The groups of atoms (functional groups) attached to it
- A **functional group** affects a biological molecule's function in a characteristic way

## 3.2 Characteristic chemical groups help determine the properties of organic compounds

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- Compounds containing functional groups are **hydrophilic** (water-loving)
  - This means that they are soluble in water, which is a necessary prerequisite for their roles in water-based life

## 3.2 Characteristic chemical groups help determine the properties of organic compounds

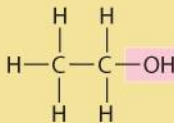
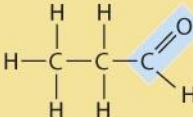
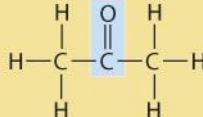
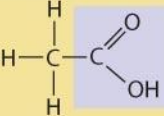
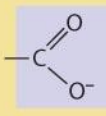
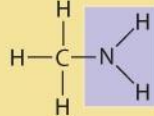
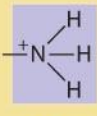
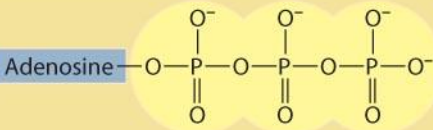
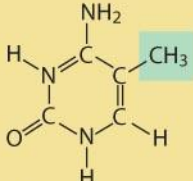
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- The functional groups are
  - **Hydroxyl group**—consists of a hydrogen bonded to an oxygen
  - **Carbonyl group**—a carbon linked by a double bond to an oxygen atom
  - **Carboxyl group**—consists of a carbon double-bonded to both an oxygen and a hydroxyl group
  - **Amino group**—composed of a nitrogen bonded to two hydrogen atoms and the carbon skeleton
  - **Phosphate group**—consists of a phosphorus atom bonded to four oxygen atoms



TABLE 3.2

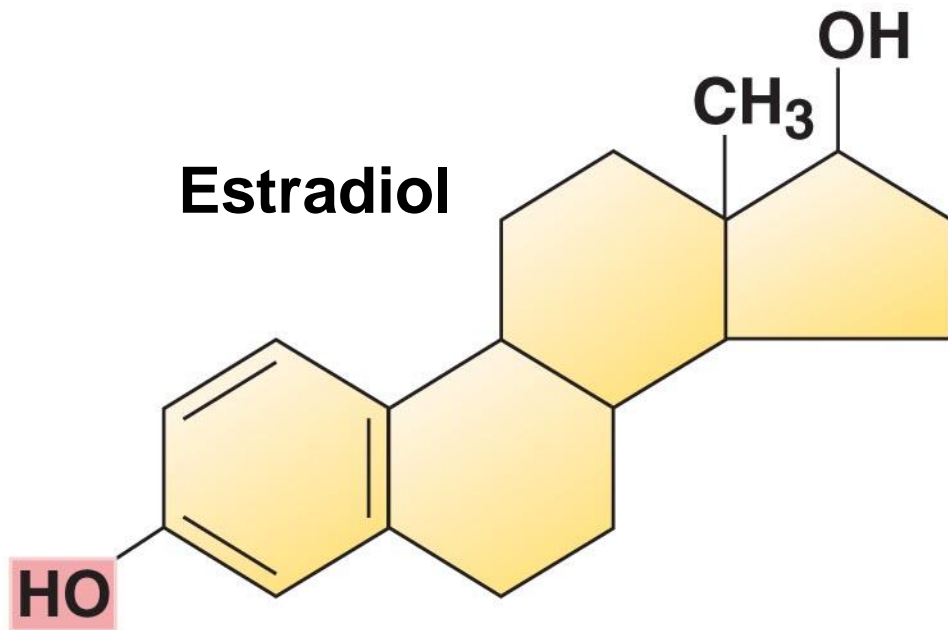
## FUNCTIONAL GROUPS OF ORGANIC COMPOUNDS

Functional Group	Examples
Hydroxyl group $\text{—OH}$	 Alcohol
Carbonyl group $\text{C=O}$	 Aldehyde  Ketone
Carboxyl group $\text{—COOH}$	 Carboxylic acid  Ionized
Amino group $\text{—NH}_2$	 Amine  Ionized
Phosphate group $\text{—OPO}_3^{2-}$	 Organic phosphate (ATP)
Methyl group $\text{—CH}_3$	 Methylated compound

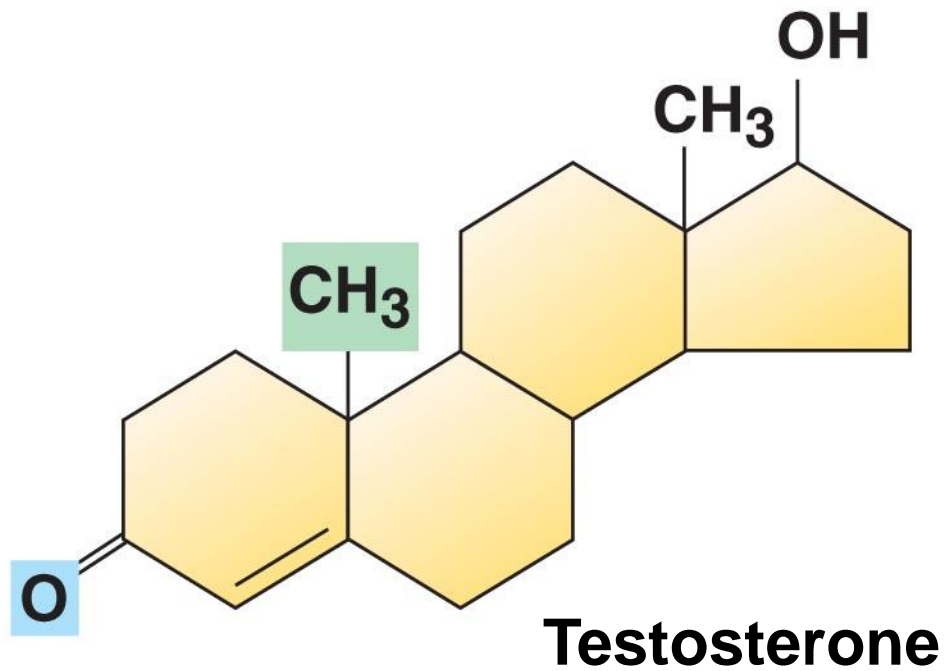
## 3.2 Characteristic chemical groups help determine the properties of organic compounds

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- An example of similar compounds that differ only in functional groups is sex hormones
  - Male and female sex hormones differ only in functional groups
  - The differences cause varied molecular actions
  - The result is distinguishable features of males and females



**Female lion**



**Male lion**

# Organic Compounds

- Molecules unique to living systems contain carbon and hence are organic compounds
- They include:
  - Carbohydrates
  - Lipids
  - Proteins
  - Nucleic Acids

## 3.3 Cells make a huge number of large molecules from a small set of small molecules

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- The four classes of biological molecules contain very large molecules
  - They are often called **macromolecules** because of their large size
  - They are also called **polymers** because they are made from identical building blocks strung together
  - The building blocks are called **monomers**

## 3.3 Cells make a huge number of large molecules from a small set of small molecules

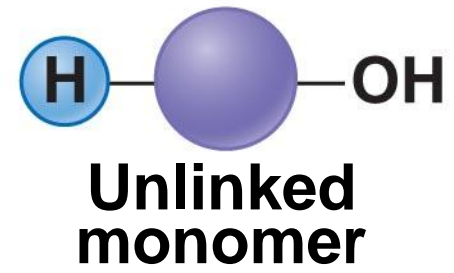
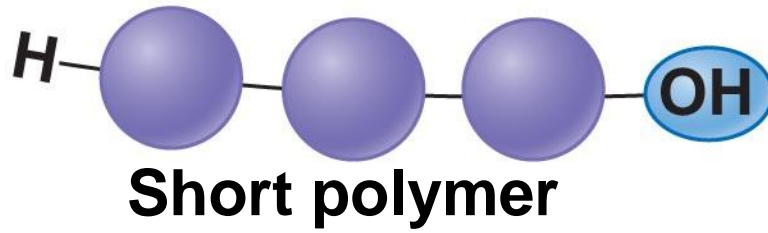
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- A cell makes a large number of polymers from a small group of monomers
  - Proteins are made from only 20 different amino acids, and DNA is built from just four kinds of nucleotides
- The monomers used to make polymers are universal

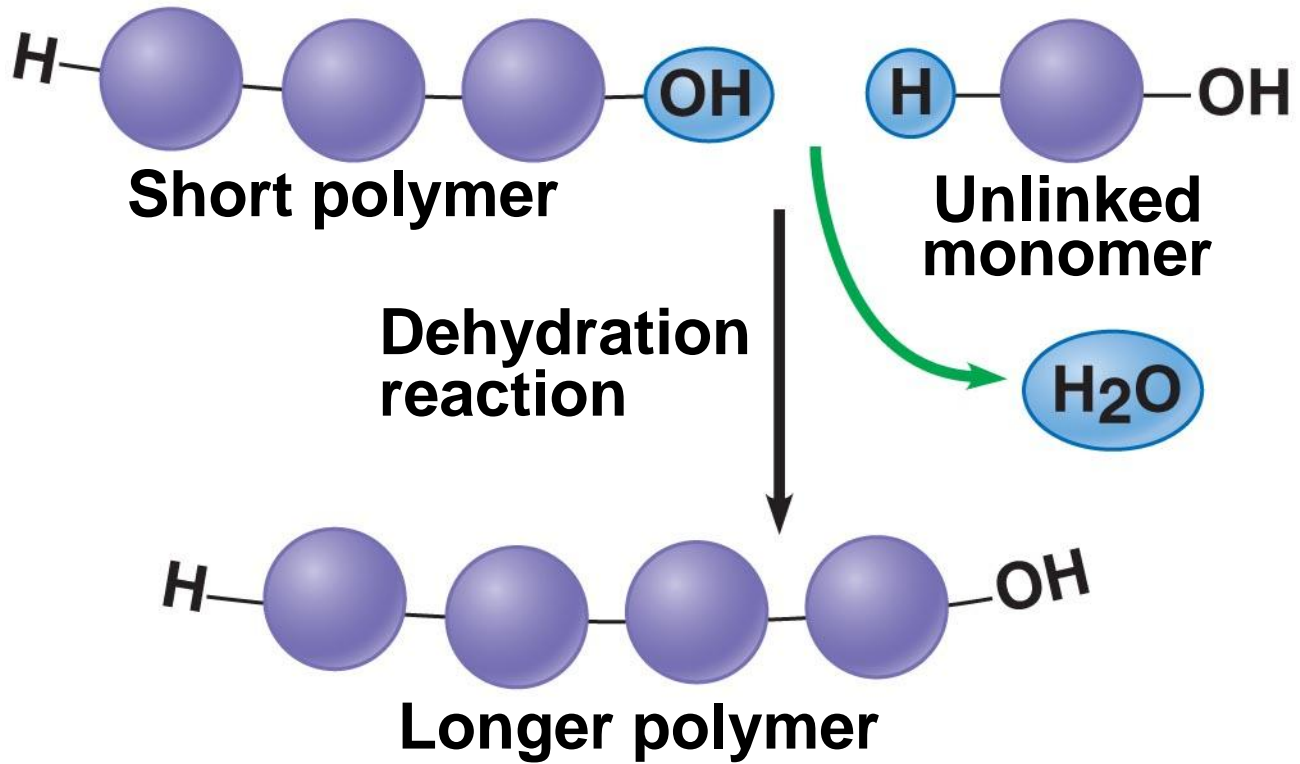
## 3.3 Cells make a huge number of large molecules from a small set of small molecules

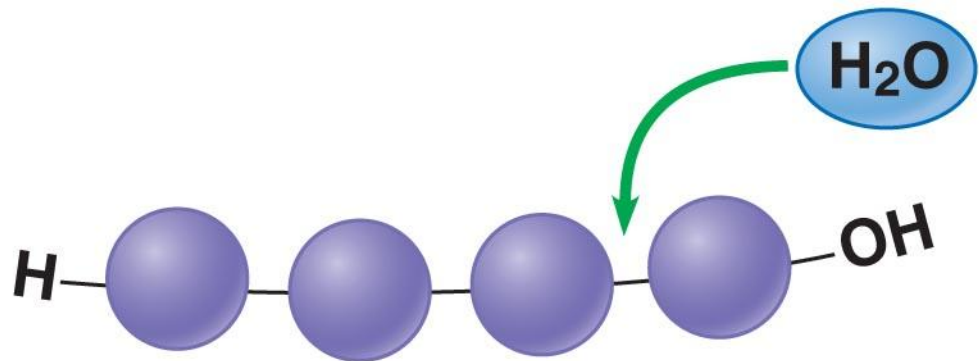
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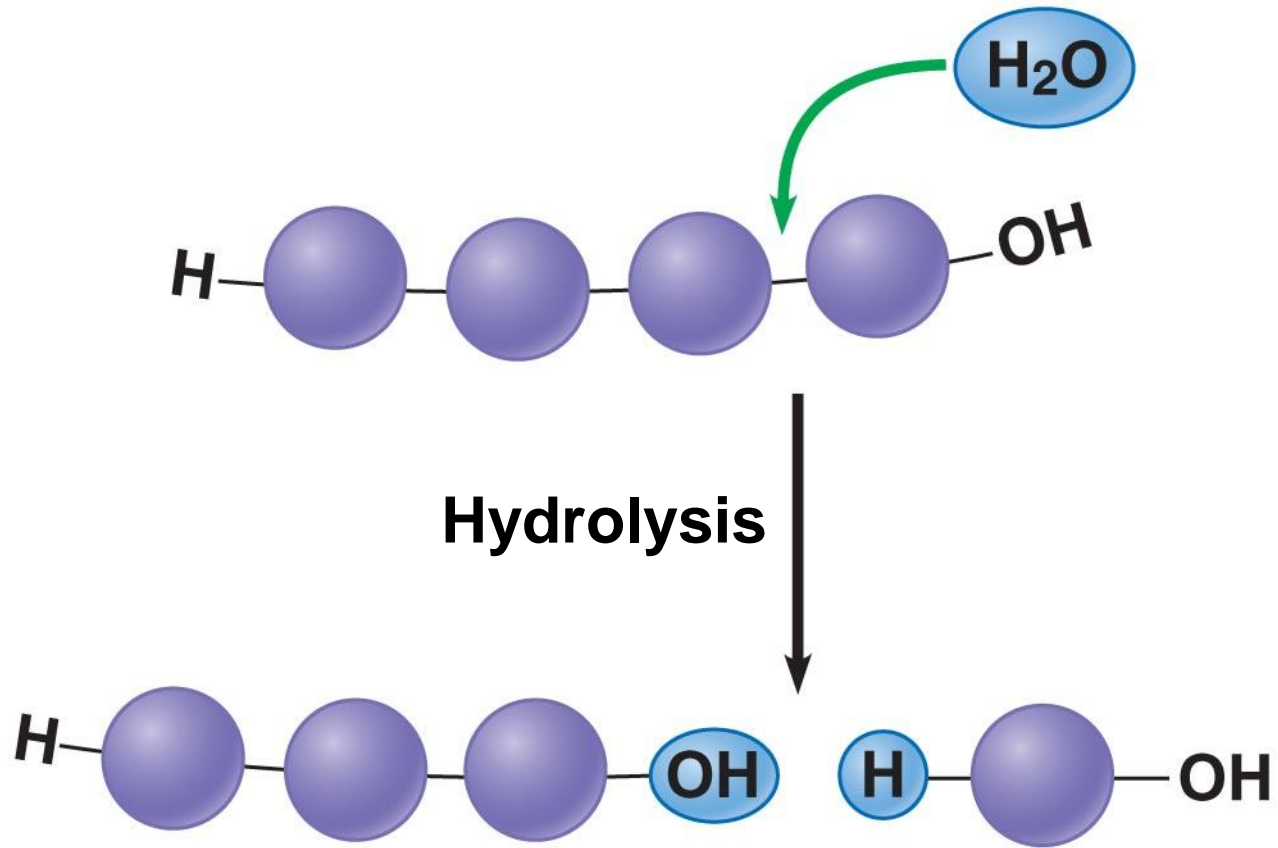
- Monomers are linked together to form polymers through **dehydration reactions**, which remove water
- Polymers are broken apart by **hydrolysis**, the addition of water
- All biological reactions of this sort are mediated by **enzymes**, which speed up chemical reactions in cells











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# CARBOHYDRATES

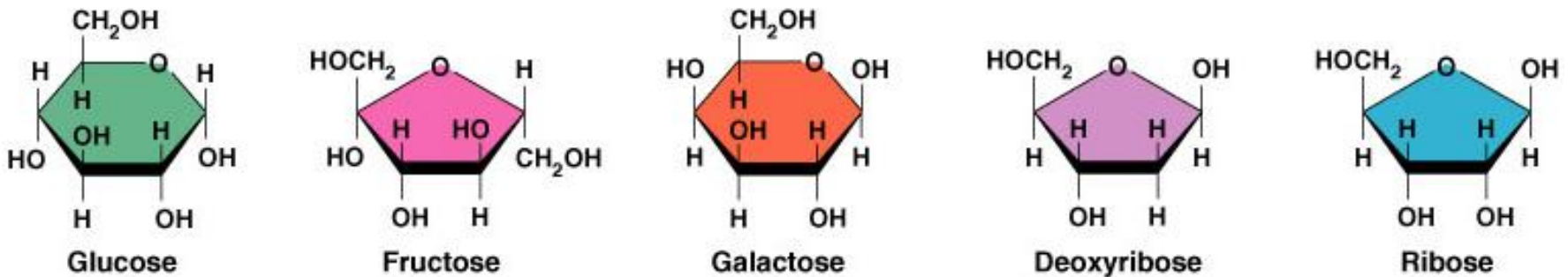
## 3.4 Monosaccharides are the simplest carbohydrates

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- Carbohydrates range from small sugar molecules (monomers) to large polysaccharides
  - Sugar monomers are **monosaccharides**, such as glucose and fructose
  - These can be hooked together to form the polysaccharides

# Carbohydrates

- Contain C, H, and O
- Their major function is to supply a source of cellular food
- Always have a 2:1 H:O ratio
  - Monosaccharides or simple sugars



**(a) Monosaccharides**

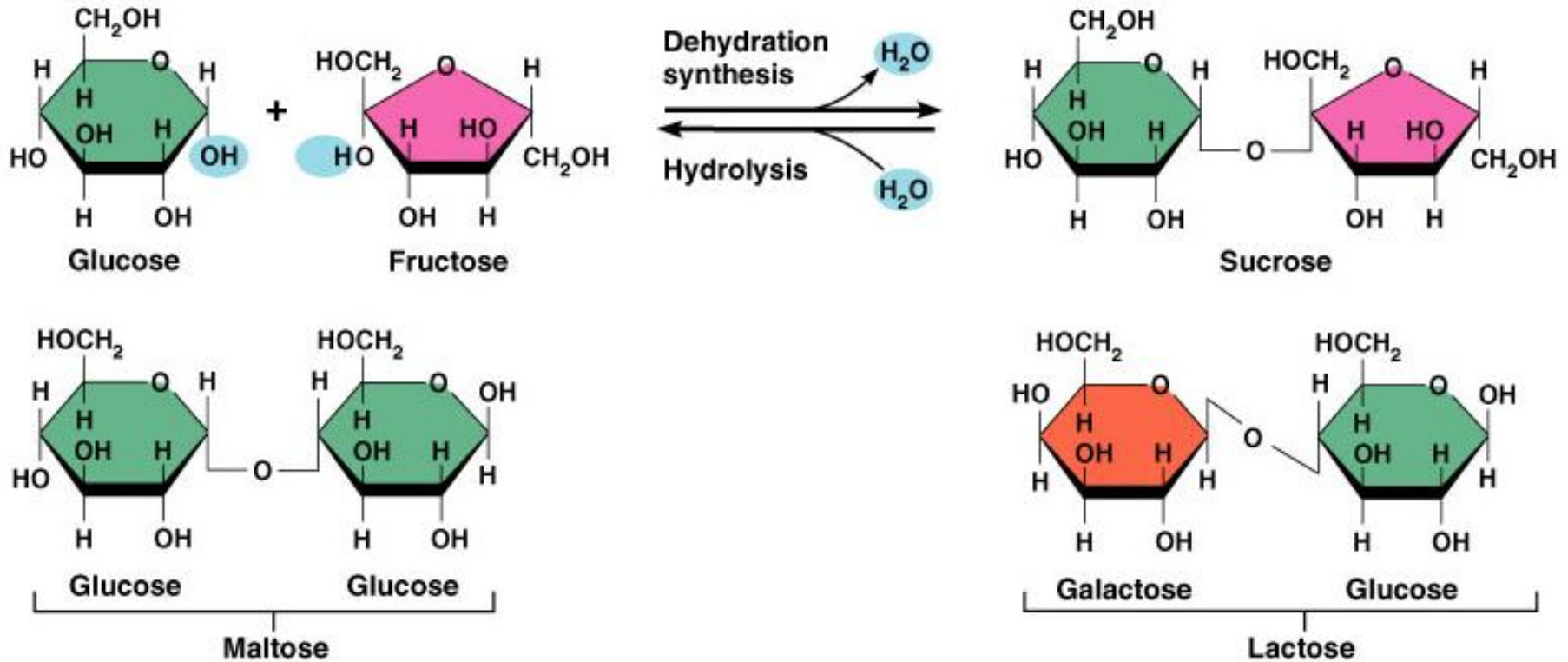
## 3.5 Cells link two single sugars to form disaccharides

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- Two monosaccharides (monomers) can bond to form a **disaccharide** in a dehydration reaction
  - An example is a glucose monomer bonding to a fructose monomer to form sucrose, a common disaccharide

# Carbohydrates

- Disaccharides or double sugars



**(b) Disaccharides**

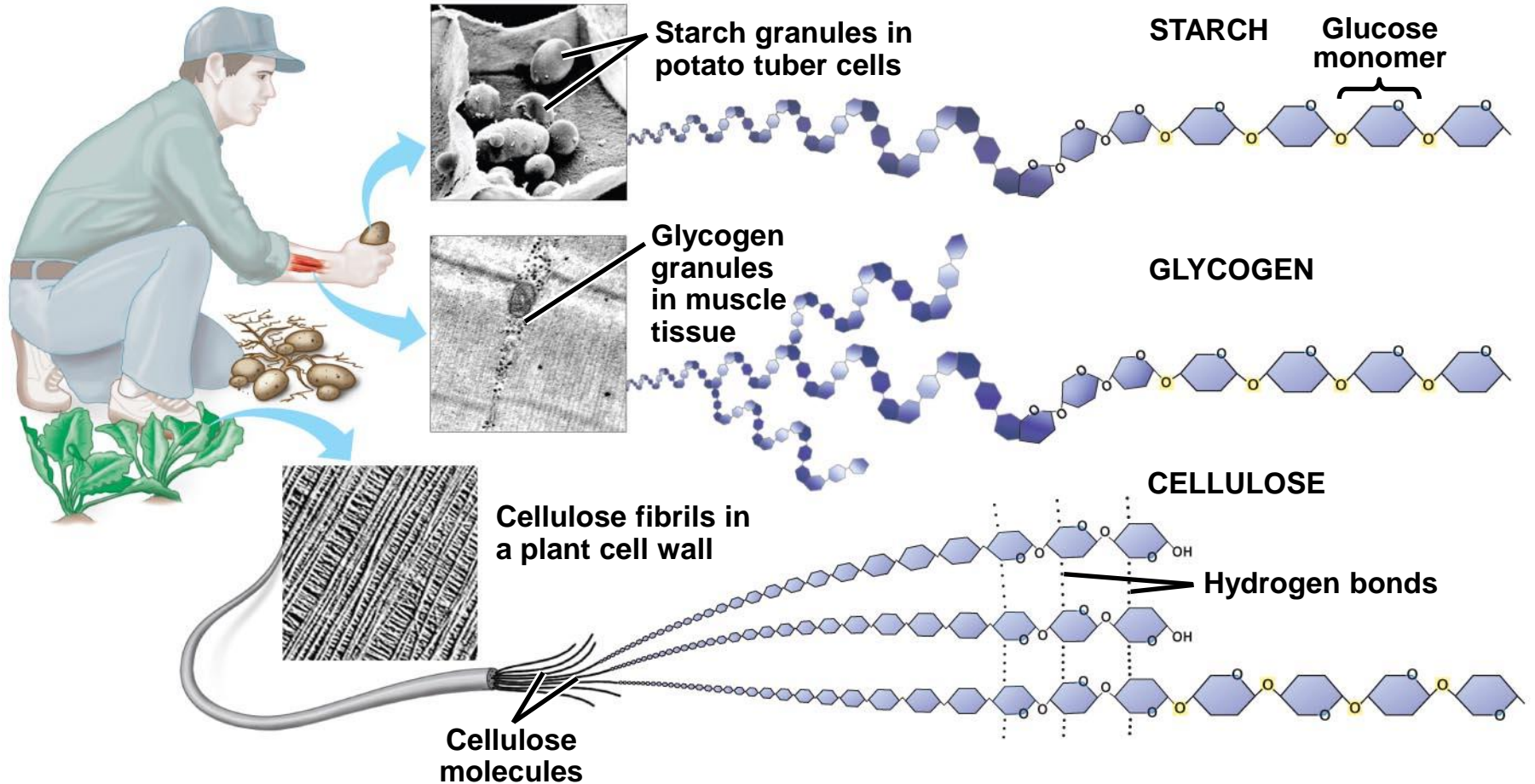


## 3.7 Polysaccharides are long chains of sugar units

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- **Starch** is a storage polysaccharide composed of glucose monomers and found in plants
- **Glycogen** is a storage polysaccharide composed of glucose, which is hydrolyzed by animals when glucose is needed
- **Cellulose** is a polymer of glucose that forms plant cell walls
- **Chitin** is a polysaccharide used by insects and crustaceans to build an exoskeleton

# ■ Polysaccharides or polymers of simple sugars



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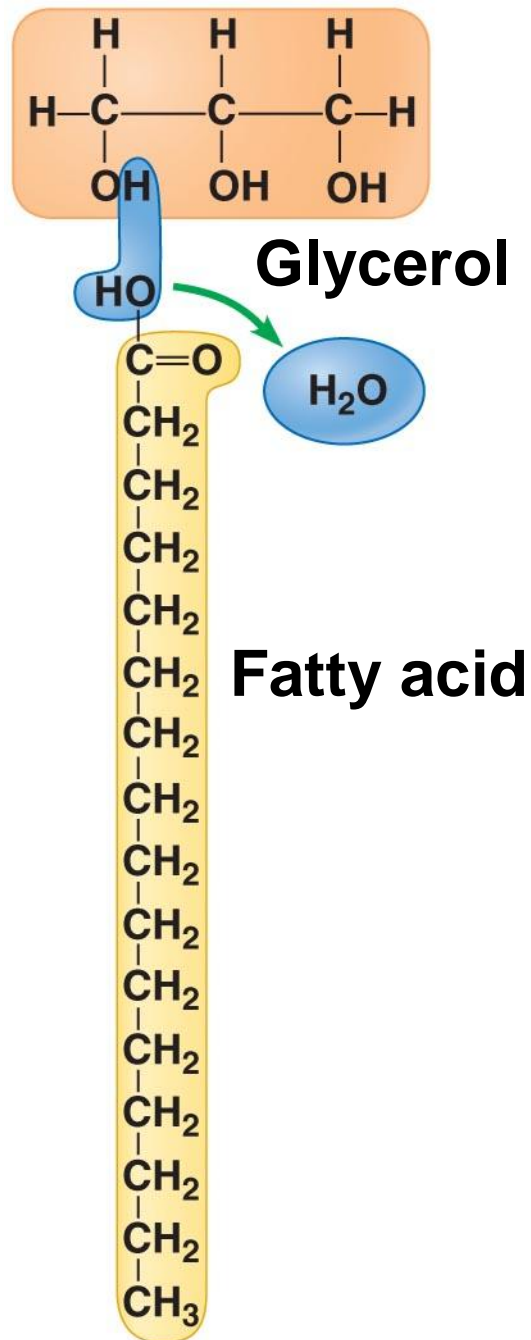
# LIPIDS

## 3.8 Fats are lipids that are mostly energy-storage molecules

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- **Lipids** are water insoluble (**hydrophobic**, or water fearing) compounds that are important in energy storage
  - They contain twice as much energy as a polysaccharide
- Contain C, H, and O, but no 2:1 ratio of H to O
- Examples:
  - Neutral fats or triglycerides
  - Phospholipids
  - Steroids

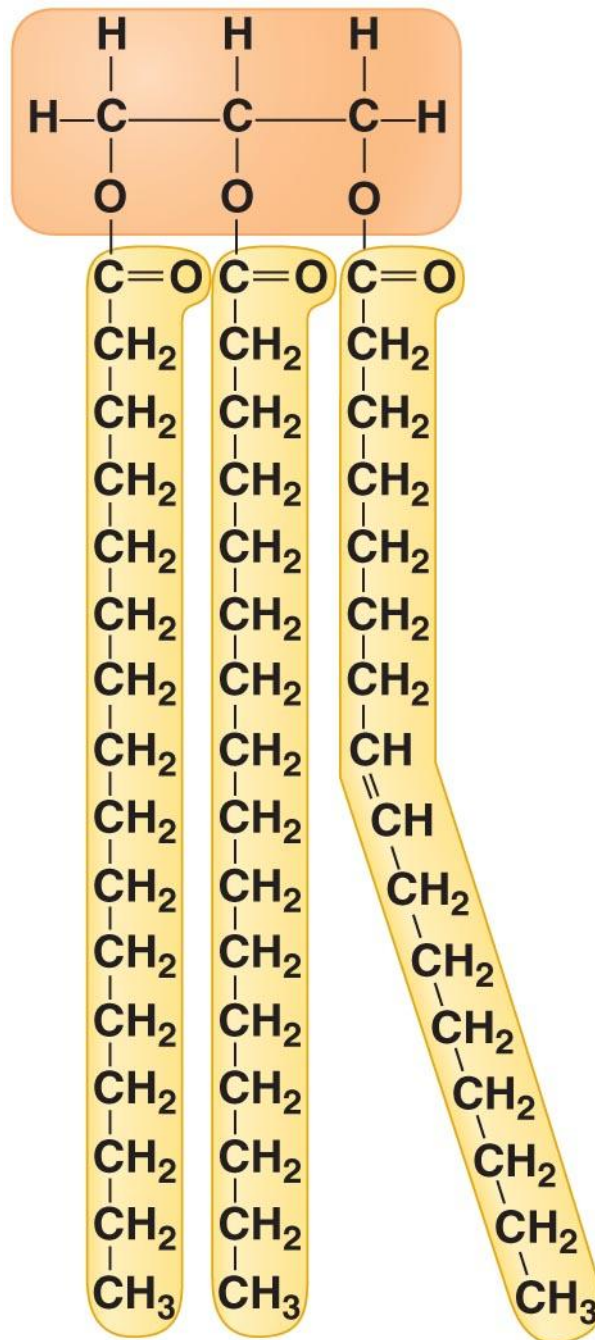
**Fats are lipids  
made from  
glycerol and fatty  
acids**



**Fatty acids link  
to glycerol by a  
dehydration  
reaction**

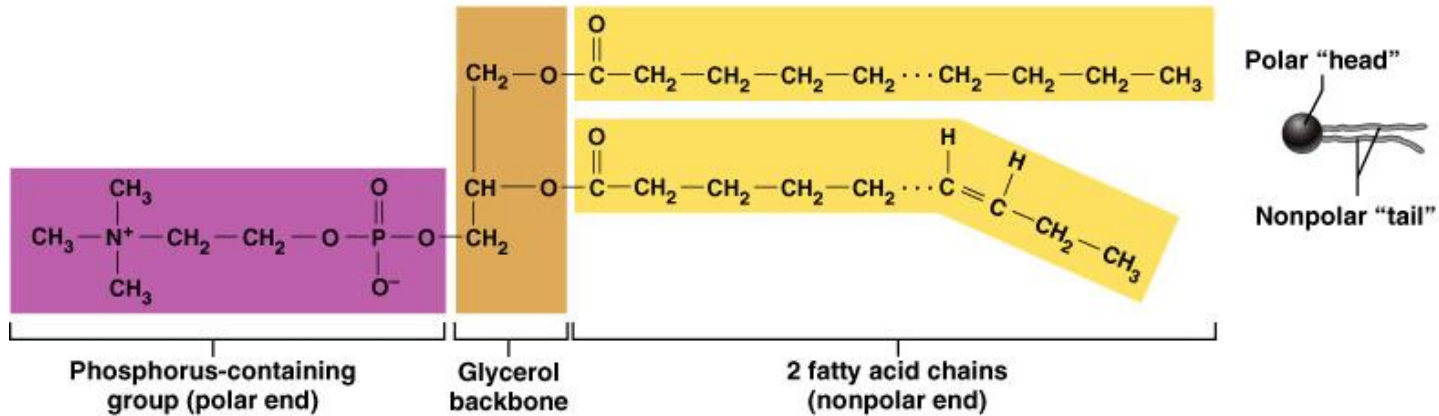
A fat contains **one glycerol** linked to **three fatty acids**

Fats with the maximum number of hydrogens are called **saturated fats**

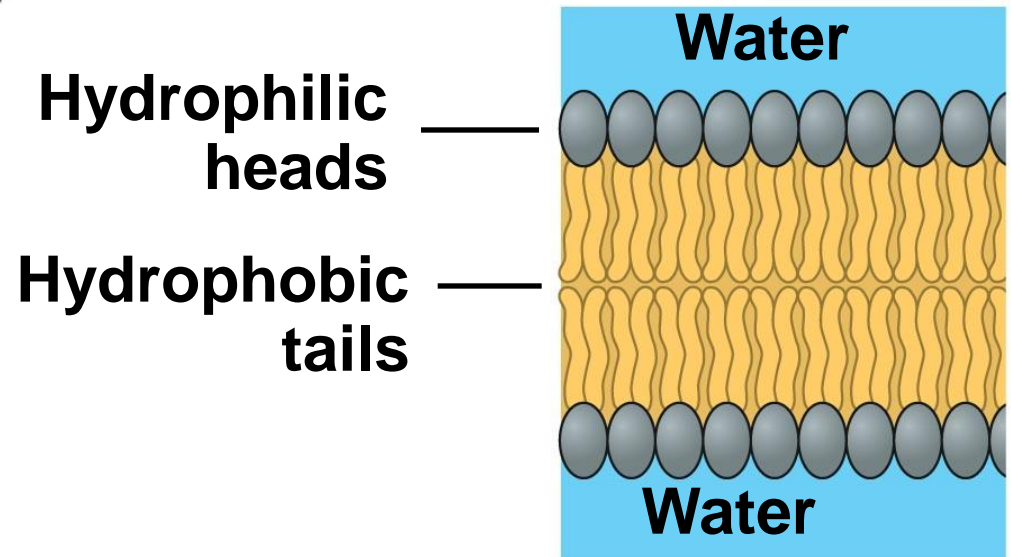


Some fatty acids contain double bonds causing kinks or bends in the carbon chain, they are called **unsaturated fats**

- Phospholipids – modified triglycerides with two fatty acid groups and a phosphorus group

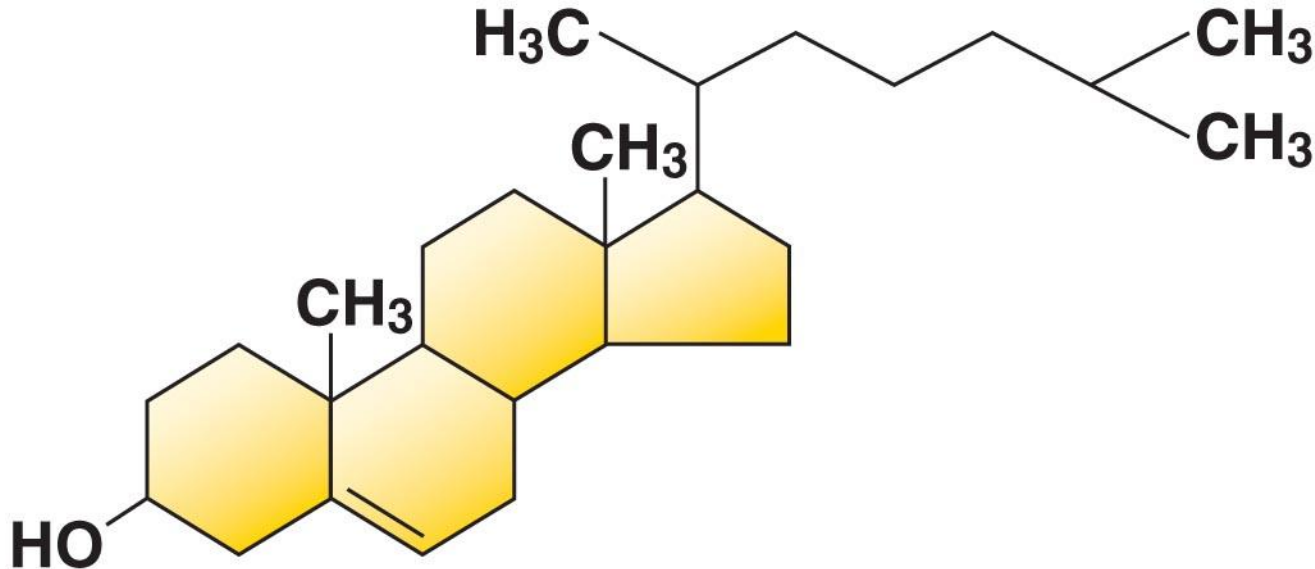


**(b) Phospholipid molecule (phosphatidylcholine)**



## 3.9 Phospholipids and steroids are important lipids with a variety of functions

- **Steroids** are lipids composed of fused ring structures
  - **Cholesterol** is an example of a steroid that plays a significant role in the structure of the cell membrane
  - In addition, cholesterol is the compound from which we synthesize sex hormones



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# Representative Lipids Found in the Body

- Neutral fats – found in subcutaneous tissue and around organs
- Phospholipids – chief component of cell membranes
- Steroids – cholesterol, bile salts, vitamin D, sex hormones, and adrenal cortical hormones