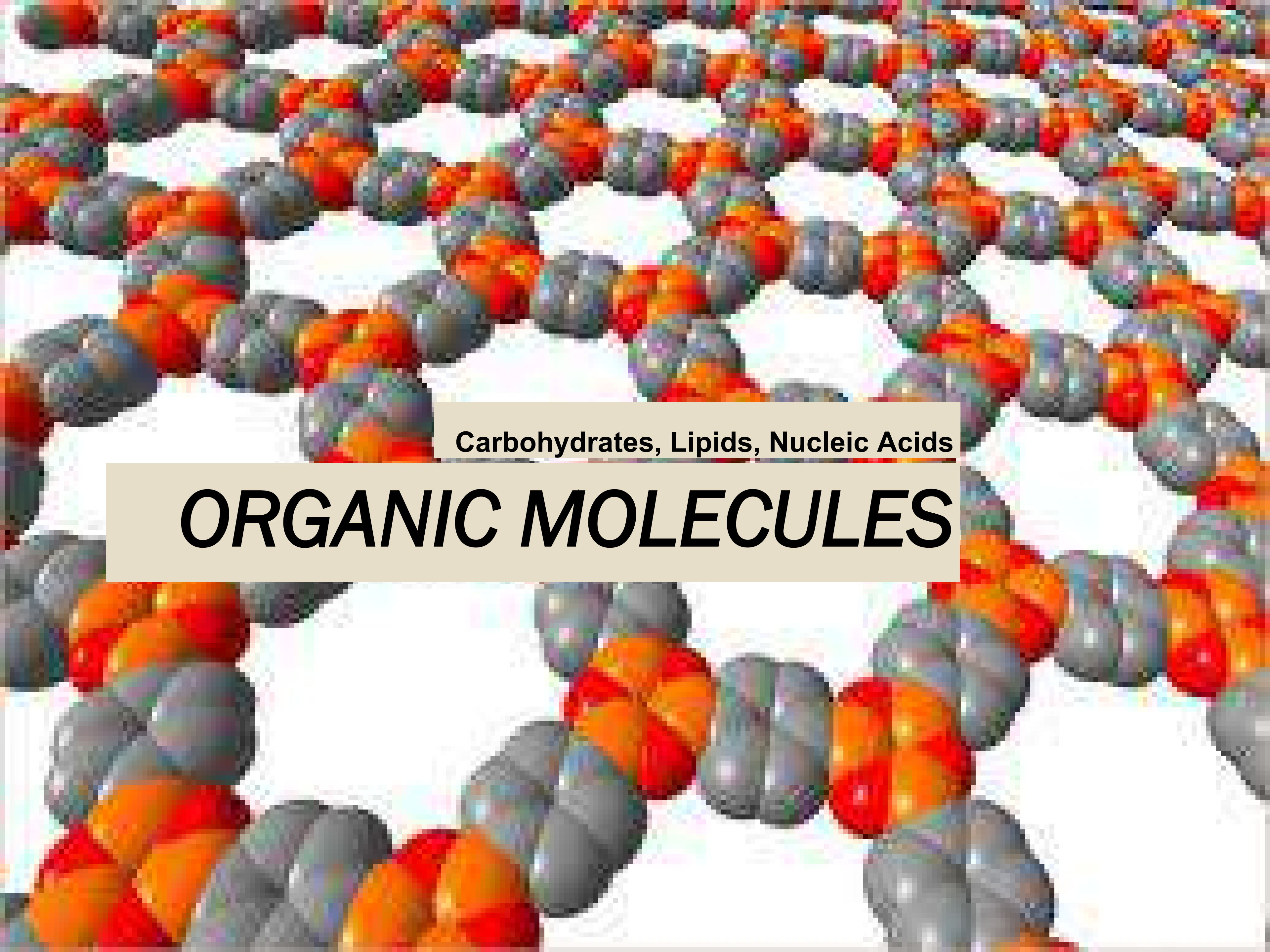
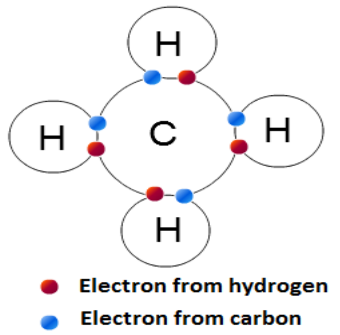


Carbohydrates, Lipids, Nucleic Acids

ORGANIC MOLECULES



3.2.1 Distinguish between organic and inorganic compounds

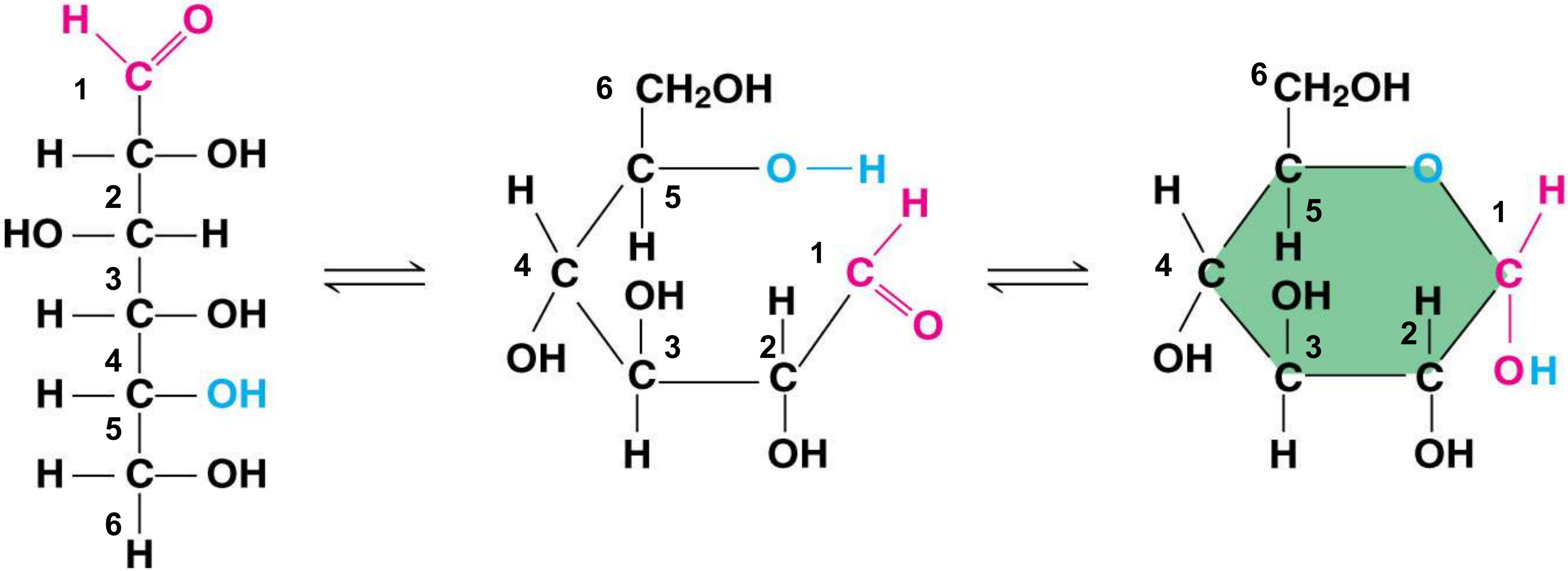
- All organic molecules contain the element Carbon, but not all molecules that contain Carbon are organic
  - Hydrogencarbonates, carbonates, and oxides of carbon are **not** considered organic.
- Carbon atoms can form 4 covalent bonds with either other carbon atoms or different kinds of atoms.
- This allows for a wide variety of bond formations, which determines the molecule's shape
- Shape determines a lot of the molecules properties and functions in a living system
- 4 types: Lipids, Carbohydrates, Nucleic acids, Proteins

- Most organic molecules are considered to be macromolecules
  - Large molecules that are formed from the joining together of long chains of repeating subunits called monomers
  - Macromolecule = polymers (long molecule made of many similar building blocks held together by covalent bonds)

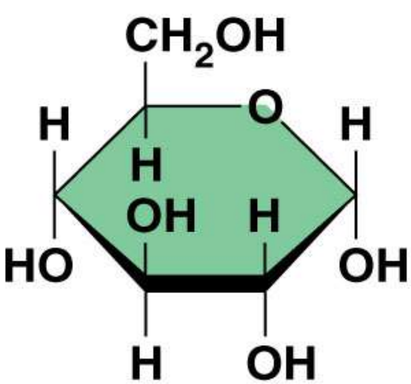
Macromolecule/polymer	monomer
Carbohydrate	Monosaccharide
Lipids	Glycerol/ fatty acids
Proteins	Amino Acids
Nucleic Acids	Nucleotides

Carbohydrates

- Organic compounds that contain C,H,O
- Always have a ratio of 2H:1O
- These include all sugars and starches
  - Sugars end in suffix "-ose"
- carbohydrates are organized by the types and number of monomers (monosaccharides) that are linked together



(a) Linear and ring forms



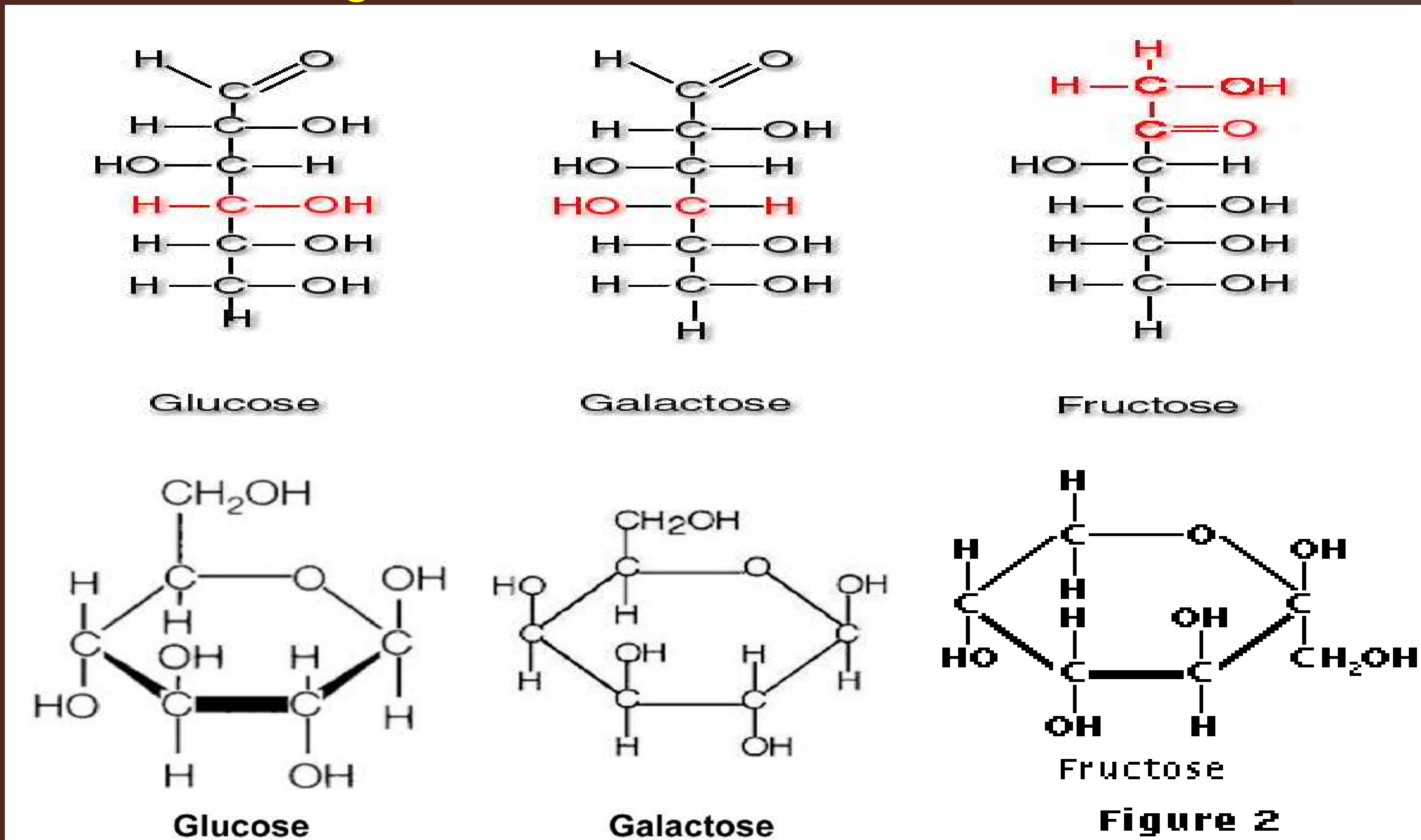
(b) Abbreviated ring structure

© 2011 Pearson Education, Inc.

Monosaccharide: simple sugars (single carb)

- Glucose, galactose, fructose

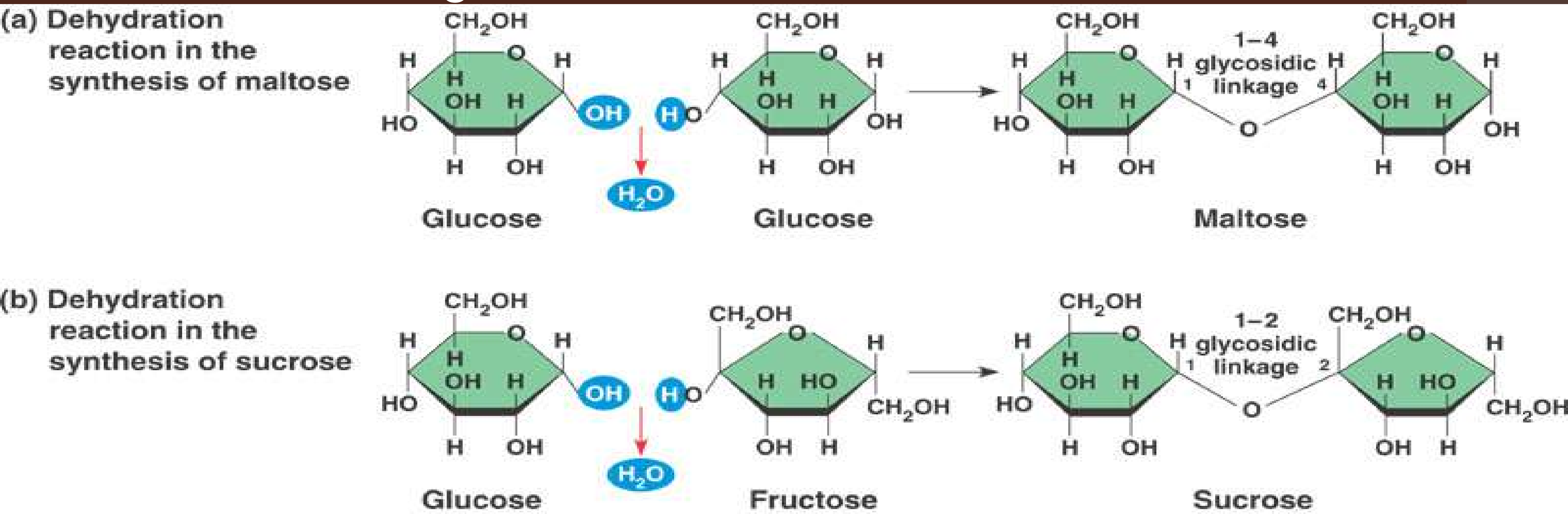
http://edu.glogster.com/glog.php?glog_id=11955644&scale=100



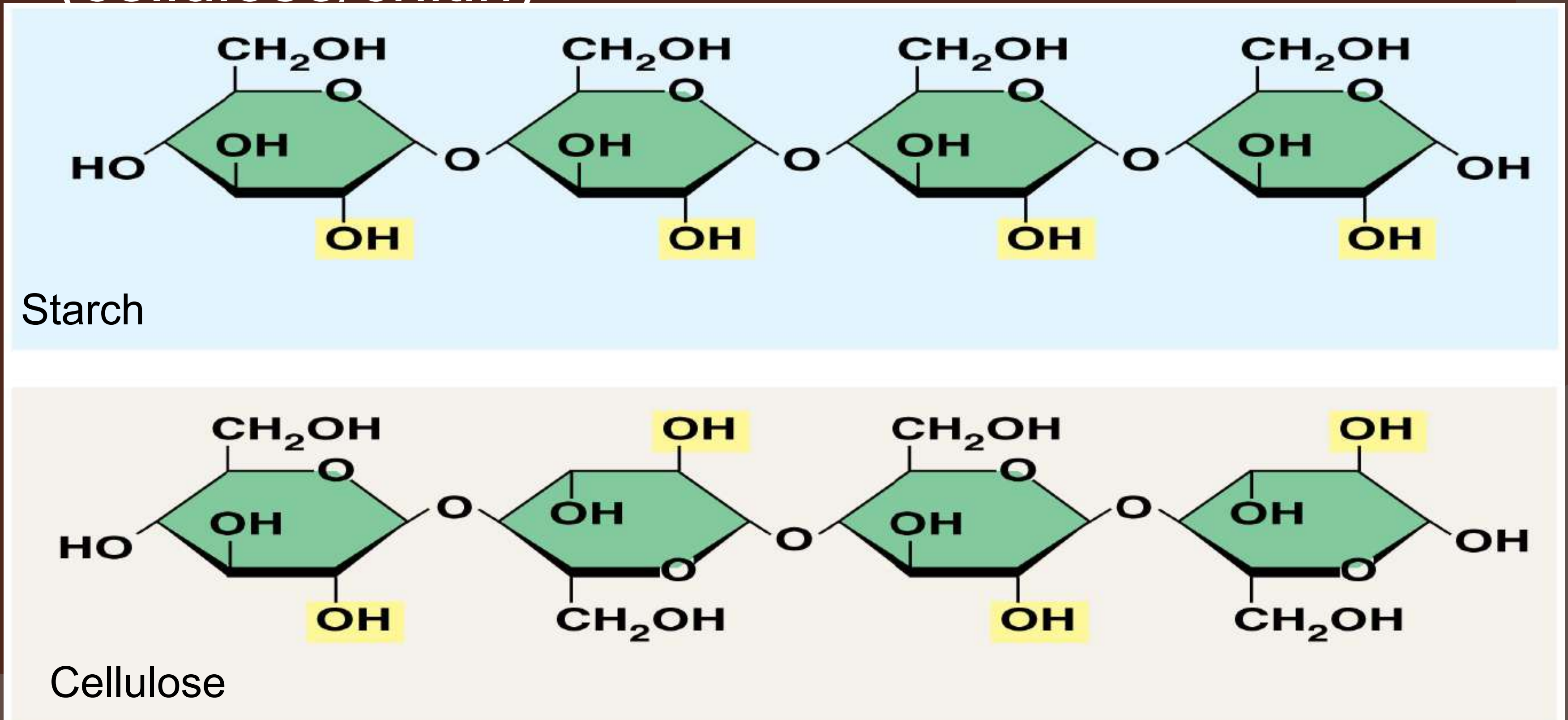
http://www.omegafields.com/blog/carbohydrates--definitions-and-relationship-to-equine-diseases

- Disaccharides: sugars formed when 2 monosaccharides are linked together by a condensation reaction (dehydration synthesis)
- This covalent bond between the sugars is called glycosidic linkage
  - Maltose - glucose + glucose
  - Lactose – glucose + galactose
  - Sucrose – glucose + fructose

http://faculty.cbu.ca/cglogowski/2008%20BIOL101%20Biomolecules%20WS.htm



- Polysaccharides: 3 or more monosaccharides joined together by a condensation reactions
  - Starch, glycogen, cellulose
- Mainly used for energy storage(glycogen/starch) and for structure in plants and animals (cellulose/chitin)



© 2011 Pearson Education, Inc.

Functions of Sugars in Animals

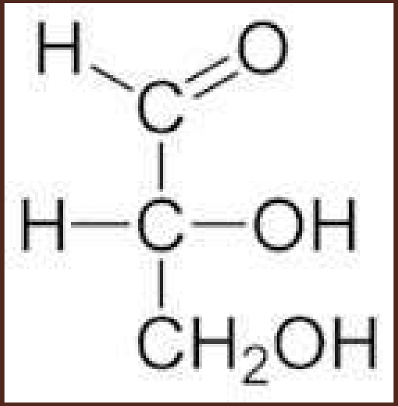
Name	Type	Function
glucose	monosaccharide	Chemical fuel for cell respiration
lactose	disaccharide	Sugar found in milk (glucose + galactose)
glycogen	polysaccharide	Stores glucose in the liver and muscles of animals (mainly vertebrates)

Function of Sugars in Plants

Name	Type	Function
fructose	monosaccharide	Sugar found in many fruits (makes them sweet)
sucrose	disaccharide	Transported from leaves of plants to other locations in plant by vascular tissues (glucose + fructose)
cellulose	polysaccharide	One of the primary components of plant cell walls
starch	polysaccharide	Surplus glucose storage

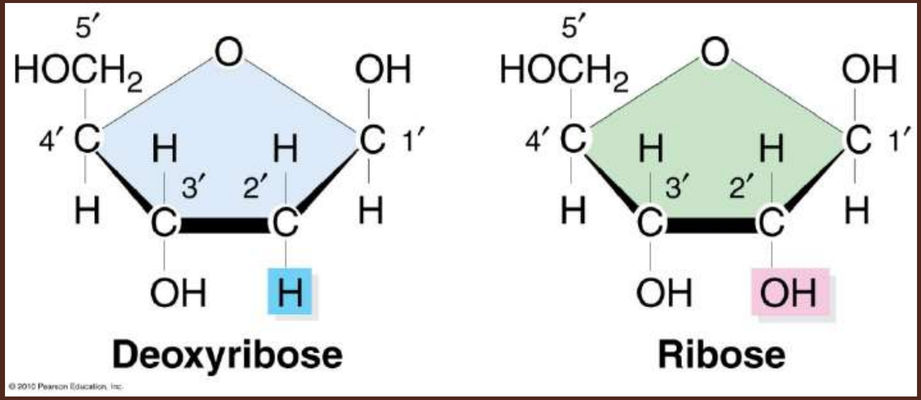
- We can also categorize carbs by the number of carbon atoms in their ring/linear structures
  - Triose : 3 Carbons; Glyceraldehyde
  - Pentose: 5 Carbons; Ribose and Deoxyribose (RNA and DNA)
  - Hexose: 6 Carbons; glucose, galactose

Triose Sugar



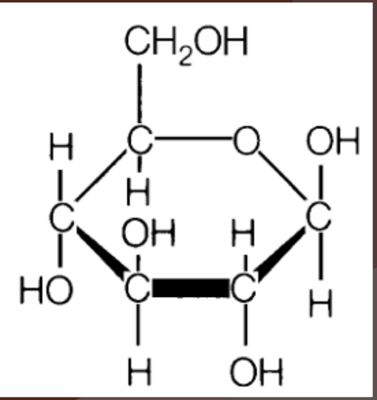
http://www.websters-online-dictionary.org/definition/Aldose

Pentose Sugars



http://www.mun.ca/biology/scarr/iGen3_02-07.html

Hexose Sugar



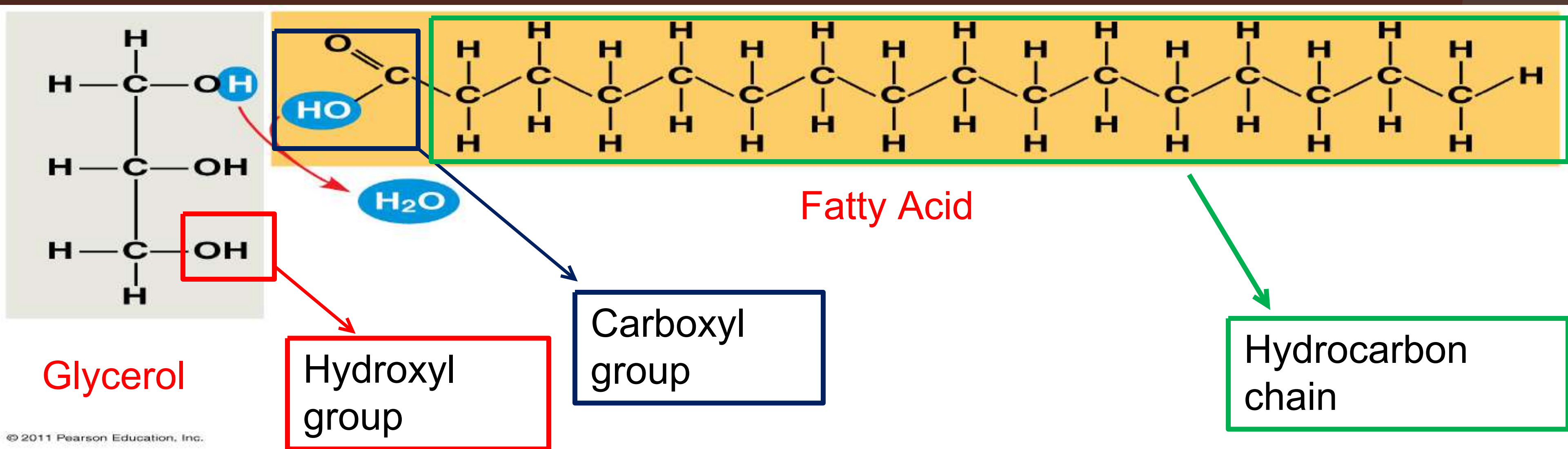
http://www.science.marshall.edu/murraye/alpha_amylase.htm

Lipids

- Fats, oils, phospholipids, steroids, and waxes
- Composed of long chains of C, H, O
- All lipids have little or no affinity for water
- Hydrophobic because they are composed mostly of hydrocarbons which form non-polar covalent bonds
- Majority consist of glycerol and fatty acid molecules joined together by dehydration synthesis reactions
- Contain many more C-H bonds for energy storage than carbohydrates
  - Stores about double the amount of energy as a polysaccharide (37 KJ g^{-1})

Fats and Oils

- Formed from the condensation reaction (dehydration synthesis) of glycerol + fatty acid (1,2, or 3 = mono-, di-, or triglycerides)
- Fatty acids are large carbon chains with a carboxyl group attached at the end
- Glycerol molecules are three carbon alcohols with a hydroxyl group (OH) attached to each carbon

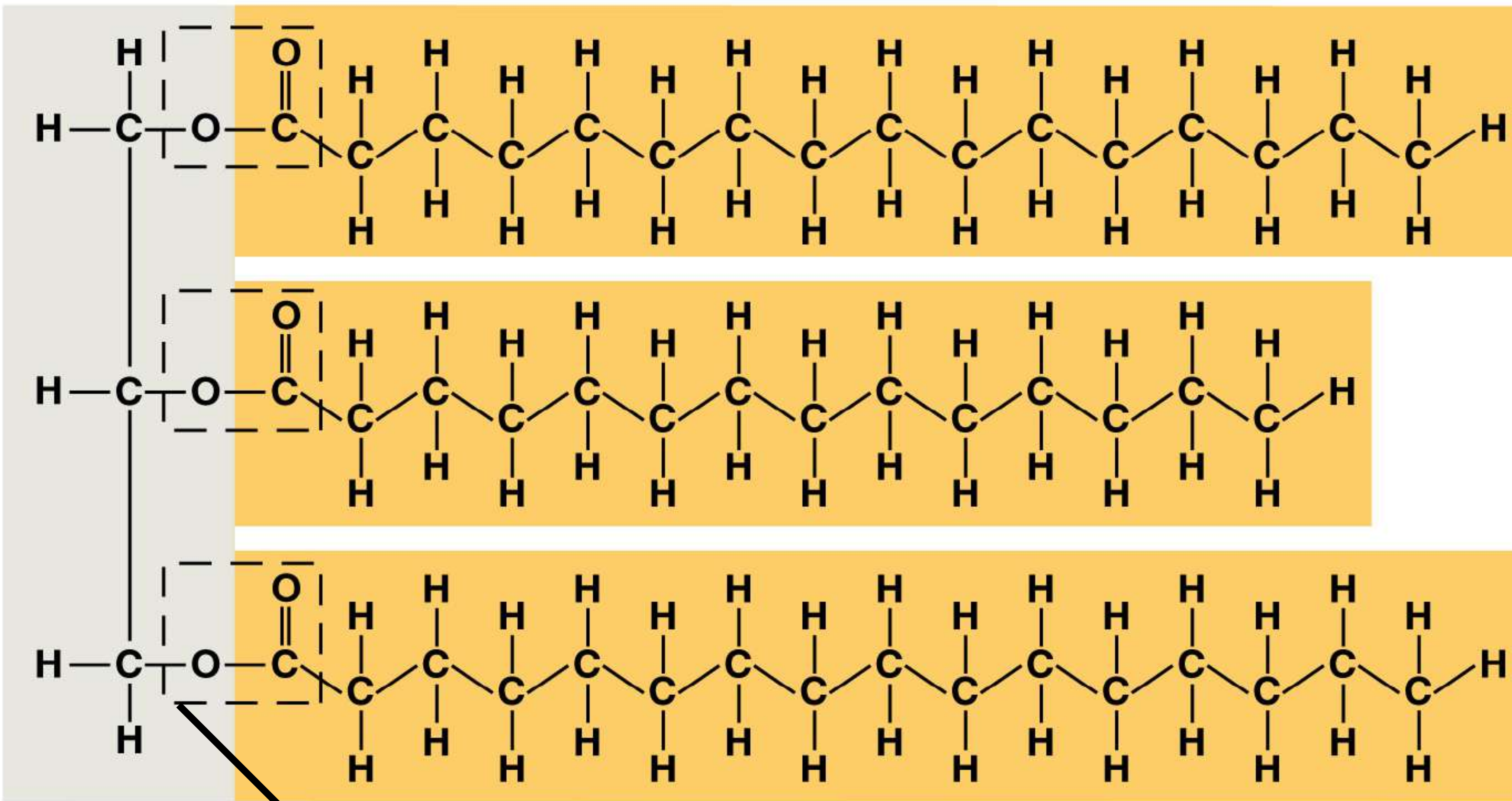


© 2011 Pearson Education, Inc.

Triglycerides

- Fats and oils composed of 3 fatty acids attached to a glycerol
- Unsaturated fats: liquid at room temp; (ex. oils)
  - double bond between 2 adjacent carbon atoms in hydrocarbon chain doesn’t allow the triglycerides to pack closely together and form a solid.
- Saturated Fats: solid at room temp (ex. animal fat)
  - No double bonds in hydrocarbon chain.
  - Allows to pack tightly together to form solid
- Trans Fats: solid at room temp
  - Formed by hydrogenating unsaturated fats and forming trans double bonds
  - Contribute to artherosclerosis

Triglyceride Molecule

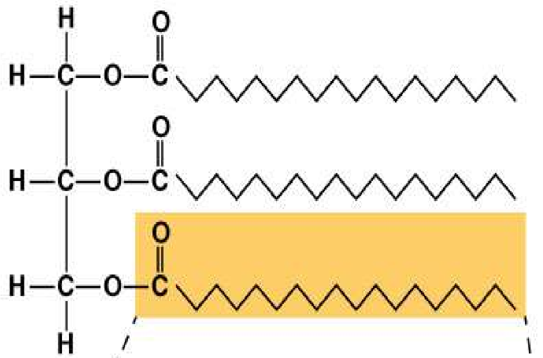


Ester Linkage

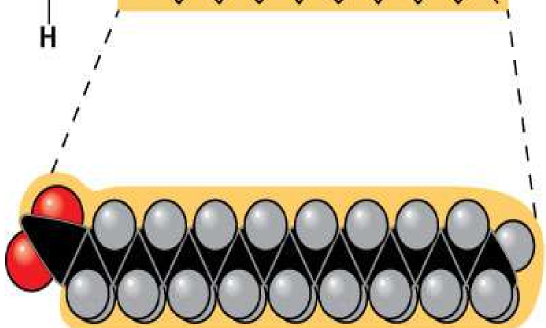
© 2011 Pearson Education, Inc.

Saturated Fat

Structural formula of a saturated fat molecule

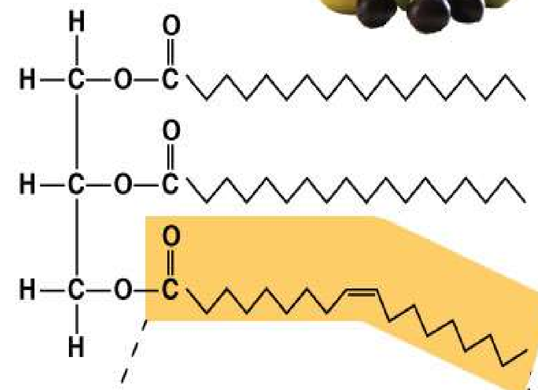


Space-filling model of stearic acid, a saturated fatty acid

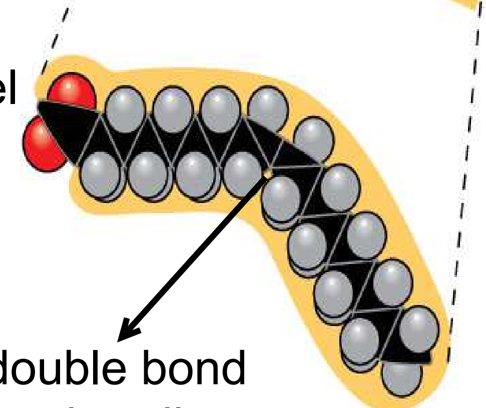


Unsaturated Fat

Structural formula of an unsaturated fat molecule



Space-filling model of oleic acid, an unsaturated fatty acid

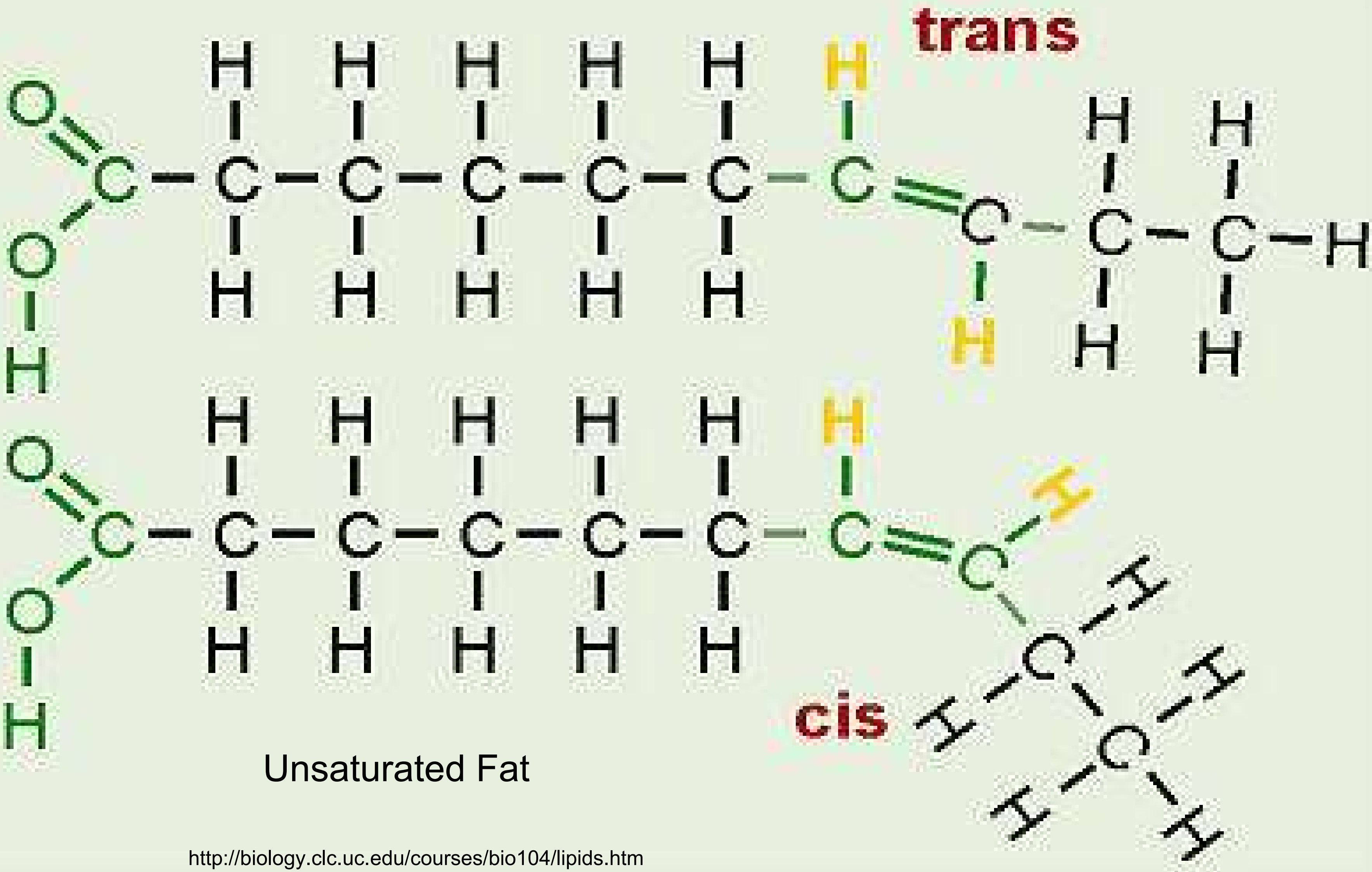


Cis double bond causes bending

© 2011 Pearson Education, Inc.

Saturated fatty acids	Unsaturated fatty acids
no double bonds	one or more double bonds
abundant in fats	abundant in oils
more reduced	less reduced
more energy	less energy
high melting point	low melting point

Trans Fat Example…..

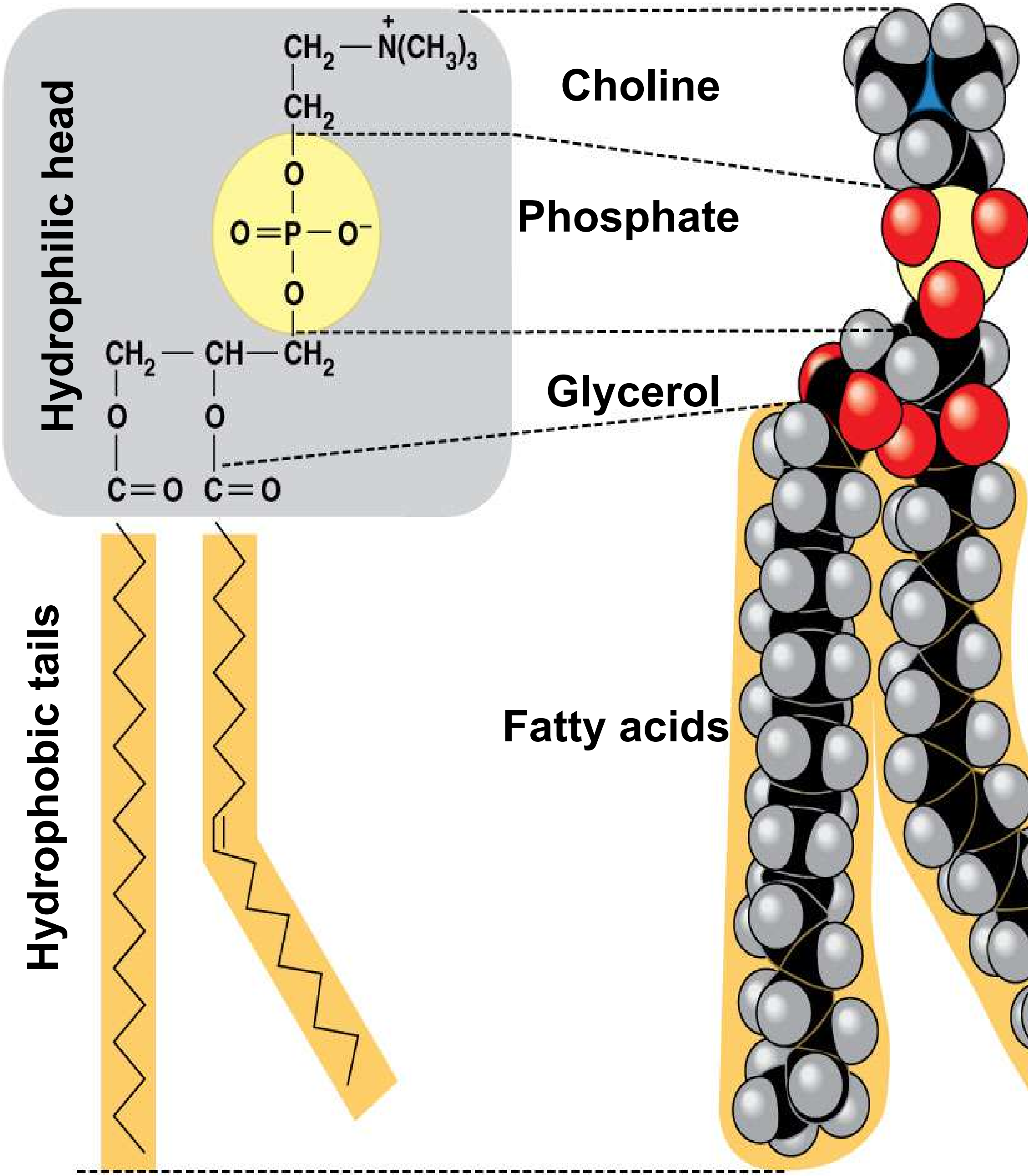


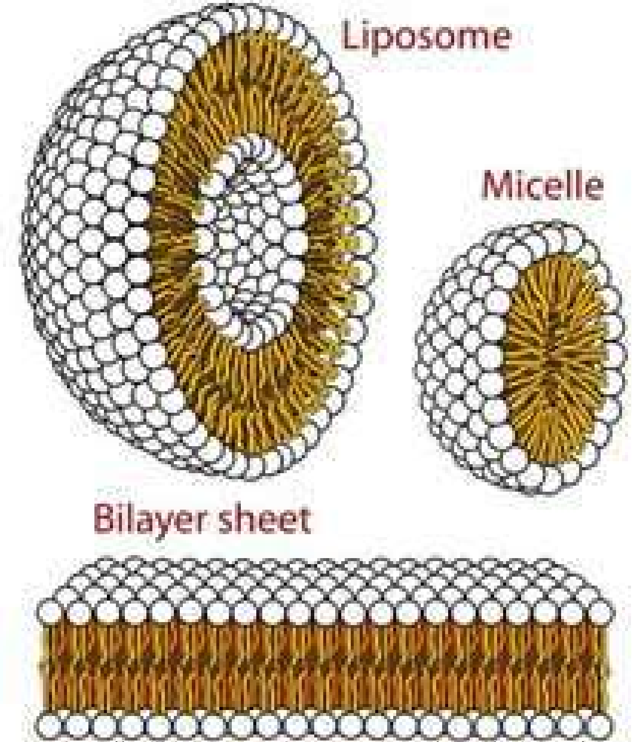
Unsaturated Fat

http://biology.clc.uc.edu/courses/bio104/lipids.htm

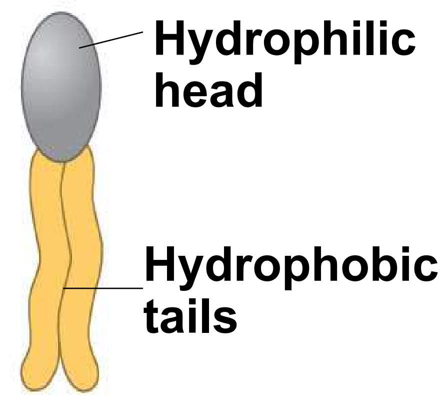
Phospholipids

- Integral part of cell membranes
- Composed of two fatty acid chains and a single phosphate group attached to a glycerol molecule.
- Phosphate group is negative in charge, creating a hydrophilic phosphate head and a hydrophobic lipid tail.
  - Form a lipid bilayer when put into water because phosphate heads are attracted to water while the lipid tails are repelled by water.





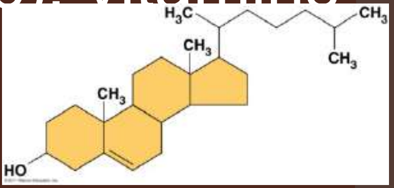
http://cellbiology.med.unsw.edu.au/units/science/lecture0803.htm



© 2011 Pearson Education, Inc.

Other Lipids

- Steroids: multiple ring structures (4 carbon rings)
  - (ex. cholesterol)
  - Functions: cell membrane structure, digestion (help to emulsify fats), hormones (testosterone etc), vitamins (e.g. Vitamin D), plant poisons/venoms



- Waxes: long chain alcohol + fatty acids
  - Water proof coating to leaves, fur feathers, insect exoskeletons.
  - Used by bees to construct their honey combs.

Basic Functions of Lipids

- STRUCTURAL: biological membranes (phospholipids, steroids, glycolipids), cushioning (fat deposits round the kidneys)
- ELECTRICAL INSULATION: myelin sheath round axons
- THERMAL INSULATION: subcutaneous fat deposits.
- WATER PROOFING: waxes and oils
- ENERGY STORE AND SUBSTRATE: very condensed form of energy (37 kJ g-1) used by animals and seeds.
- HORMONES: steroids
- VITAMINS: precursor to Vit D
- BUOYANCY: oil droplets in plankton

Energy Storage: Carbs vs. Lipids

- Carbohydrates are an immediate source of energy for both plants and animals.
  - Energy is stored in the bonds formed when joining the monosaccharides into more complex carbs (dehydration synthesis)
  - Plants store energy primarily by linking excess glucose molecules into molecules of starch.
  - Energy is released by the hydrolysis of the starch molecule
  - Animals and other organisms have enzymes to hydrolyze plant starches which is used as food
  - Smaller amounts of carbohydrates are stored as Glycogen in liver and muscle cells of animals.
  - Glycogen is hydrolyzed when demands increase (can be completely depleted in 1 day)

Energy Storage (cont)

- Lipids are a far more efficient method of energy storage
  - Excess food/energy that is not burned is stored in adipose tissue as lipids
  - Lipids store nearly twice as much energy in their bonds than carbohydrates (37 KJ g-1)
  - Used more for long term energy storage
  - Carbohydrates are more soluble and easier to transport than lipids
  - Glycogen storage will be used up first before lipids when in need of energy

Synthesis and Decomposition of Macromolecules

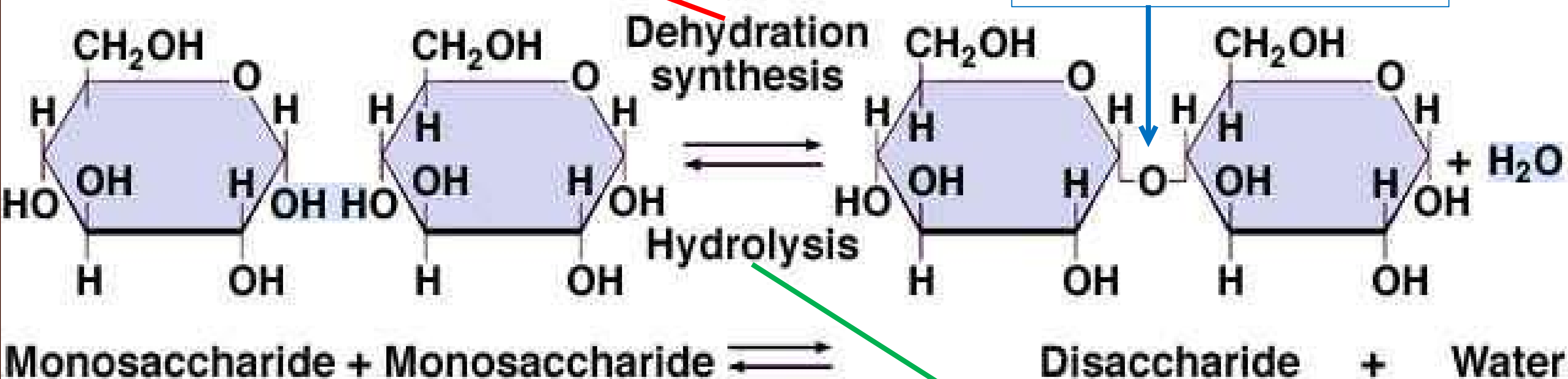
- Polymers of carbohydrates, lipids, nucleic acids, and proteins are all synthesized by joining 2 monomers and removing a water molecule
  - These are called dehydration synthesis or condensation reactions (water lost)
  - Each monomer donates either a H+ or OH- ion which combine to form H20.
- Breaking down of these polymers is the same process but occurs in the opposite direction.
  - Hydrolysis: Water is split and added back into the monomer molecules in order to break down a macromolecule.
- Both reactions are driven by enzymes.
- There are separate enzymes that catalyze dehydration synthesis and hydrolysis of macromolecules

Copyright © The McGraw-Hill Companies, Inc. Permission required for reproduction or display.

Dehydration Synthesis—Sugar Molecule

Anabolic reaction:
puts small monomers together in order to produce a polymer

Glycosidic linkage:
bond between 2 monosaccharides



Catabolic reaction:
Breaks down molecules into smaller components (digestion)

Reaction will occur again to add another monosaccharide in order to produce a polysaccharide

http://faculty.southwest.tn.edu/rburkett/Cell_Physiology.htm

Examples of Hydrolysis reactions

- Hydrolysis of a disaccharide to 2 monosaccharides

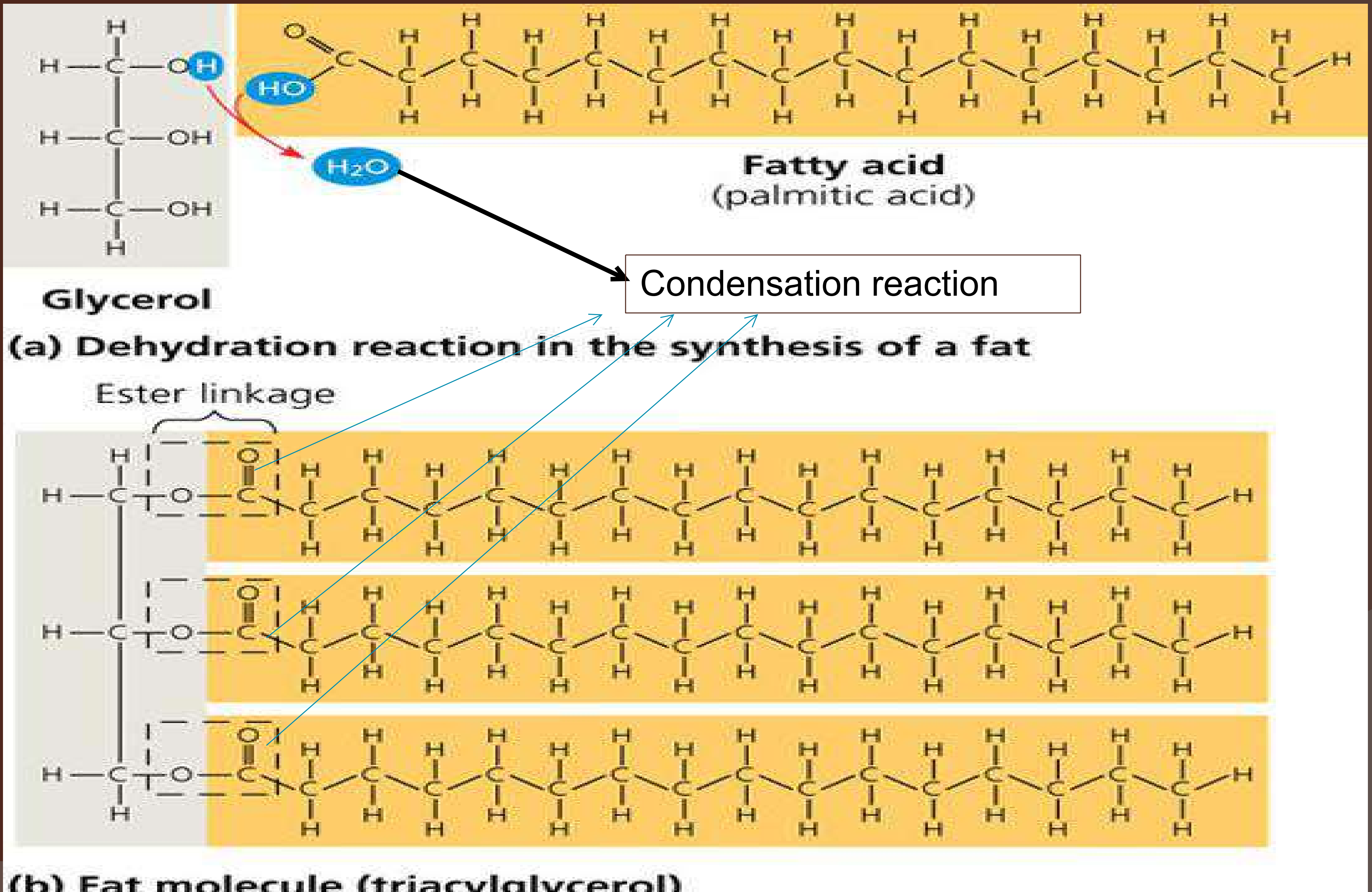
  Lactose + water → glucose + galactose

- Hydrolysis of a polysaccharide to many monosaccharides

  Starch + water(many) → Glucose (many)

Picture examples on pg. 54 in Ward Biology

Dehydration synthesis of a triglyceride

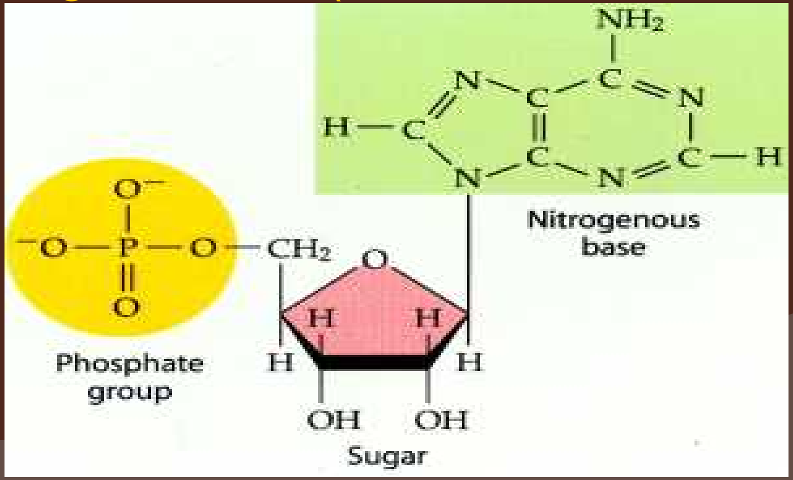


- What would be needed in order to hydrolyze a triglyceride molecule?

- What would be produced?

Nucleic Acids

- Organic Molecules consisting of C, H, O, N
  - Ex. DNA and RNA
- Made up of monomers called nucleotides
  - Consists of…
    1. Phosphate Group
    2. Pentose Sugar (Deoxyribose in DNA or Ribose in RNA)
    3. 1 of 4 Nitrogen Bases (Adenine, Guanine, Cytosine, Thymine)



DNA structure

- First Described by Watson and Crick
- DNA is double stranded
- Forms a double helix
- Alternating Phosphate groups and deoxyribose sugars make up the back-bone of each DNA strand
- Phosphates and sugars are held together by phosphodiester bonds
- Nitrogen bases form hydrogen bonds in the middle of the DNA which hold the two strands together
  - Adenine = Thymine
  - Guanine ≡ Cytosine

Hydrogen Bonds

- Both strands run in opposite directions
  - Anti-parallel
- Sequence of Nitrogen Bases determines everything about the organism
- DNA is built/read from 5’ to 3’
- Strands are complementary
  - If we know the bases on one side, we can determine the sequence on the complementary strand
  - Chargaff’s Rule