The Structure & Function of

Macromolecules
(Long molecule Chains)

Biological Macromolecules

- Carbohydrates
- Lipids
- Proteins
- Nucleic Acids

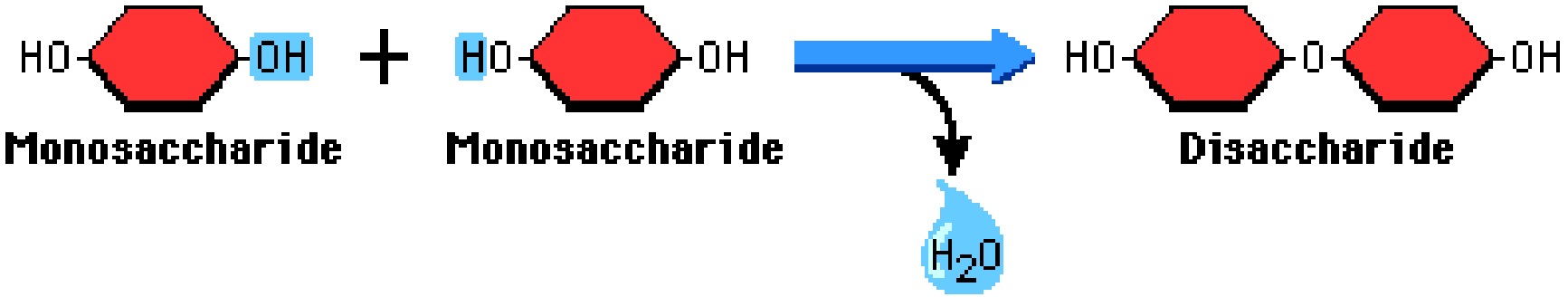
- Monomer – one unit
- Polymer – many units

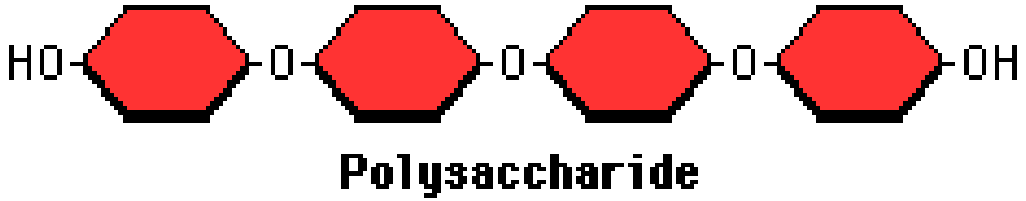
- Great variety of polymers can be made from a small set of monomers

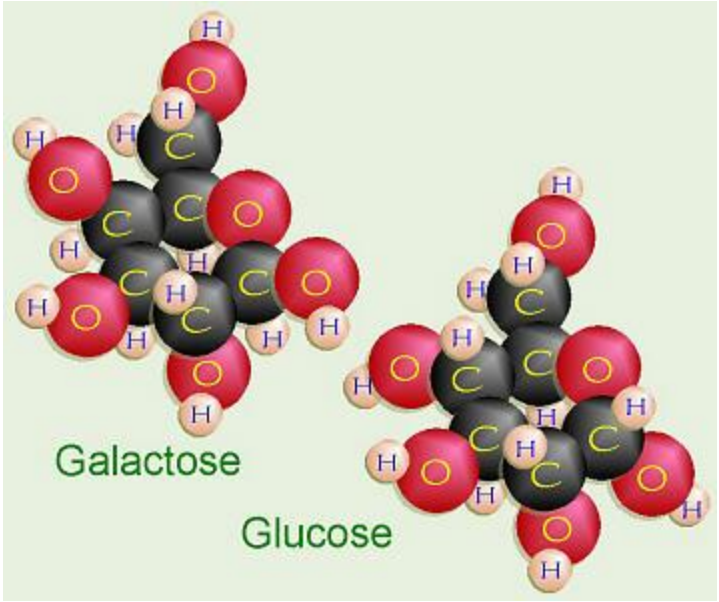
Synthesis of a polymer

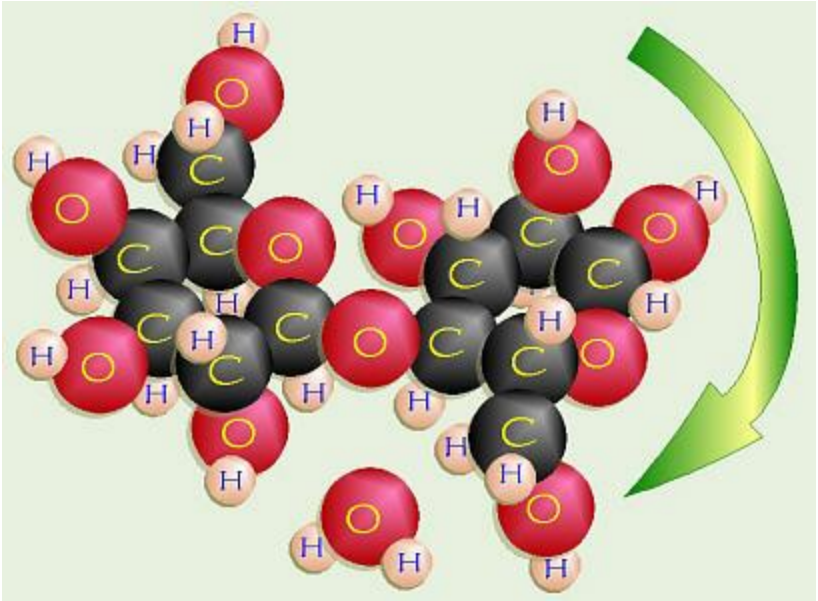
- Synthesis = putting things together (building)
- Polymers are put together by removing water (drying stuff up)
- Dehydration synthesis = Condensation

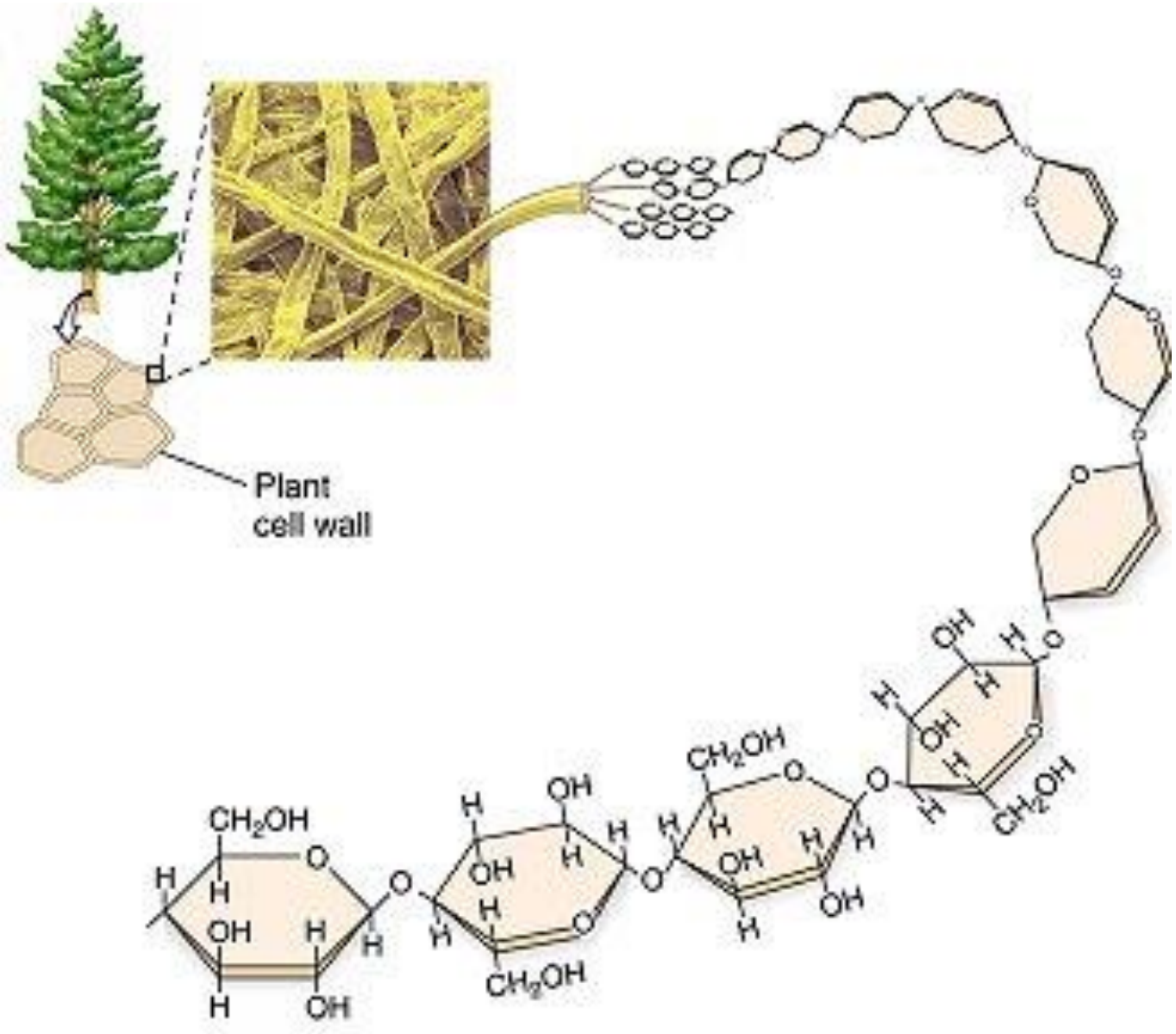
Dehydration/Condensation Synthesis



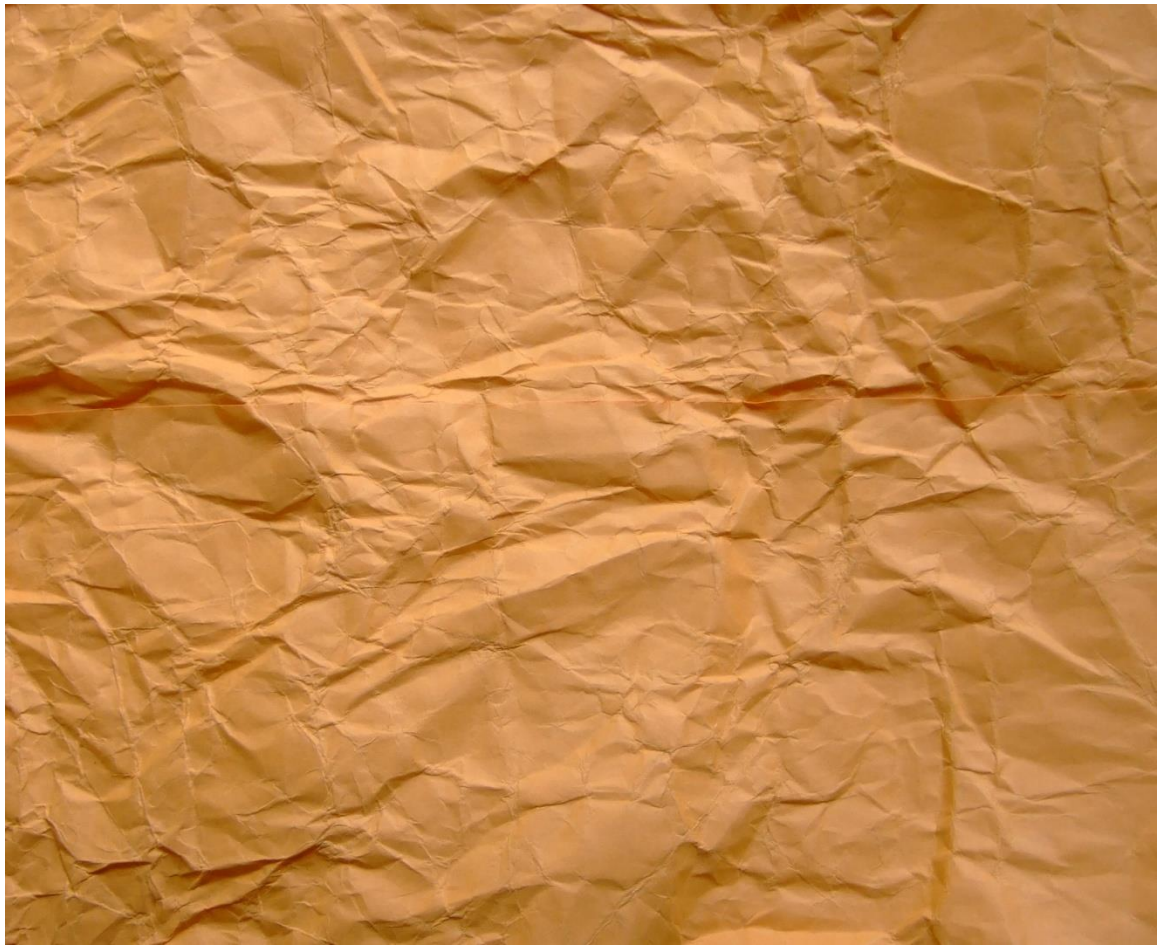



Galactose
Glucose



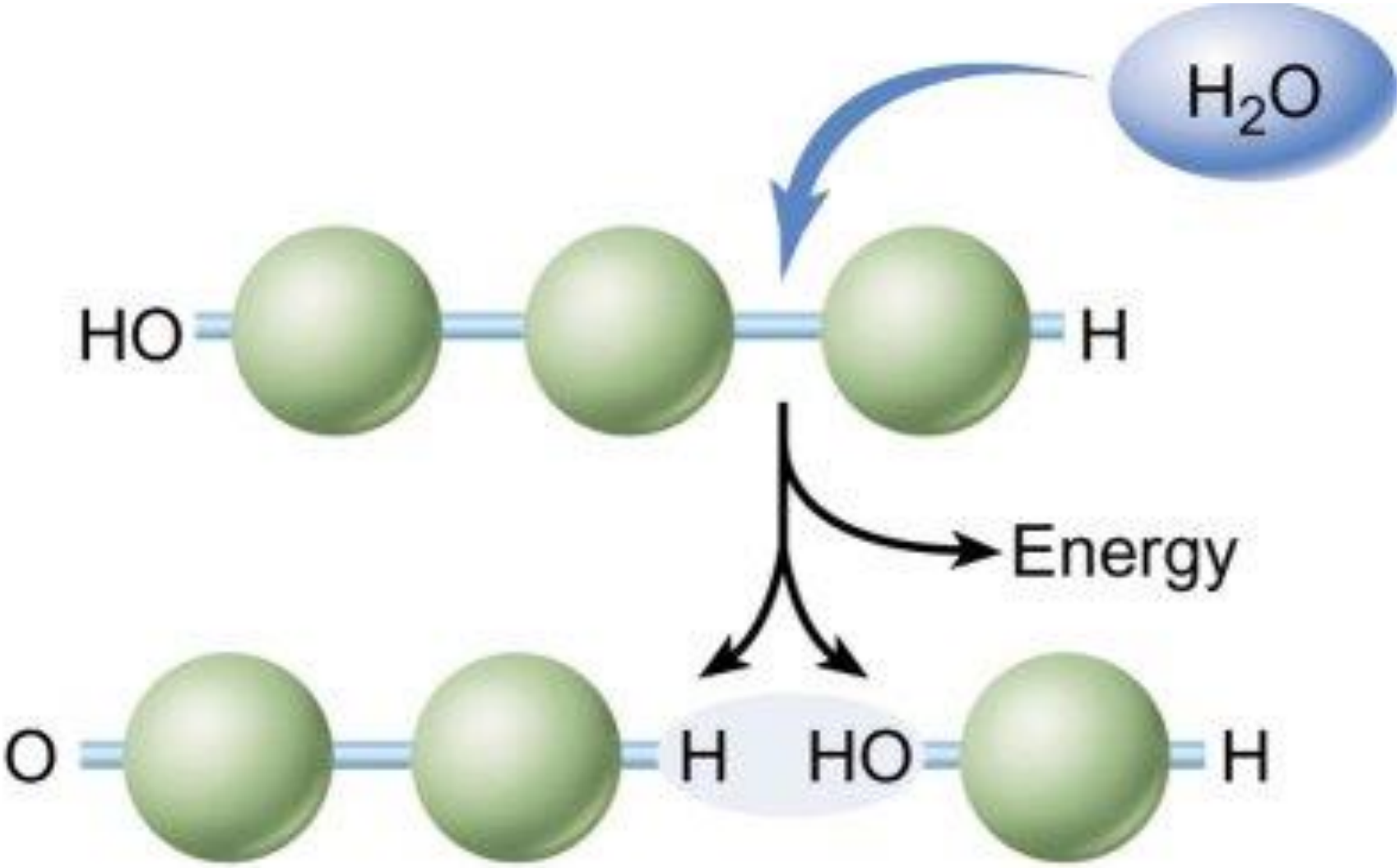

Plant
cell wall

Paper is made by taking water out

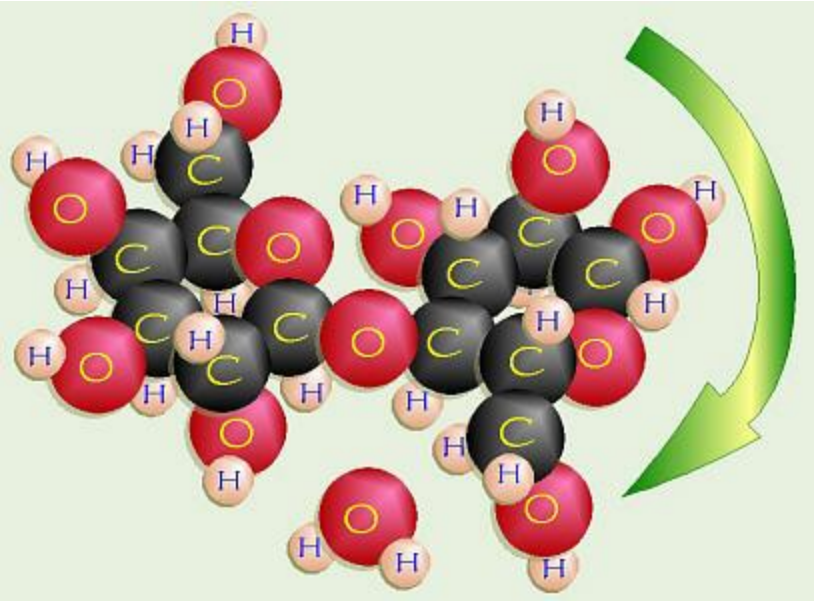


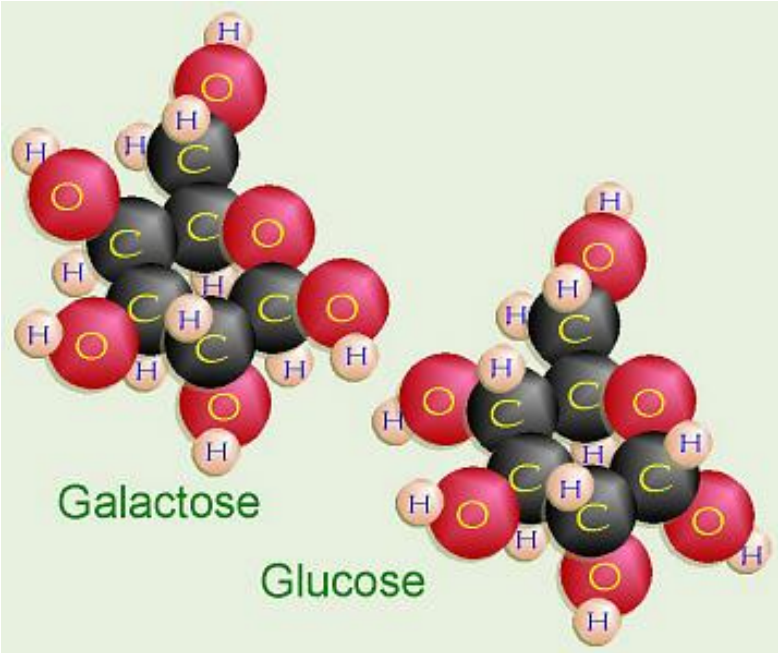
Hydrolysis

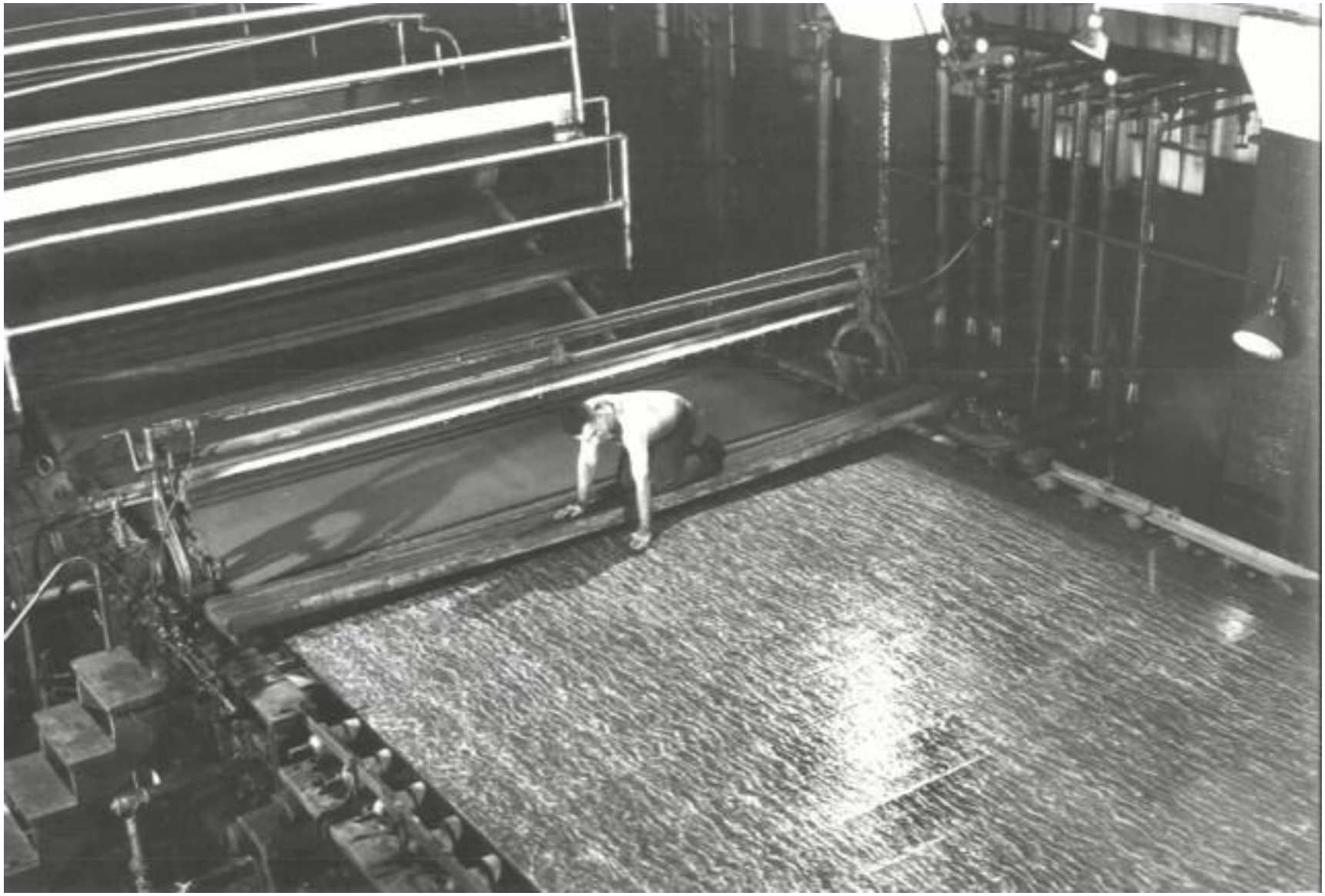
- Breakdown of a polymer by addition of water
- Hydro = water
- Lysis = breaking apart



b) Hydrolysis




Galactose
Glucose



#1 Carbohydrates

- Simple Sugars and polymers of sugars

- Monosaccharides – one sugar (simple)
- Disaccharides – two monosaccharides
- Polysaccharides – polymer of many monosaccharides

Monosaccharides

- Simple sugars
  - General formula is $(CH_2O)_x$
  - Glucose = $C_6H_{12}O_6$
  - Most names end in “ose”

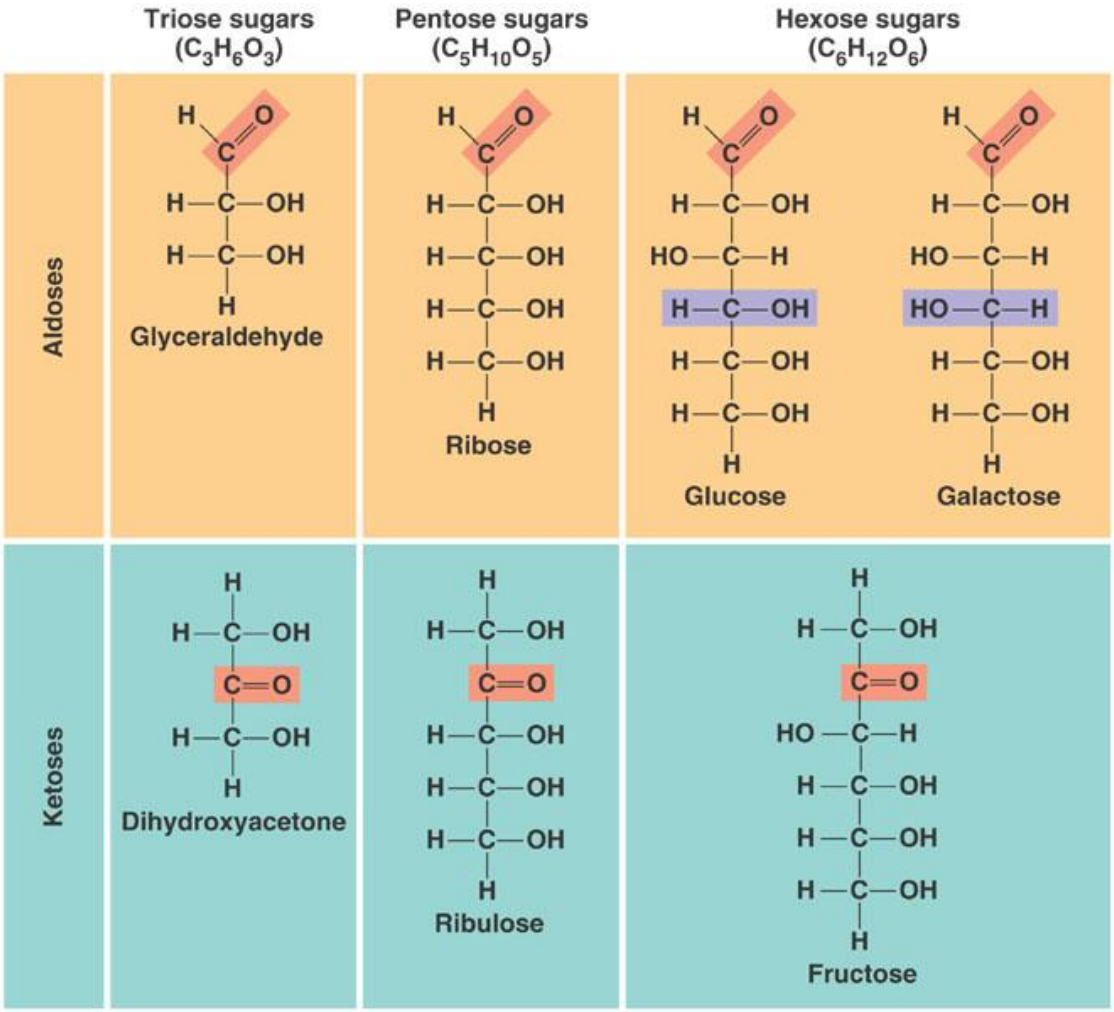
  - Glucose, Galactose, Fructose, Ribose, Ribulose
  - List more!!!!

- Diversity of sugars
  - Number of Carbons
    - 3C triose
    - 5C pentose
    - 6C hexose

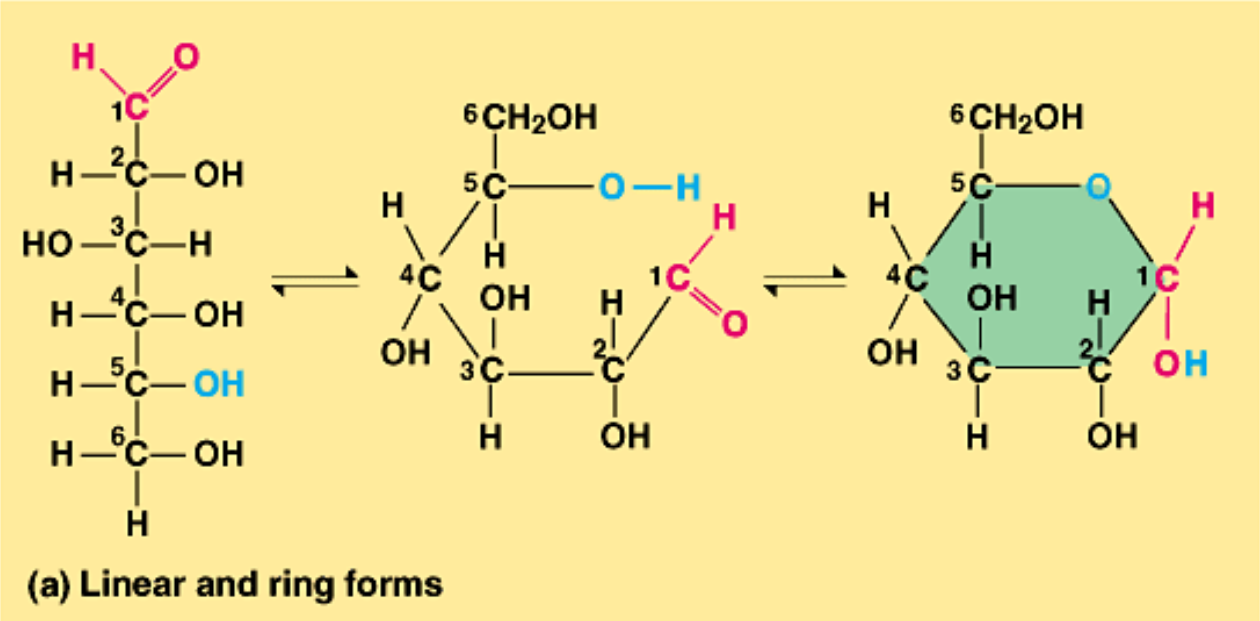
Structure and Classification of some Monosaccharides

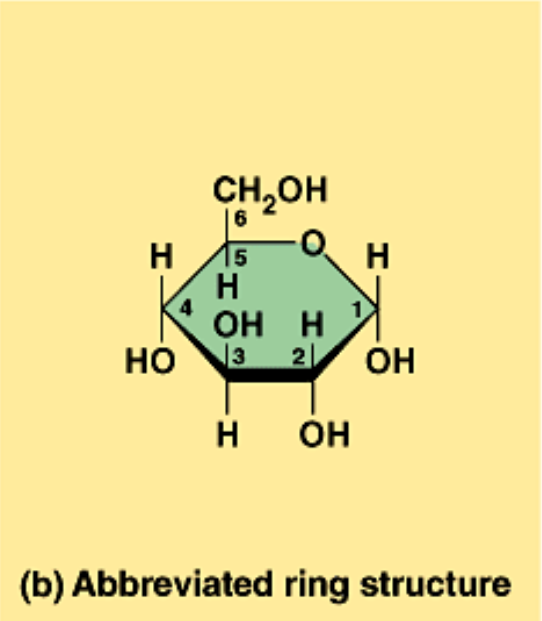
aldoses

ketoses



Linear and ring forms of glucose





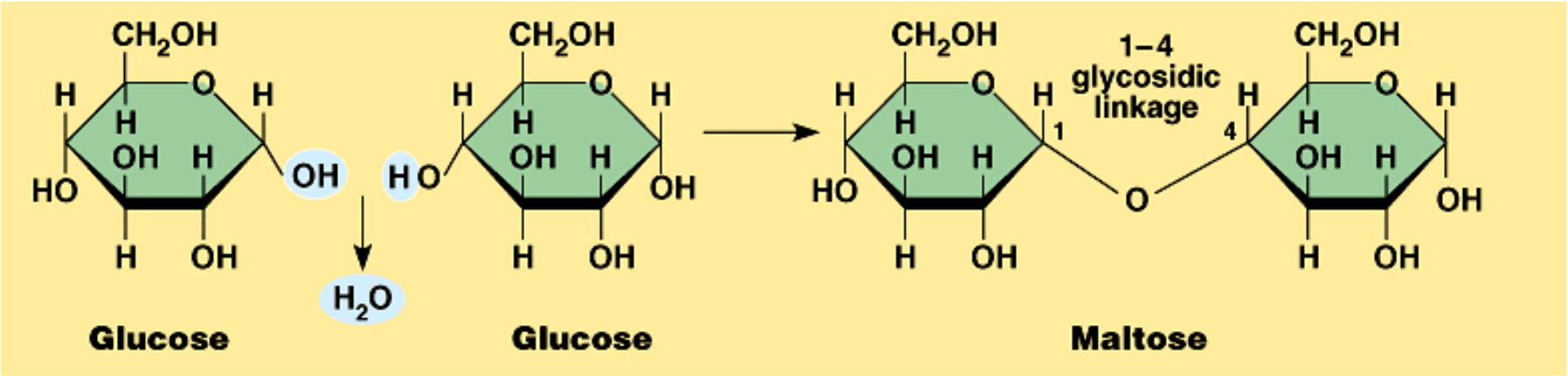
Ring form is present in aqueous solutions

Disaccharides

- Composed of two monosaccharides
- mono = one
- Di = two

Examples of disaccharides

- Maltose



(a) Dehydration synthesis of maltose

Glycosidic linkage between sugar units

Glyco = sweet

Examples of Disaccharides

- Maltose Glucose + Glucose
- Lactose Glucose + Galactose
- Sucrose Glucose + Fructose

Polysaccharides

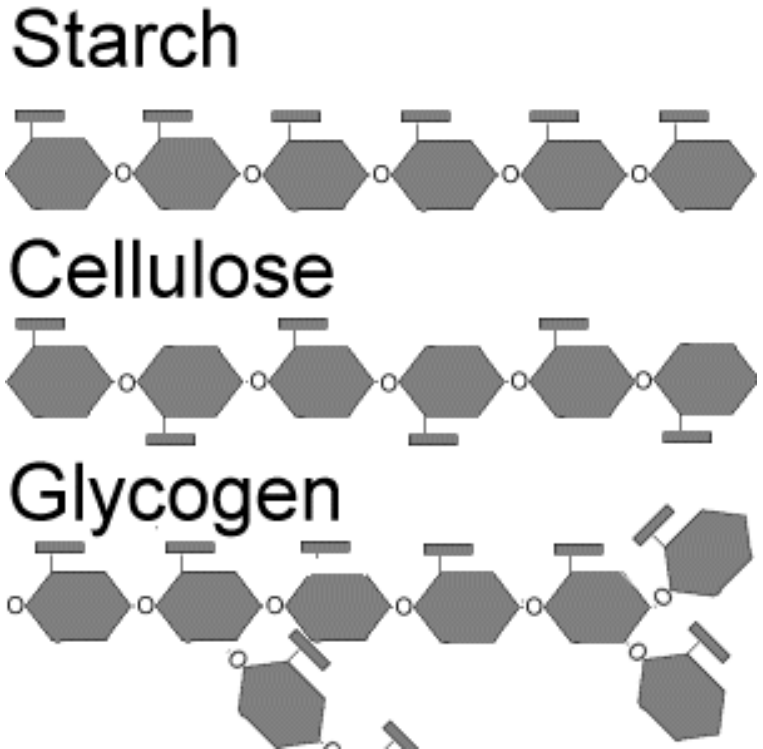
- Polymer of many monosaccharides
  - Hundreds to thousands of monomers strung together
  - Different Functions
    - Storage form of sugar
      - Starch/Glycogen
    - Structural
      - Cellulose/Chitin

Storage Polysaccharides

- Starch - plants
- Glycogen - animals

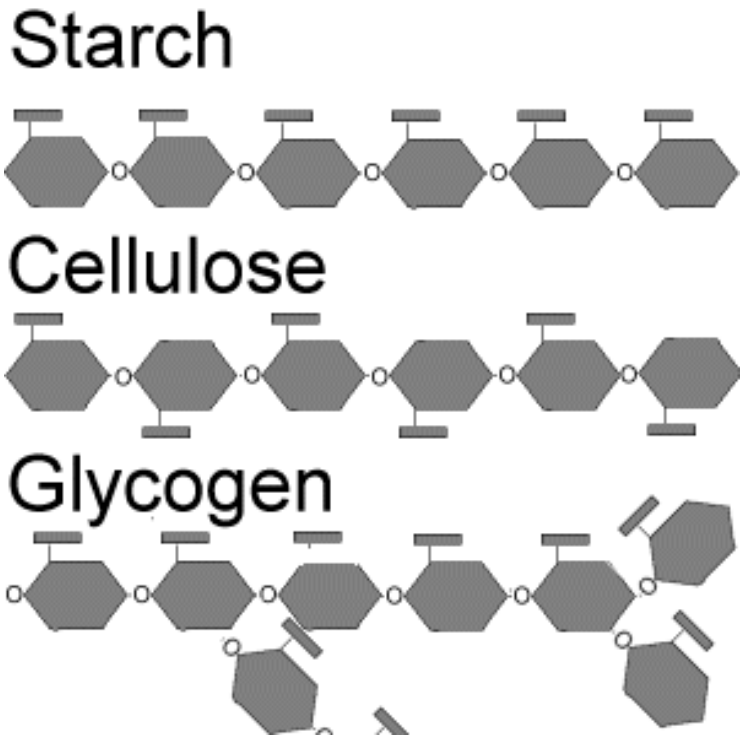
Starch – sugar storage in plants

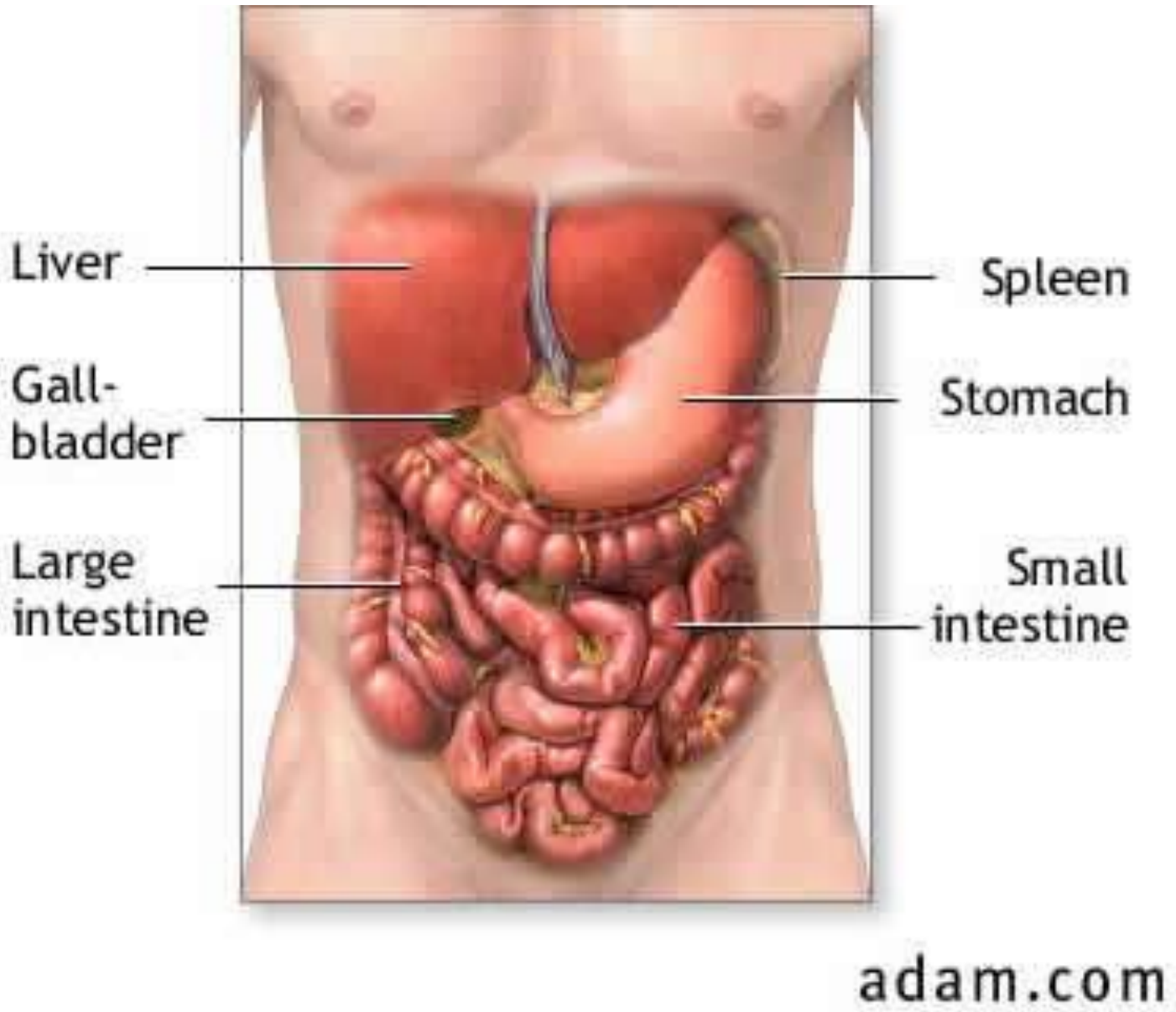
- Starch (Amylose)
  - Composed of glucose monomers (straight chain)



Glycogen – sugar (glucose) storage in animals

- Glycogen
  - Branched polymer
  - Short term storage
  - Liver & muscles



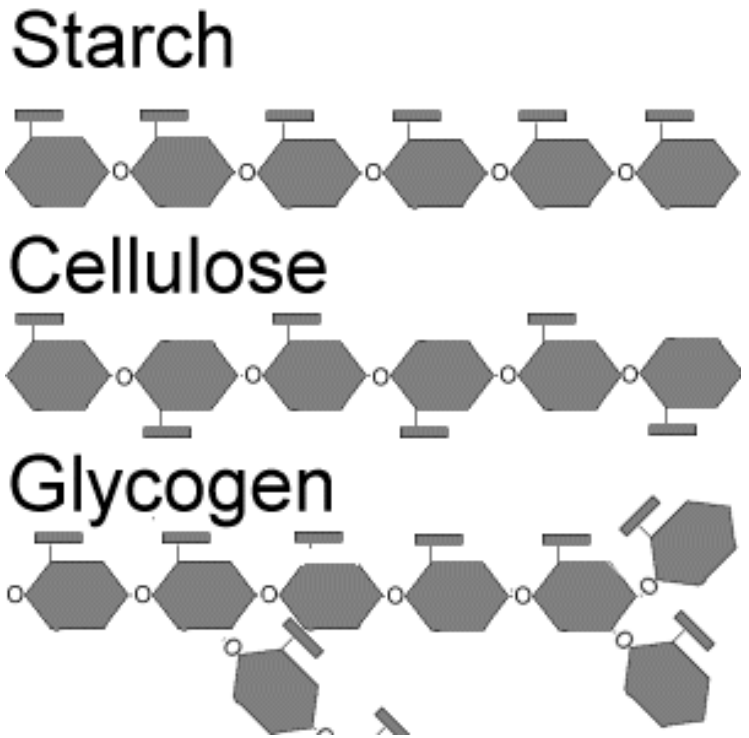

Liver
Gall-
bladder
Large
intestine
Spleen
Stomach
Small
intestine
adam.com

Structural Polysaccharides

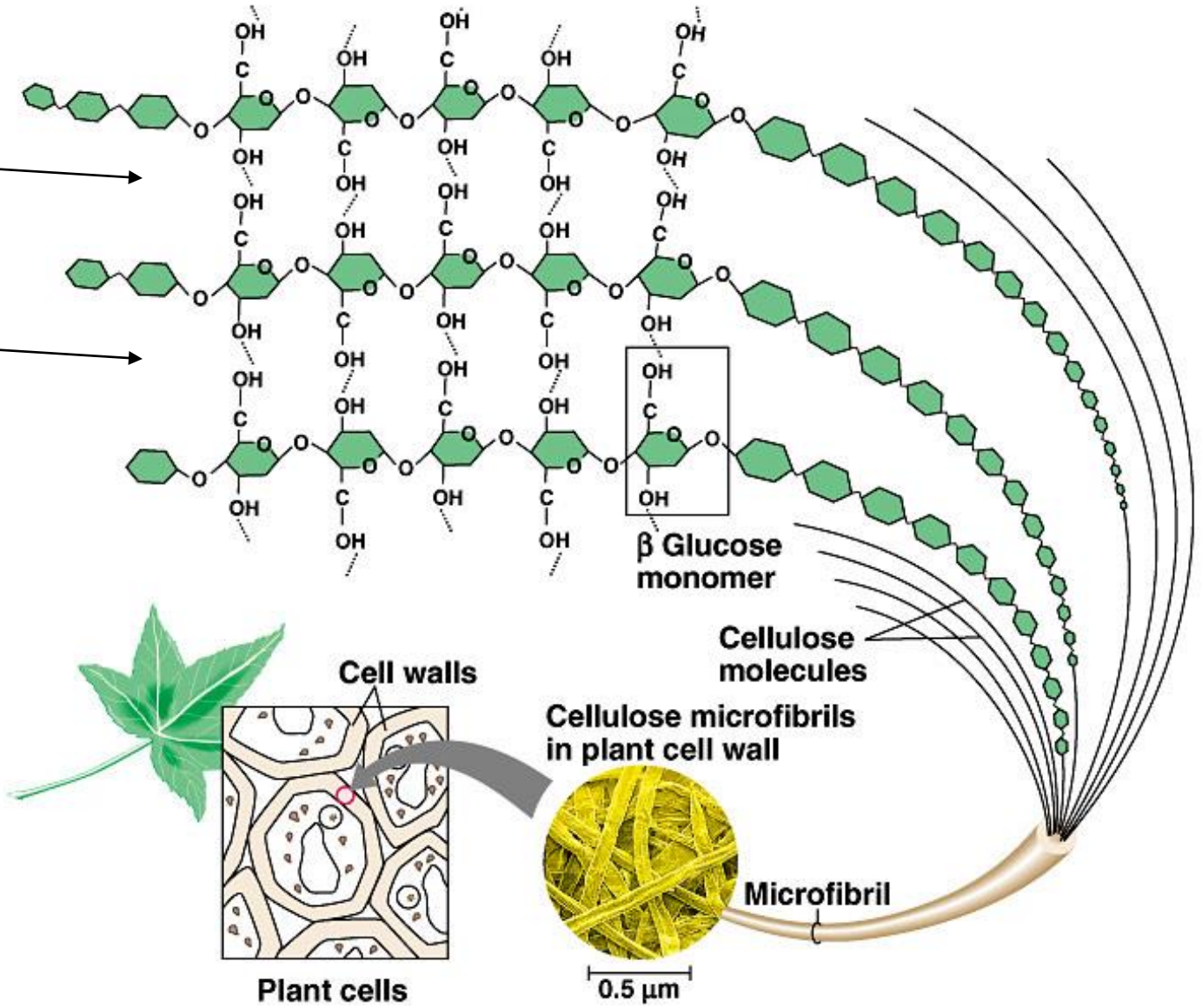
- Cellulose (plants)
- Chitin (some animals)

Cellulose – gives structure to plant cell walls

- Composed of glucose monomers



Arrangement of cellulose in plant cell walls



Cellulose in Celery

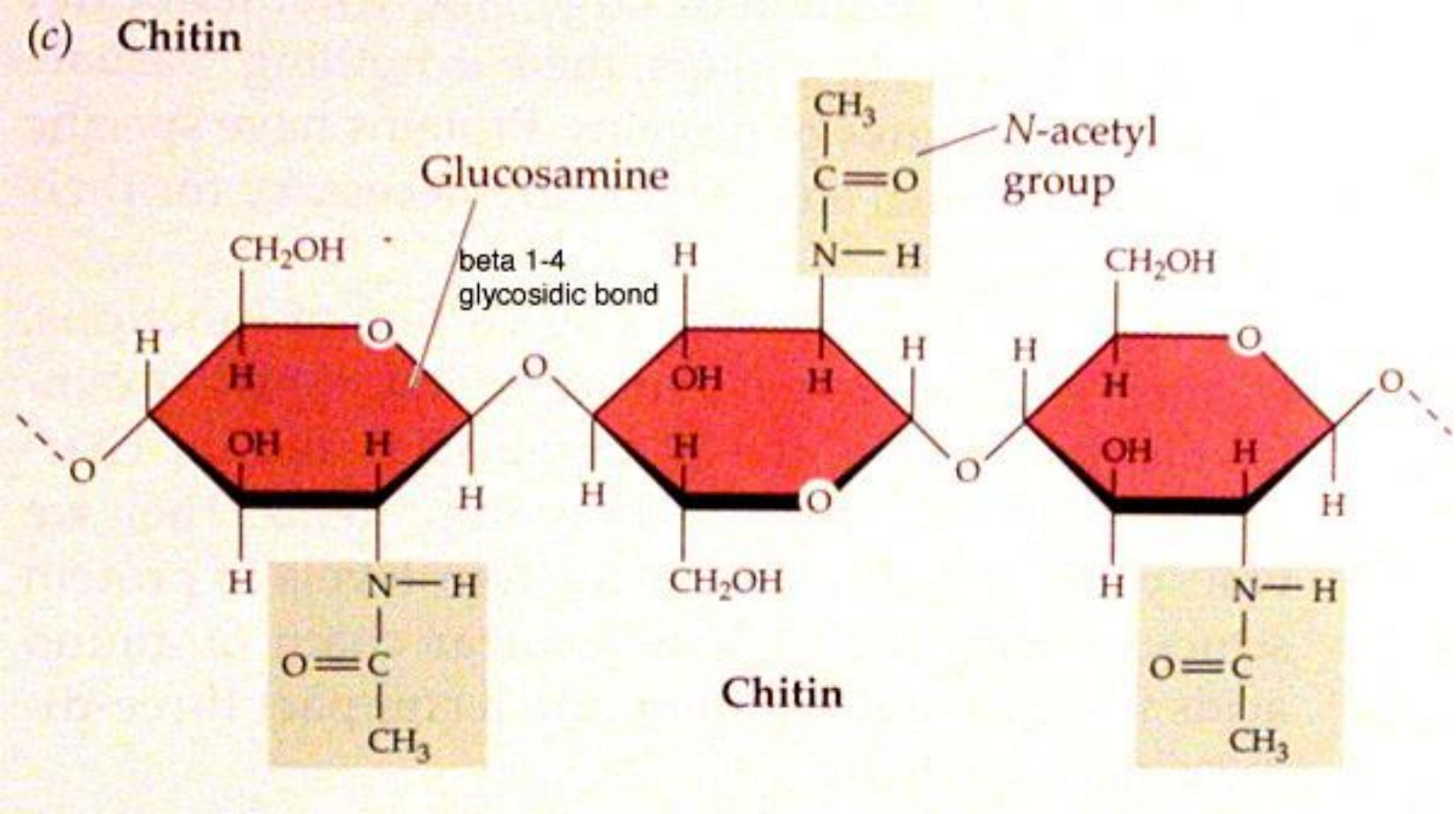
Cellulose has strength!!!

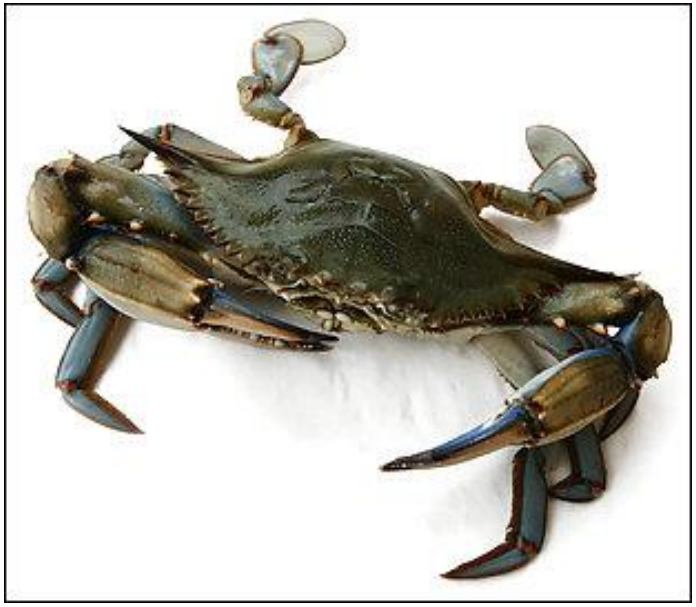
Chitin – give structure to some types of animals

- Composed of a modified glucose
- Found primarily in arthropod exoskeletons

  (insects, spiders, lobsters, crabs, shrimp, etc.)

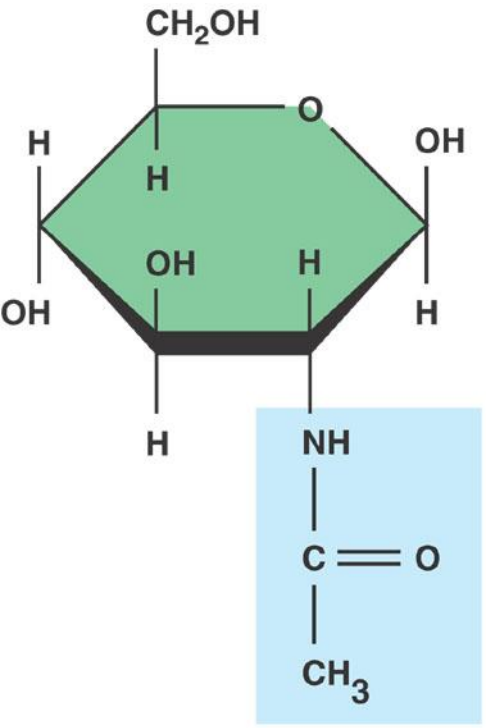
Chitin Structure






cuticle made
of chitin

Chitin, structural polysaccharide

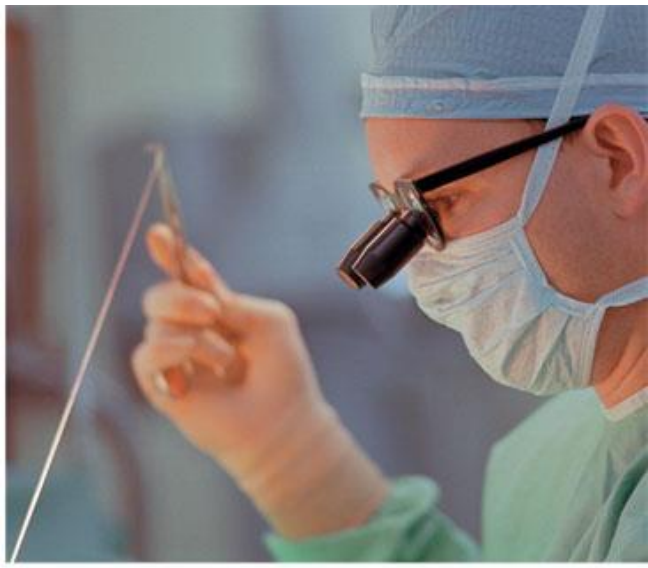


The structure of the chitin monomer

…as insect exoskeleton

…as degradable surgical thread

(b)



(c)

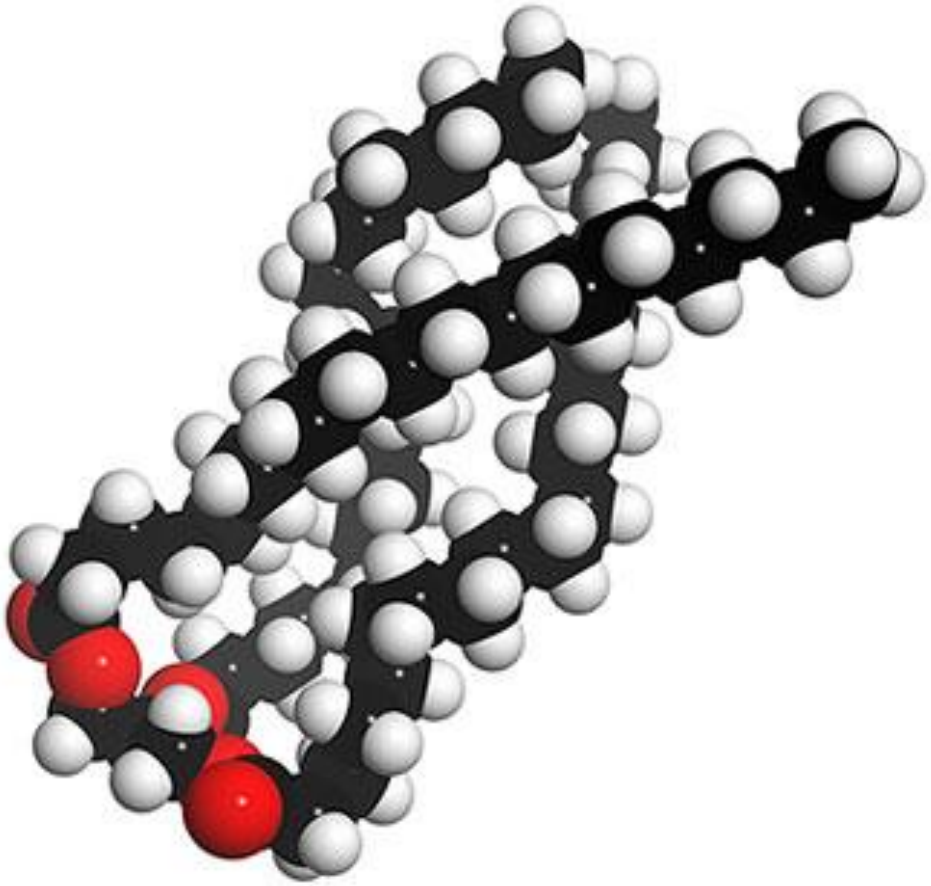
2. Lipids

- The only one of the four macromolecules that is NOT a polymer
  - hydrophobic nature (water-fearing)
  - contains mainly nonpolar covalent bonds
  - polar “head” and hydrophobic “tail”
  - Fats, oils, waxes, steroids
  - Contains C,H,O

Fats & Oils

- Glycerol + fatty acid structure

Fat = triacylglycerol

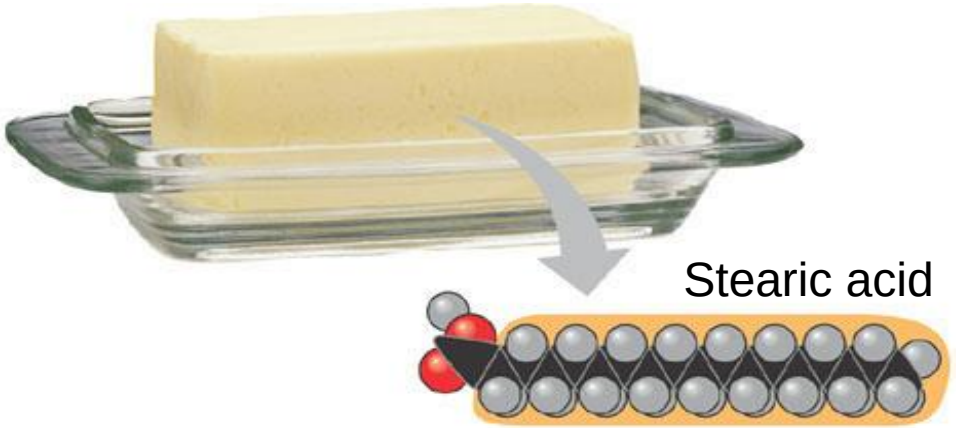


Diversity of Fatty Acids (Fats)

- Different Fats have different numbers of carbon atoms
    - Saturated Fats have no C=C bonds (all single bonds – straight chains)
    - Unsaturated - one or more C=C bonds (a double or triple bond makes the chain crooked

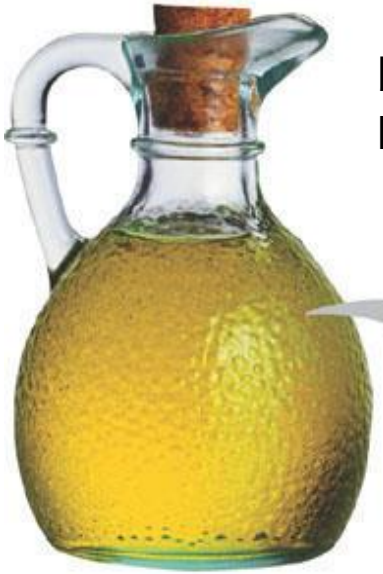
Saturated and unsaturated fats and fatty acids

Saturated fatty acid:
no C=C double bonds
"solids" at room temp.

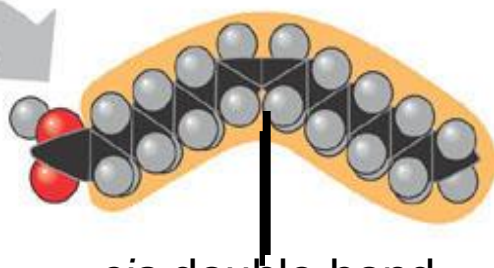


(a) Saturated fat and fatty acid

Unsaturated fatty acid:
C=C double bonds cause kinks that prevent tight packing which keeps the fat liquid.



b) Unsaturated fat and Fatty acid(



Saturated Fats

- Saturated Fats
  - contain saturated fatty acids (all single bonds)
  - most animal fats
  - solid at room temperature
  - A diet rich in saturated fats may contribute to cardiovascular disease (atherosclerosis) through plaque deposits.

Unsaturated Fats

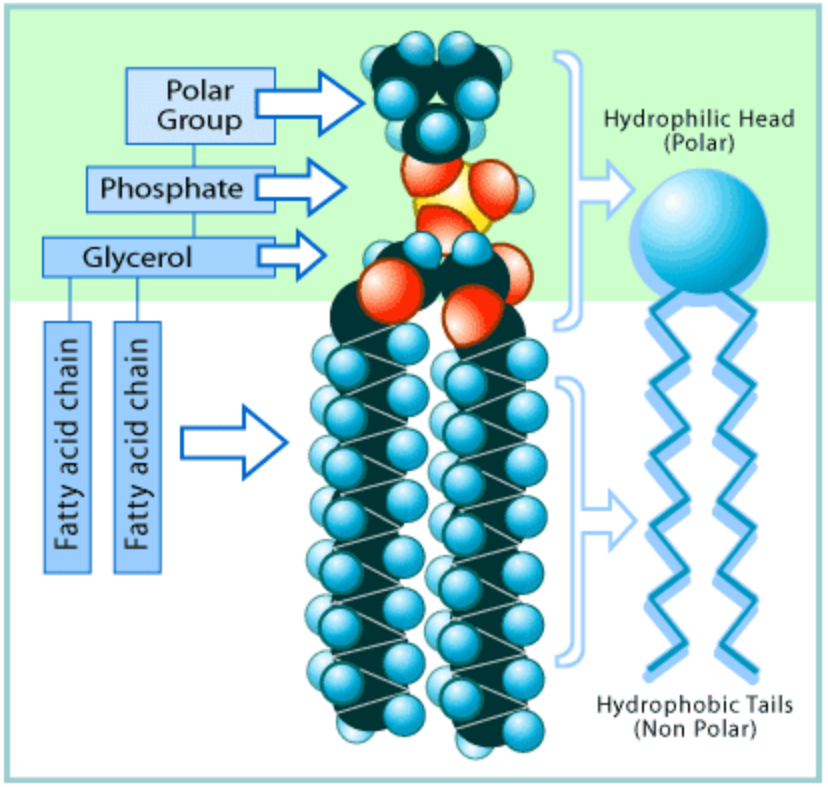
- Unsaturated Fats
  - contain unsaturated fatty acids
  - have at least one C=C double bond
  - Plant and fish fats (oils)
  - Liquid at room temperature

Major Function – energy storage

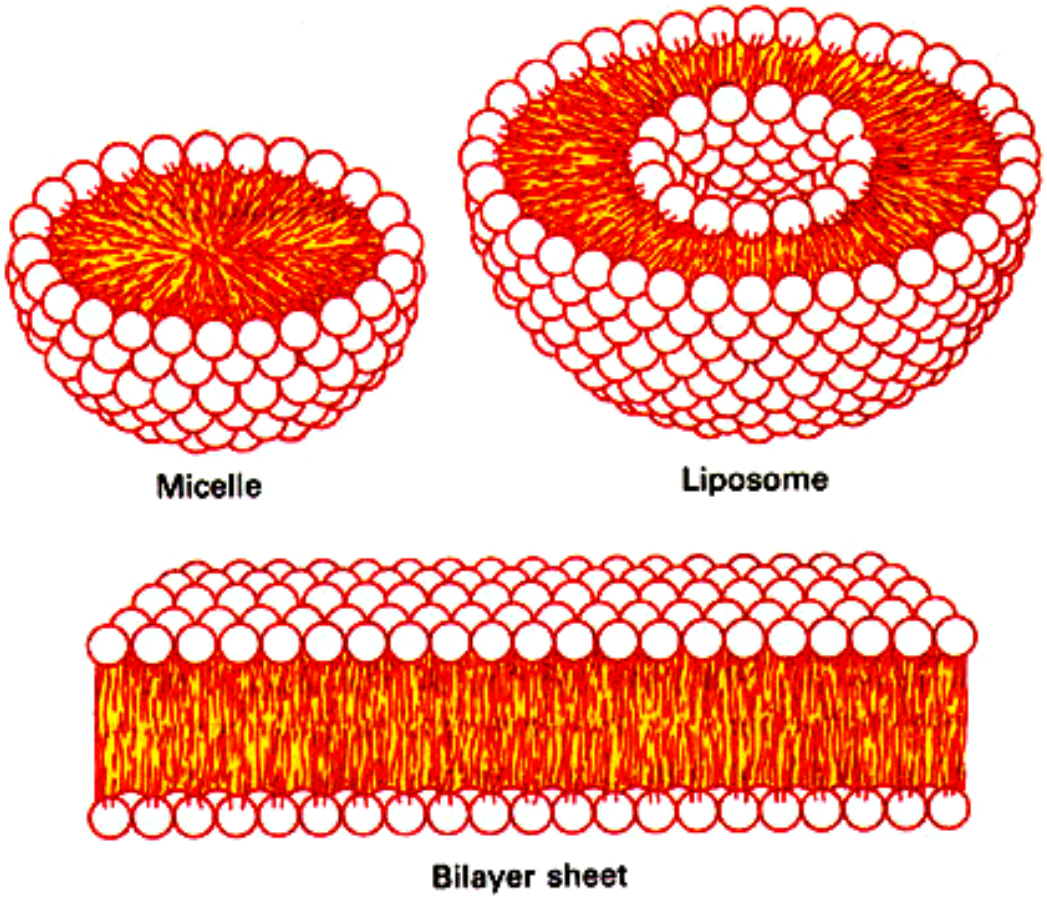
- gram of fat stores twice as much energy a gram of polysaccharide
  - Humans and other mammals store fats as long-term energy reserves in adipose cells.
  - Plants use starch for energy storage when mobility is not a concern but use oils when dispersal and packing is important, as in seeds.
  - functions as insulation (whales, seals, etc.)
  - functions to cushion vital organs
  - Function as insulation around nerves

Phospholipids

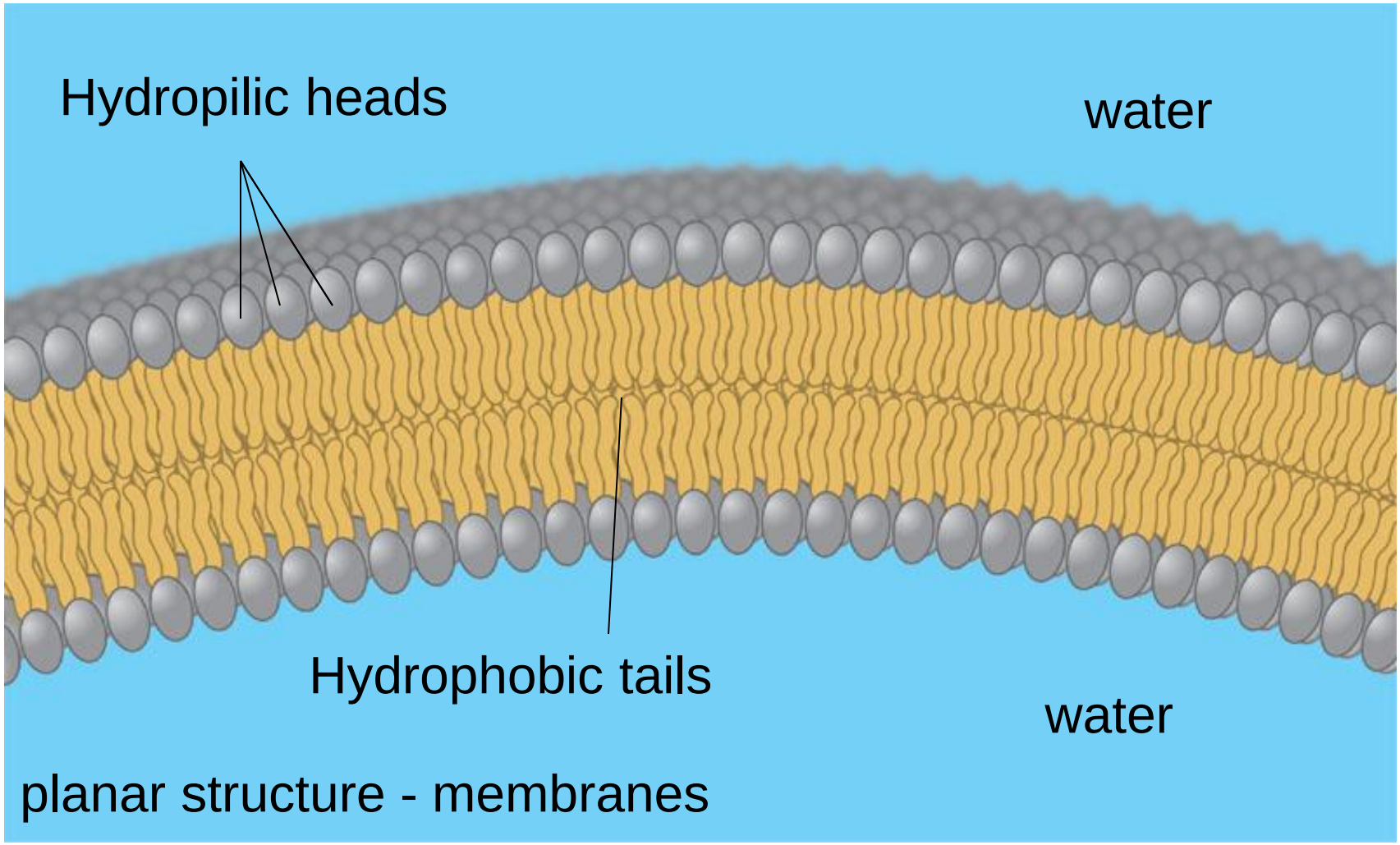
- Polar “head” group
  - One fatty acid replaced by phosphate with another group (polar) attached to it



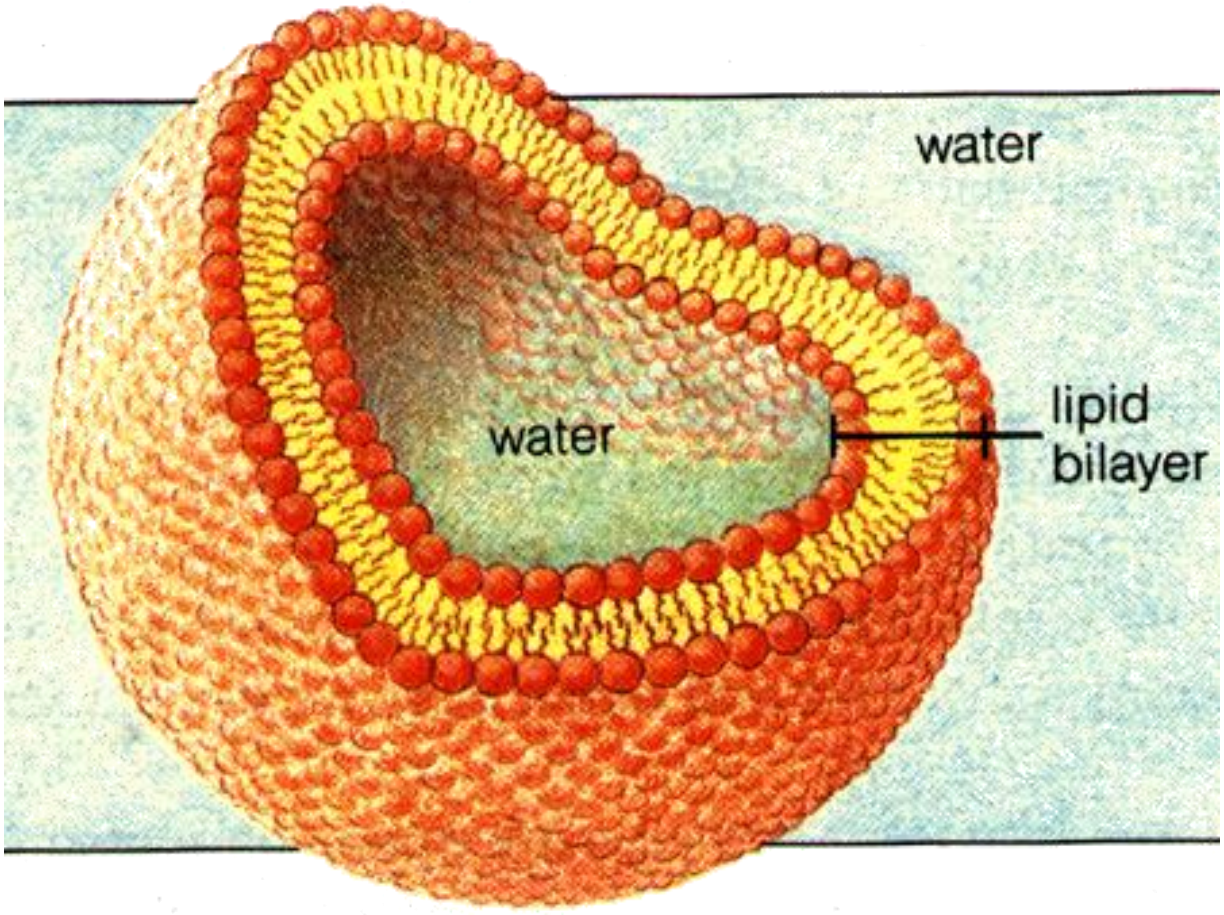
Fats can form structures



Bilayer – membrane structure



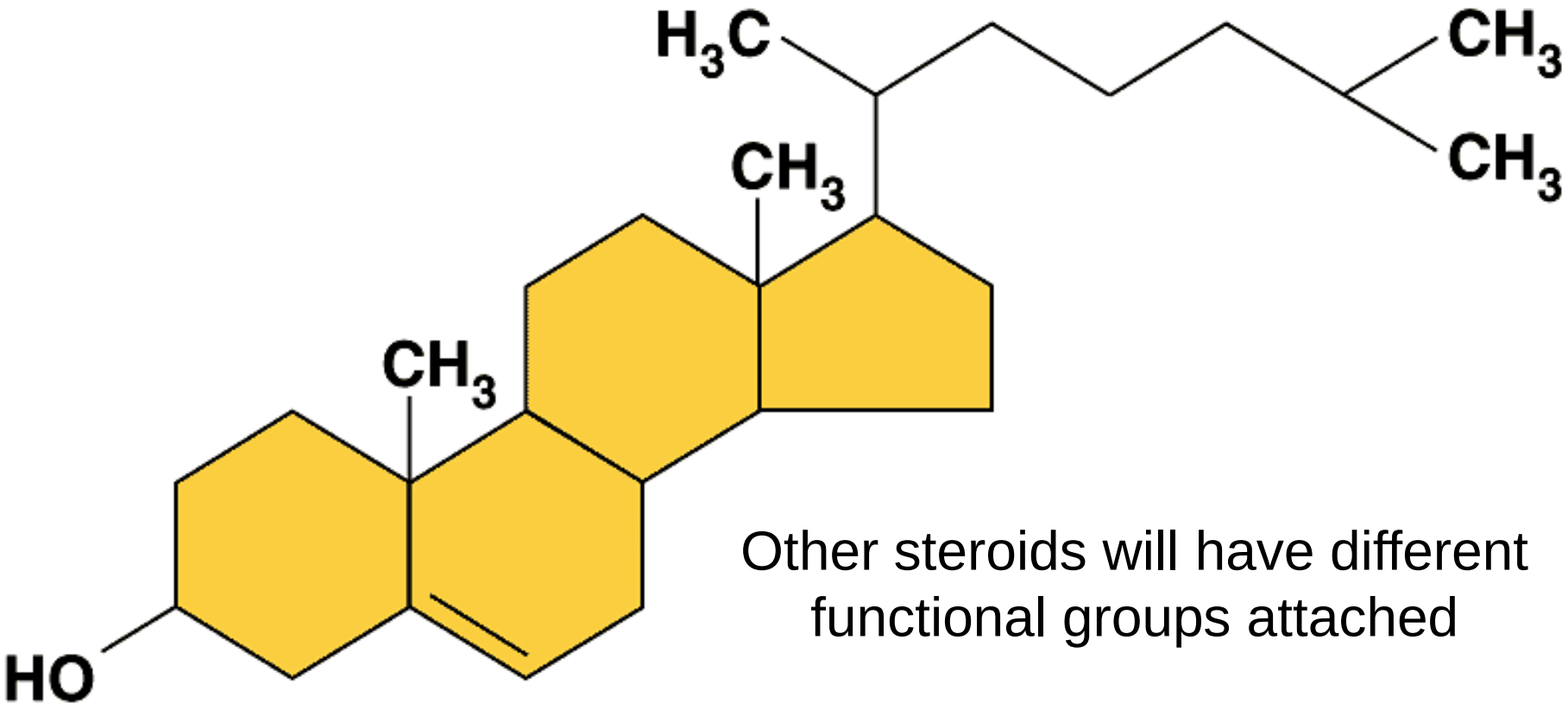
Micelle – like fat globs in dishwater



Steroids (Sterol lipids)

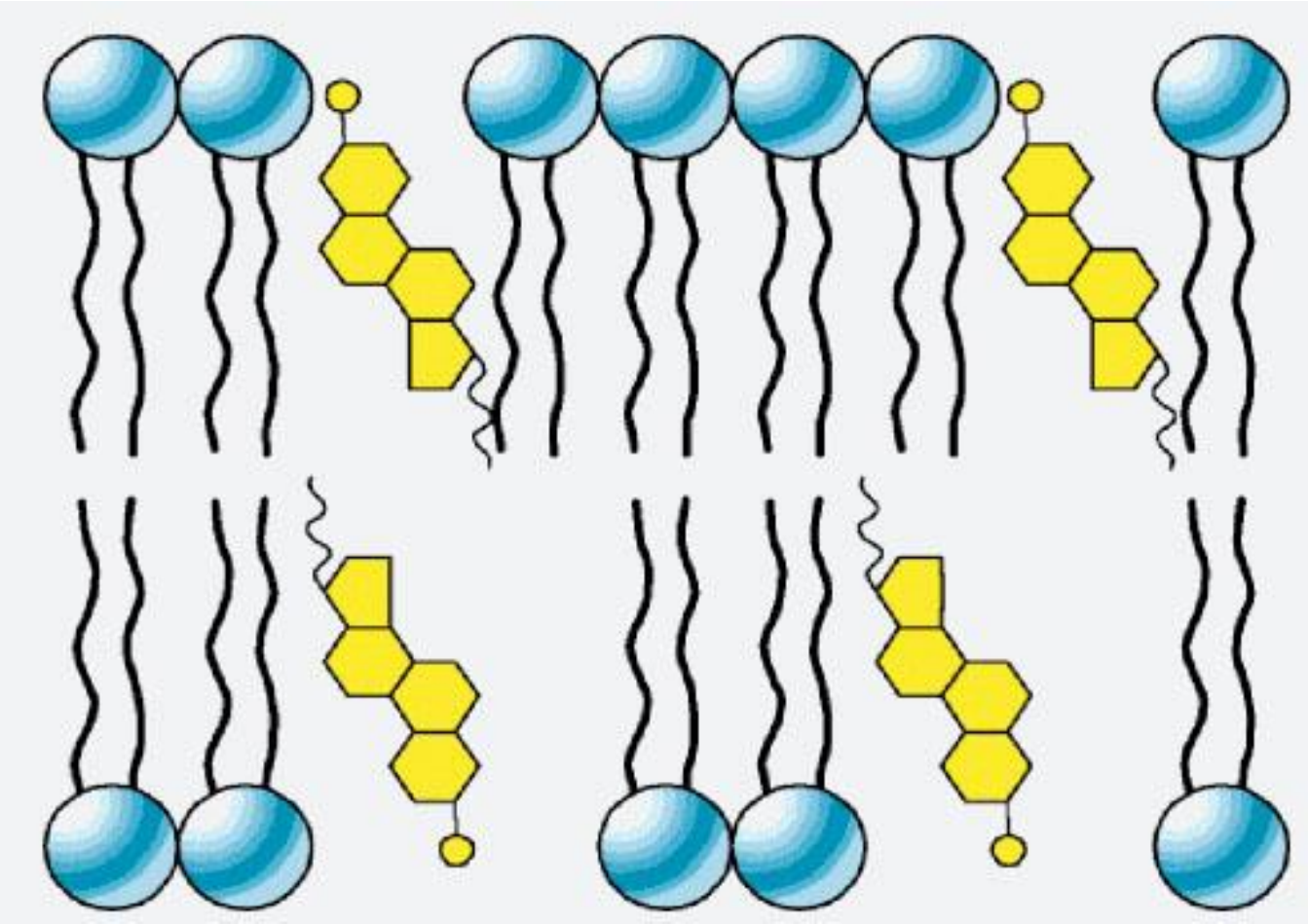
- Carbon-skeleton is four fused rings
- Cholesterol
  - component of animal cell membranes
  - sex hormones
  - an essential molecule, but high levels in blood may contribute to cardiovascular disease

Cholesterol: a steroid

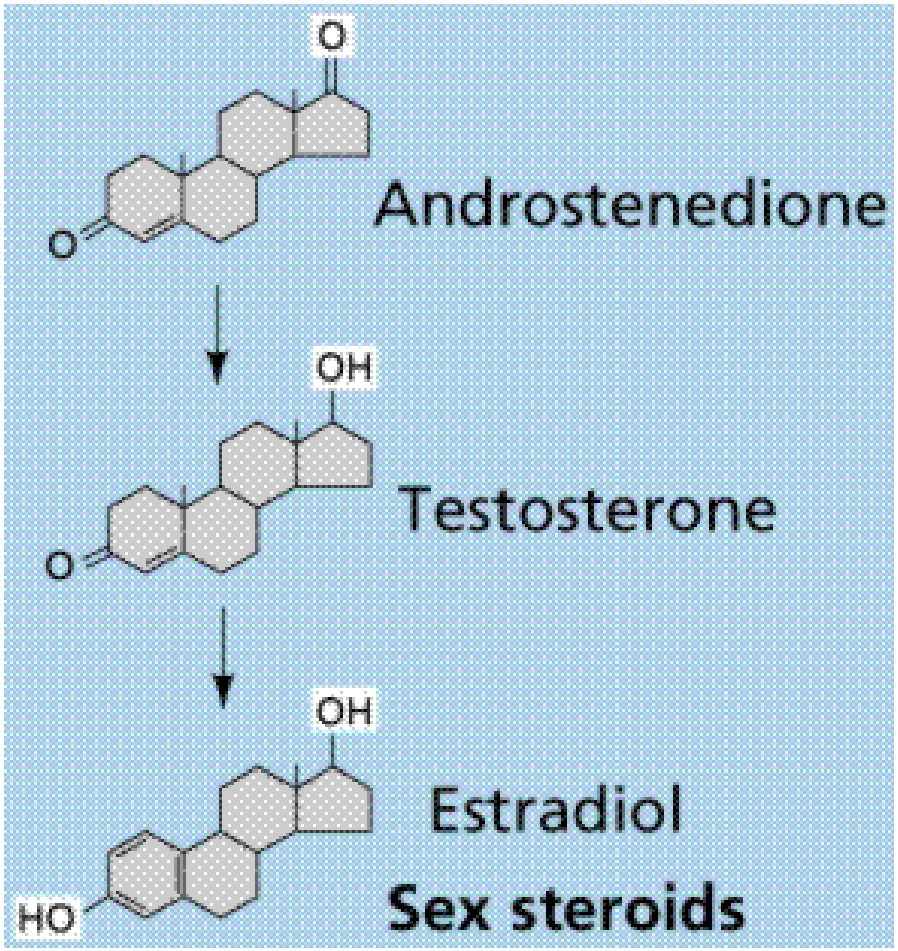


Other steroids will have different functional groups attached

Cholesterol gives cell membranes structure



Testosterone vs Estrogen –tiny difference



Maybe not…

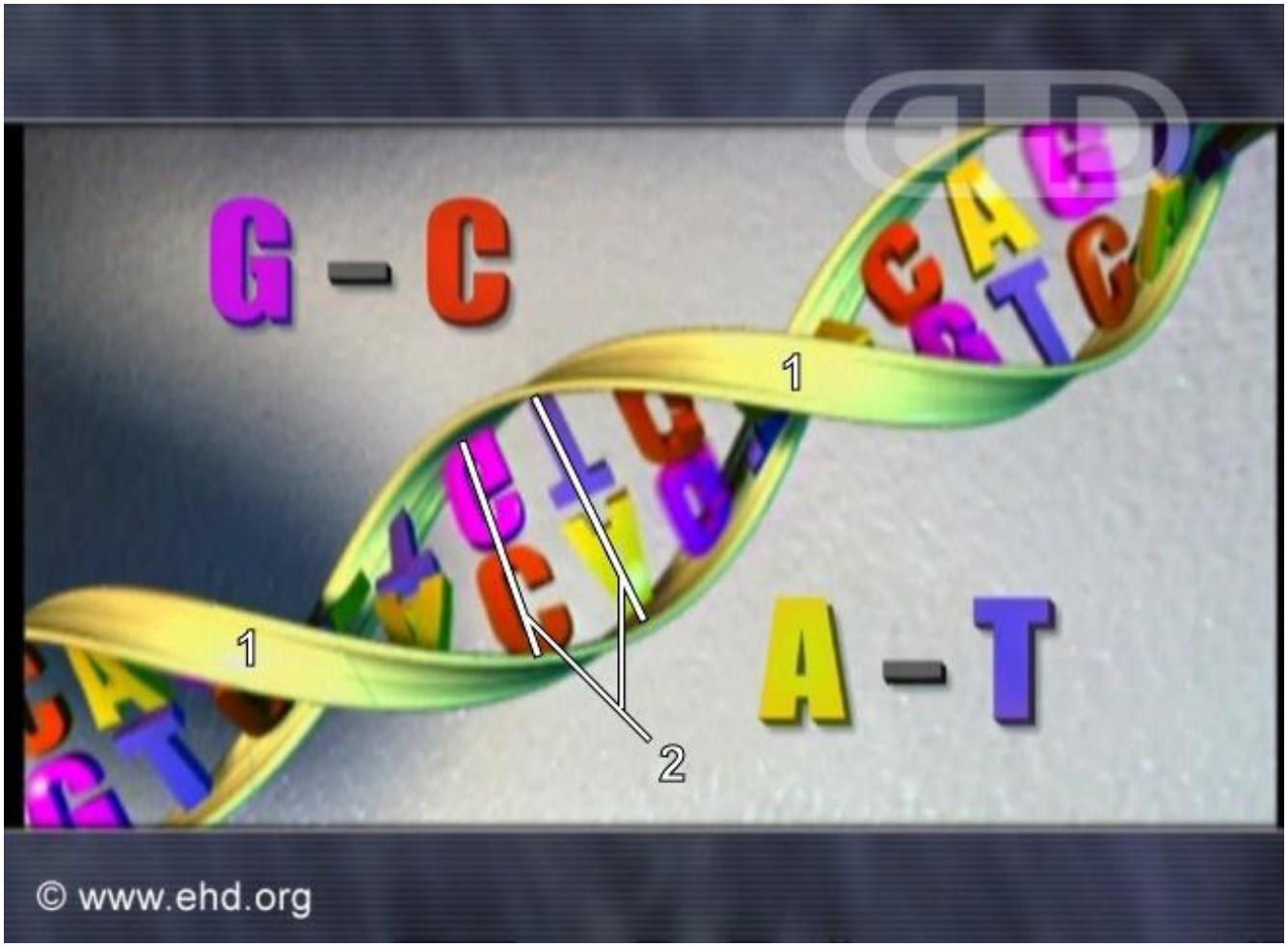
Waxes - protection

…and structure

3. Nucleic Acids

- Polymer of nucleotide monomers
- C,H,O,N,P
- DNA and RNA
- Contain code for life (control cell reproduction and protein manufacture)

DNA



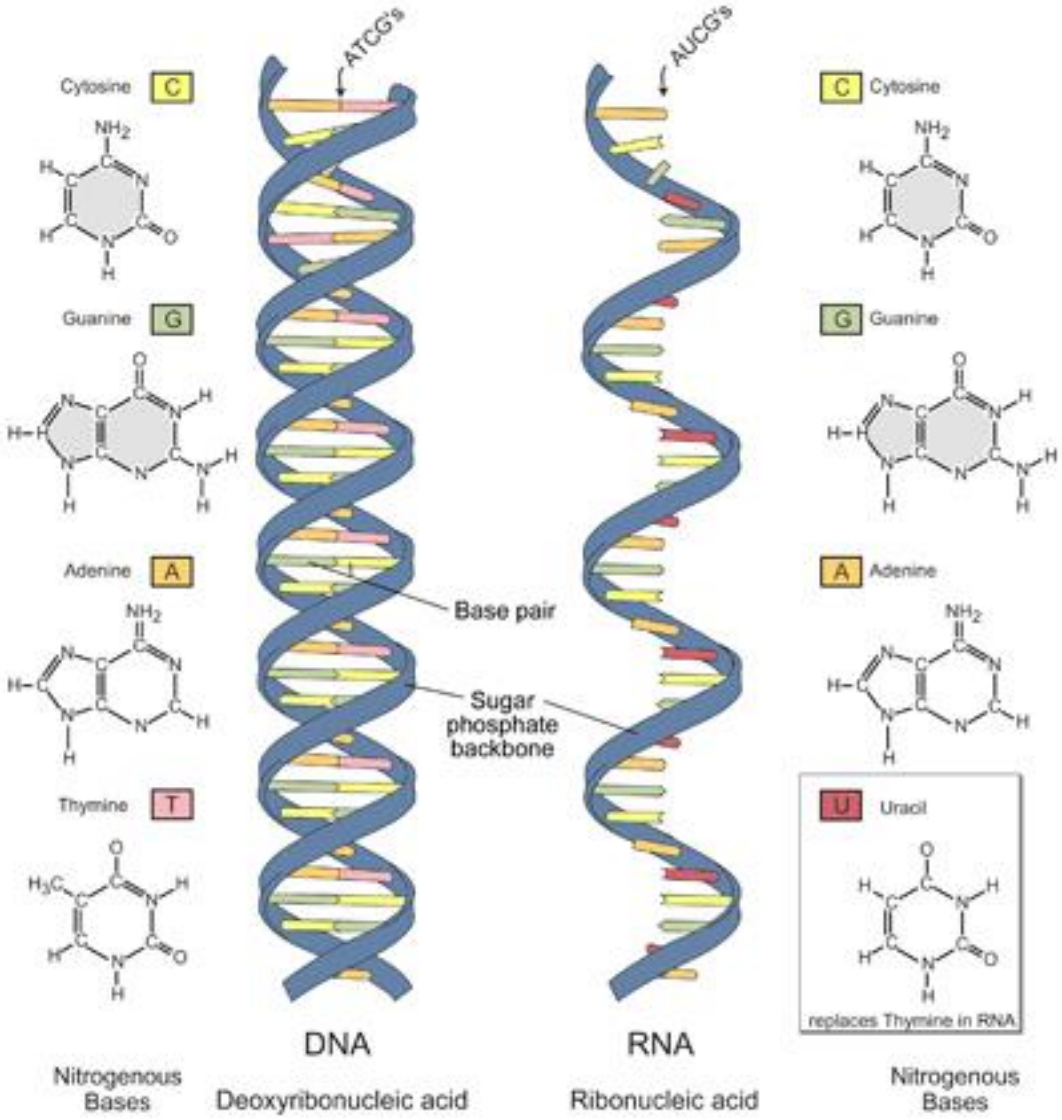
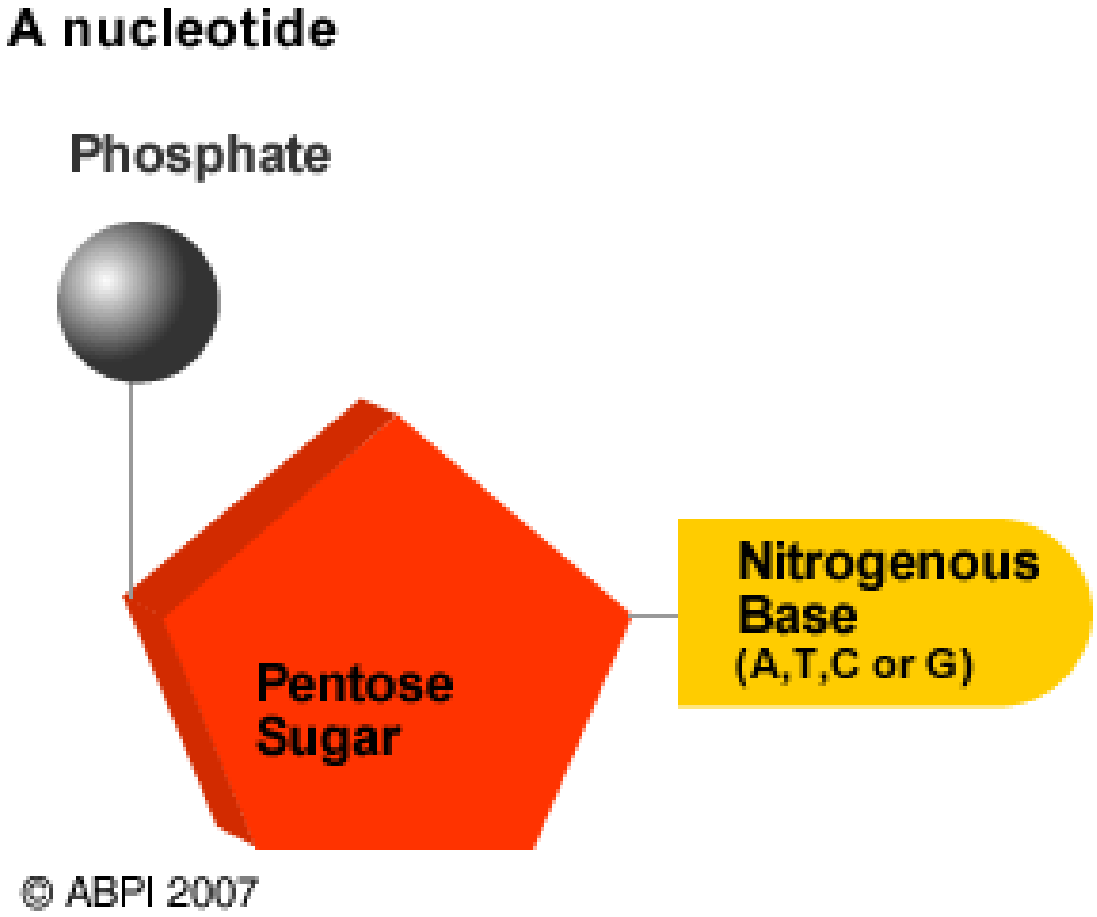
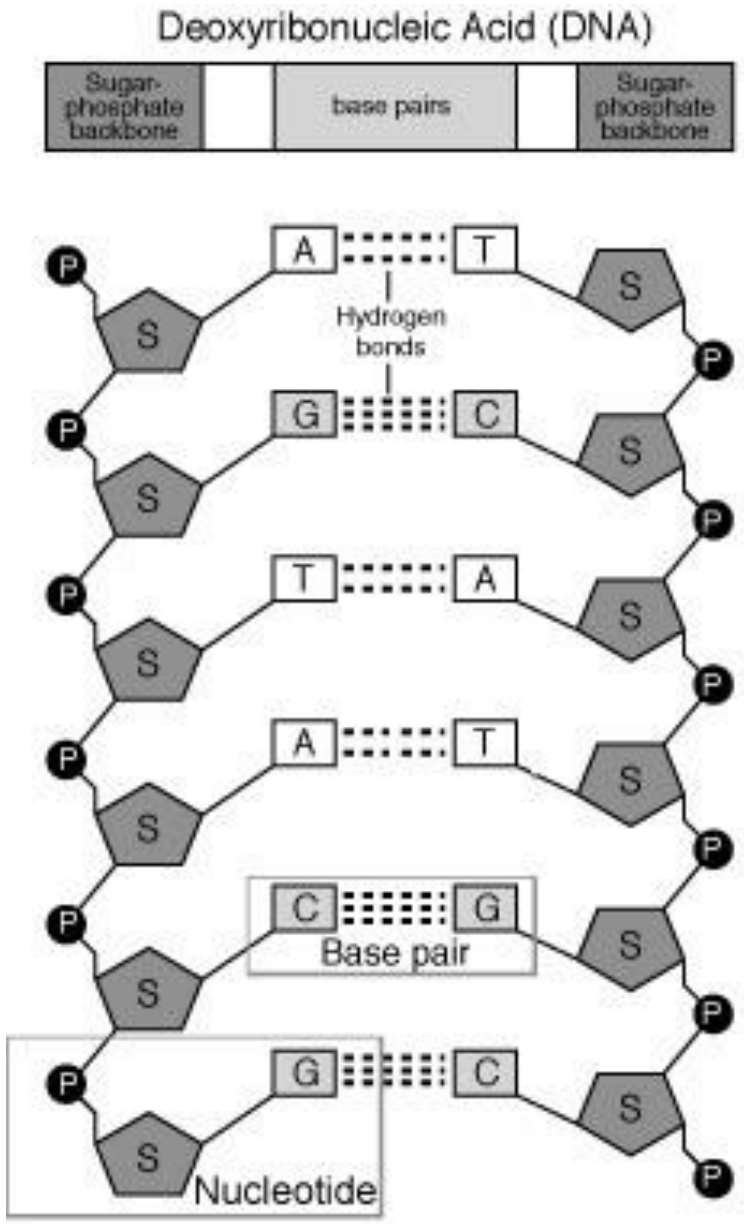


Image adapted from: National Human Genome Research Institute.

Nucleotide monomer



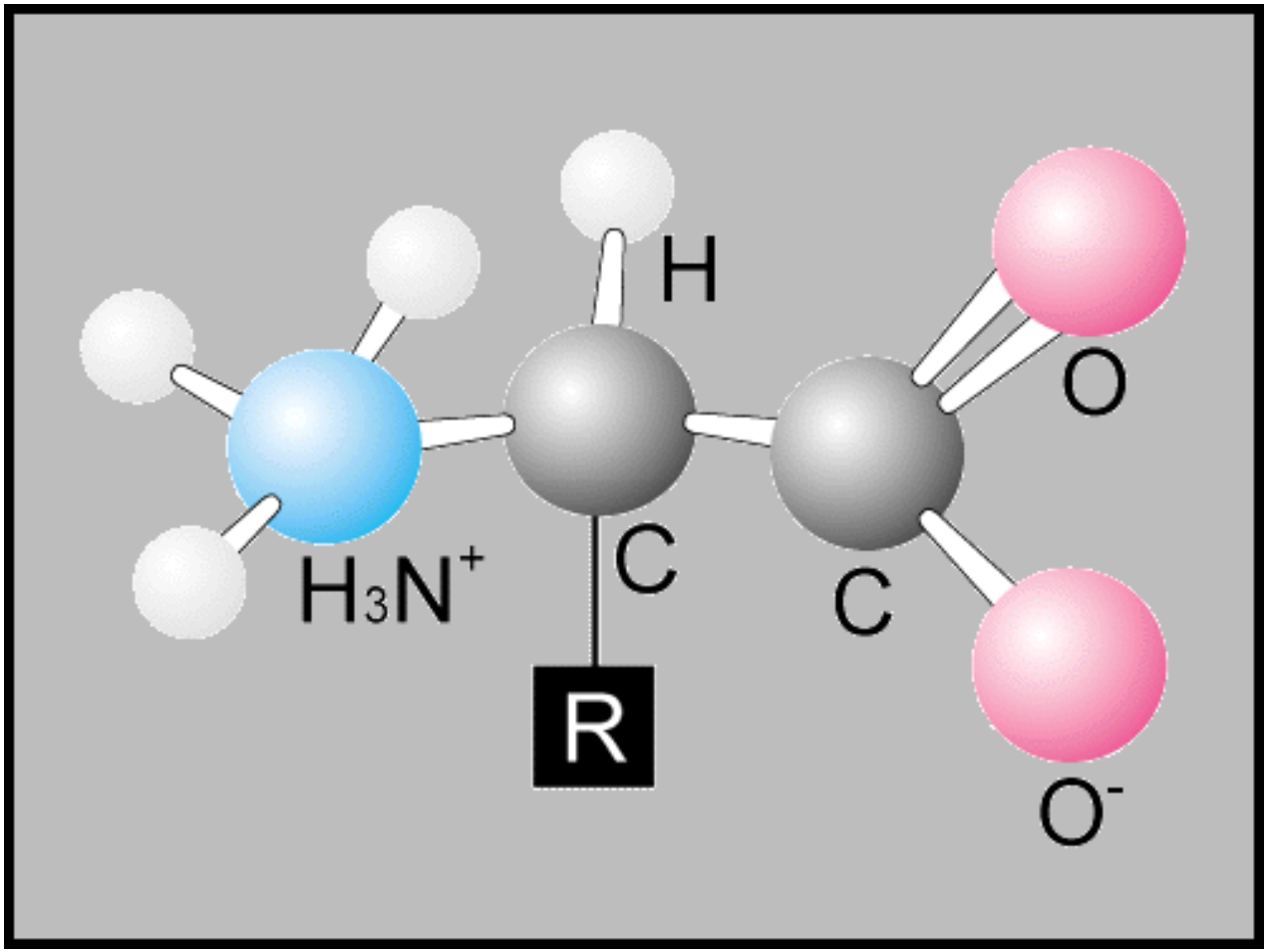
Polymer of
Nucleotides
Chained
Together
To make DNA



Proteins

- Polymer of amino acids held together with peptide bonds
- C,H,O,N
- Many functions
- Muscle tissue, skin, hair, nails, enzymes, etc.

Amino Acid Monomers



Just 20 amino acids make all of our proteins