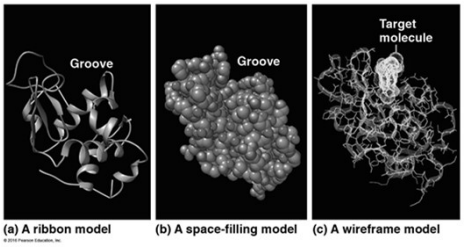


Ch. 3b: The Structure and Function of Macromolecules

You Must Know

- The role of **dehydration synthesis** in the formation of organic compounds and **hydrolysis** in the digestion of organic compounds.
- How the sequence and subcomponents of the four groups of organic compounds determine their properties.
- The cellular functions of carbs, lipids, proteins, and nucleic acids.
- How changes in these organic molecules would affect their function.

You Must Know

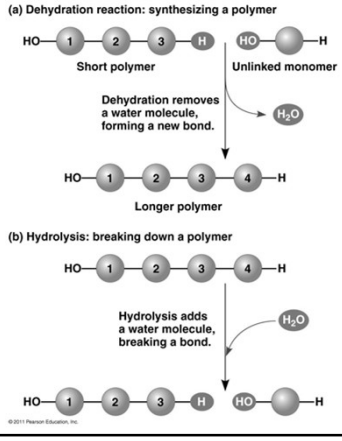
- The 4 structural levels of proteins and how changes at any levels can affect the activity of the protein.
- How proteins reach their final shape (**conformation**), the **denaturing** impact that heat and pH can have on protein structure, and how these changes may affect the organism.
- Directionality influences structure and function of polymers, such as nucleic acids (5' and 3' ends) and proteins (amino and carboxyl ends).

Monomers	Polymers	Macromolecules
•Small organic •Used for building blocks of polymers •Connects with condensation reaction (dehydration synthesis)	•Long molecules of monomers •With many identical or similar blocks linked by covalent bonds	•Giant molecules •2 or more polymers bonded together

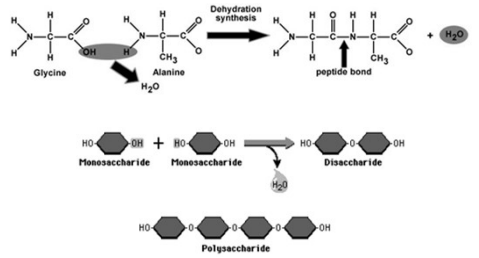
ie. amino acid → peptide → polypeptide → protein

smaller ⟶ **larger**

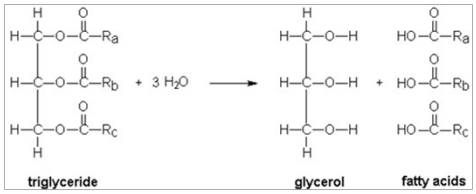
Dehydration Synthesis (Condensation Reaction)	Hydrolysis
Make polymers	Breakdown polymers
Monomers → Polymers	Polymers → Monomers
A + B → AB	AB → A + B
□ + □ ⟶ □ + H_2O	□ + H_2O ⟶ □ + □



Dehydration Synthesis



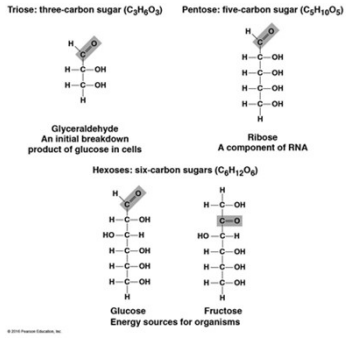
Hydrolysis



I. Carbohydrates

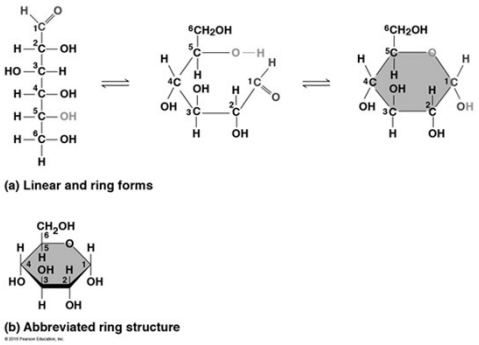
- **Fuel** and **building material**
- Include simple sugars (fructose) and polymers (starch)
- Ratio of 1 carbon: 2 hydrogen: 1 oxygen or CH_2O
- monosaccharide → disaccharide → polysaccharide
- Monosaccharides = monomers (eg. glucose, ribose)
- Polysaccharides:
  - Storage (plants-starch, animals-glycogen)
  - Structure (plant-cellulose, arthropod-chitin)

} Differ in position & orientation of glycosidic linkage

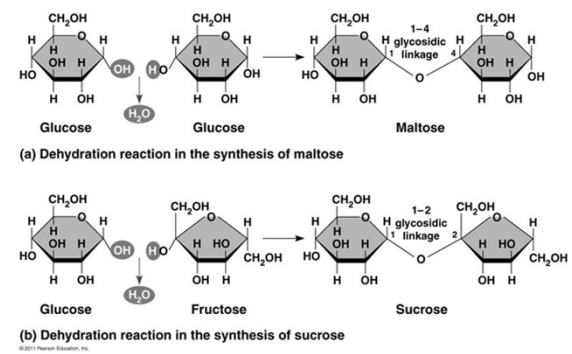


The structure and classification of some monosaccharides

An OH group is attached to each carbon except one, which is double bonded to an oxygen (carbonyl).



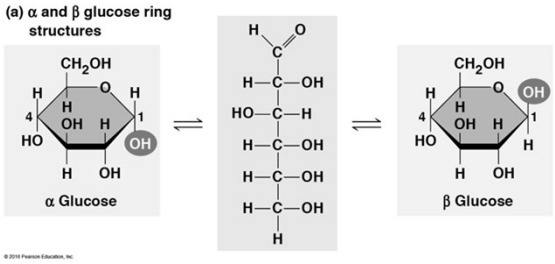
Linear and ring forms of glucose



Carbohydrate synthesis (disaccharides)
Bond = glycosidic

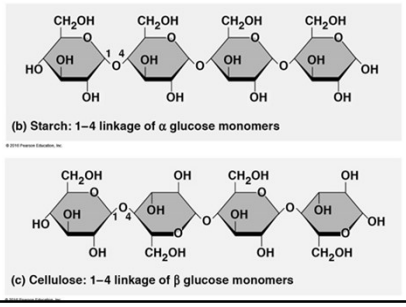
Polysaccharides
Cellulose vs. Starch

Two Forms of Glucose: α glucose & β glucose

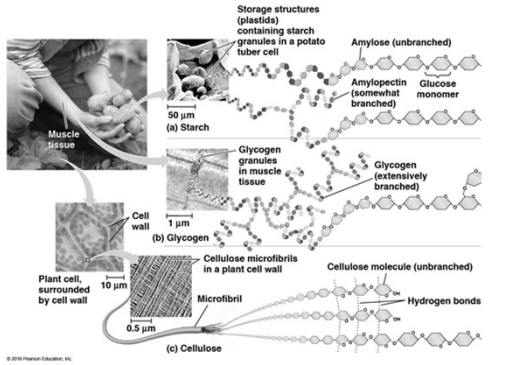


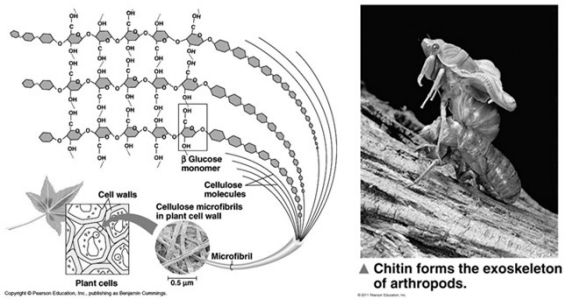
Cellulose vs. Starch

- Starch = α glucose monomers
- Cellulose = β glucose monomers



Storage polysaccharides of plants (starch) and animals (glycogen)





Structural polysaccharides: cellulose & chitin (exoskeleton)

IV. Lipids

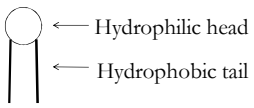
1. Structure: Greasy or oily nonpolar compounds
2. Functions:
3. Energy storage
4. Membrane structure
5. Protecting against desiccation (drying out).
6. Insulating against cold.
7. Shock-absorbers.
8. Regulating cell activities by hormone actions.

IV. Lipids

A. Fats (triglyceride): store energy
- Glycerol + 3 Fatty Acids
- saturated, unsaturated, polyunsaturated

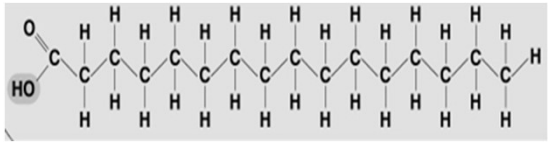
B. Steroids: cholesterol and hormones

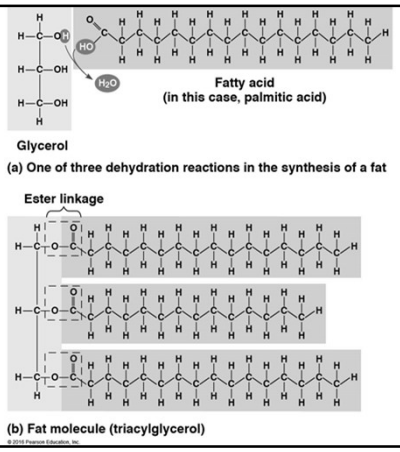
C. Phospholipids: lipid bilayer of cell membrane
- **hydrophilic head**, **hydrophobic tails**

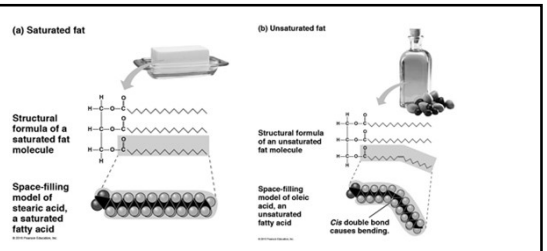


1. Structure of Fatty Acids

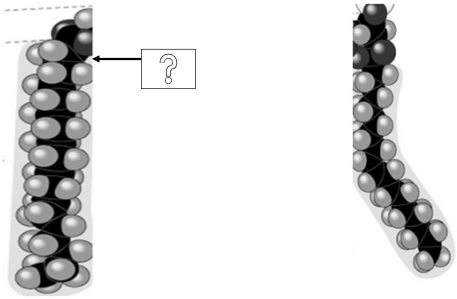
1. Long chains of mostly carbon and hydrogen atoms with a -COOH group at one end.
2. When they are part of lipids, the fatty acids resemble long flexible tails.

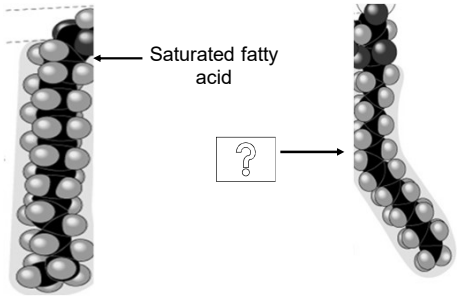


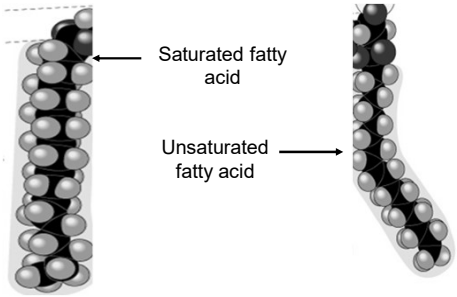




Saturated	Unsaturated	Polyunsaturated
"saturated" with H	Have some C=C, result in kinks	
In animals	In plants	
Solid at room temp.	Liquid at room temp.	
Eg. butter, lard	Eg. corn oil, olive oil	

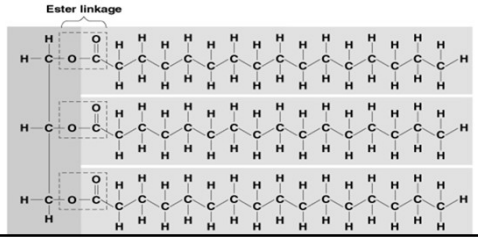






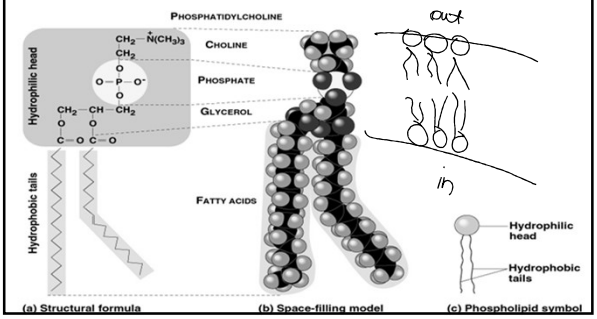
2. Structure of Triglycerides

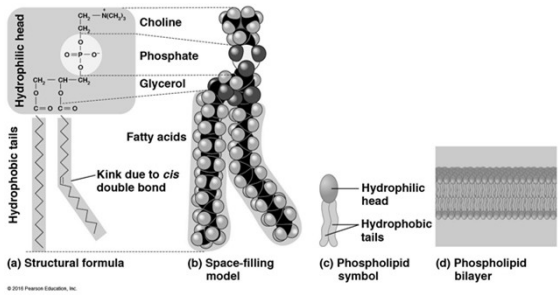
1. Glycerol + 3 fatty acids
2. 3 ester linkages are formed between a hydroxyl group of the glycerol and a carboxyl group of the fatty acid.



3. Phospholipids

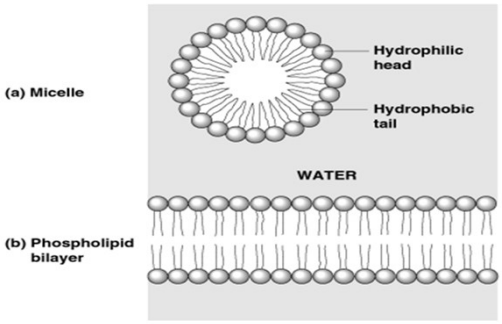
1. Structure: Glycerol + 2 fatty acids + phosphate group.
2. Function: Main structural component of membranes, where they arrange in bilayers.



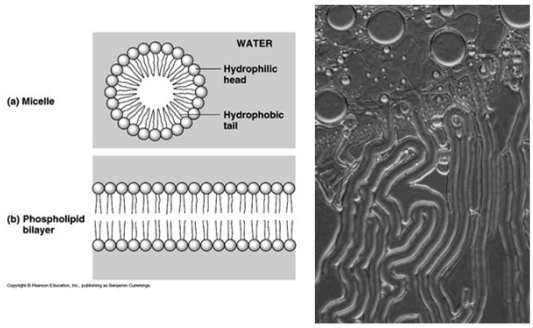


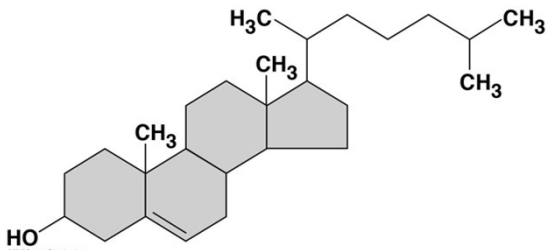
The structure of a phospholipid

Phospholipids in Water



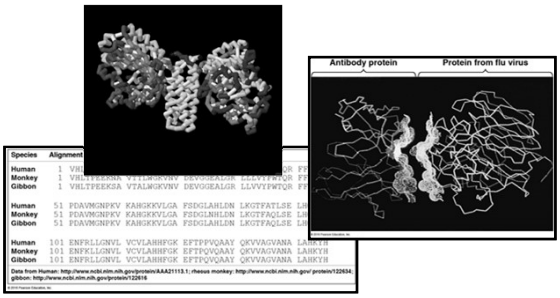
Hydrophobic/hydrophilic interactions make a **phospholipid bilayer**





Cholesterol, a steroid

Proteomics: Analysis of proteins and sequences



I. Proteins

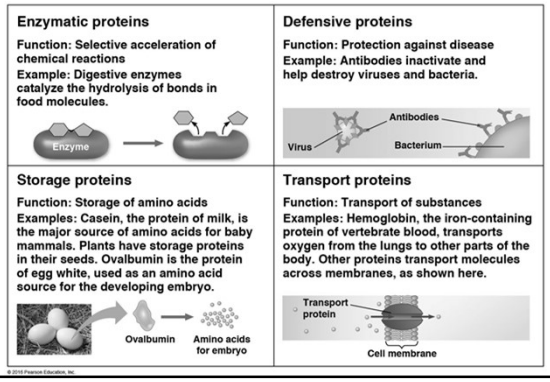
- "Proteios" = first or primary
- 50% dry weight of cells
- Contains: C, H, O, N, S

Myoglobin protein

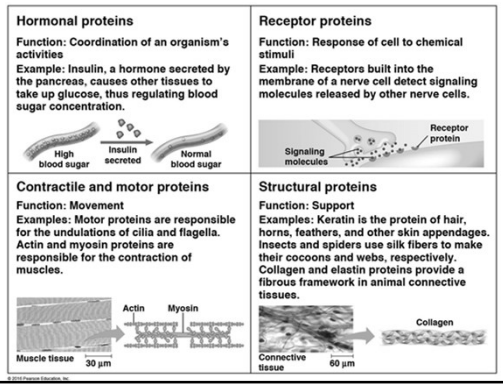
Protein Functions (+ examples)

- Enzymes (lactase)
- Defense (antibodies)
- Storage (milk protein = casein)
- Transport (hemoglobin)
- Hormones (insulin)
- Receptors
- Movement (motor proteins)
- Structure (keratin)

Overview of protein functions

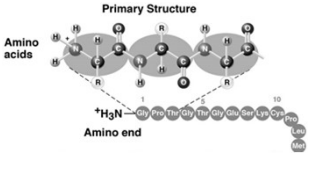


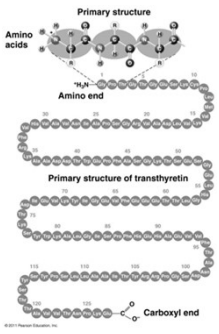
Overview of protein functions



Four Levels of Protein Structure

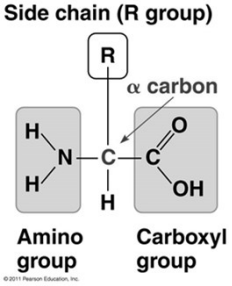
1. **Primary**
   - **Amino acid** (AA) sequence
   - 20 different AA's
   - **peptide bonds** link AA's

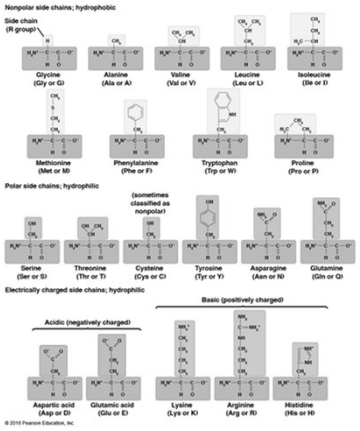


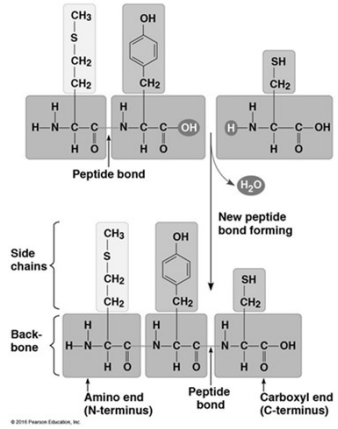


Amino Acid

- **R group** = side chains
- Properties:
  - hydrophobic
  - hydrophilic
  - ionic (acids & bases)
- "amino" : -NH_2
- "acid" : -COOH

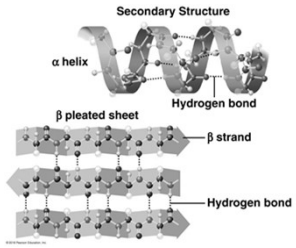






Four Levels of Protein Structure (continued)

2. **Secondary**
   - Gains 3-D shape (folds, coils) by **H-bonding**
   - **Alpha (α) helix**, **Beta (β) pleated sheet**

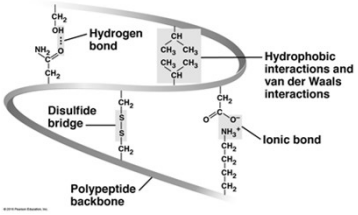


Basic Principles of Protein Folding

A. Hydrophobic AA buried in interior of protein (hydrophobic interactions)
B. Hydrophilic AA exposed on surface of protein (hydrogen bonds)
C. Acidic + Basic AA form salt bridges (ionic bonds).
D. Cysteines can form disulfide bonds.

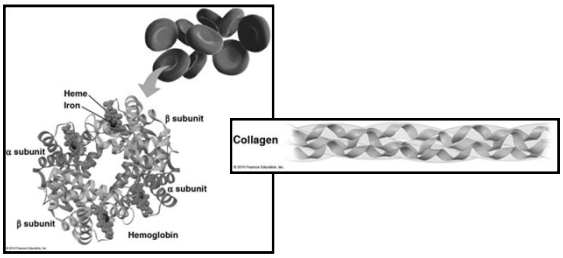
Four Levels of Protein Structure (continued)

3. **Tertiary**
   - Bonding between **side chains** (R groups) of amino acids
   - H bonds, ionic bonds, disulfide bridges, hydrophobic interactions, van der Waals interactions

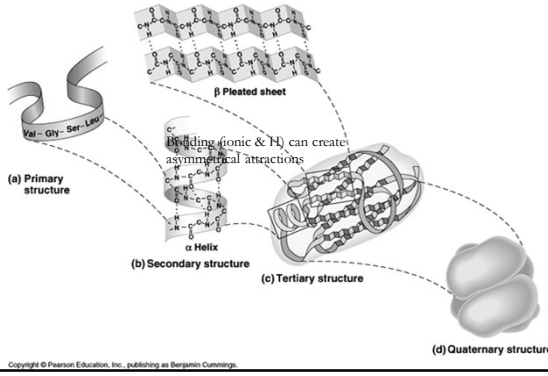


Four Levels of Protein Structure (continued)

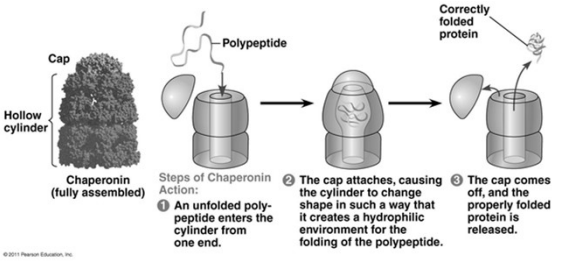
4. **Quaternary**
   - **2+ polypeptides** bond together



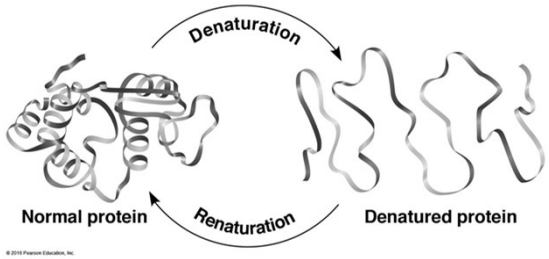
amino acids → polypeptides → protein



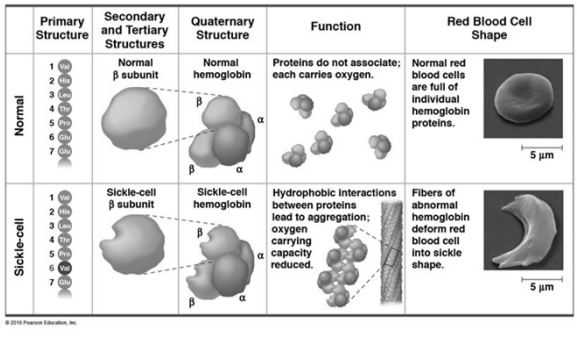
Chaperonins assist in proper folding of proteins



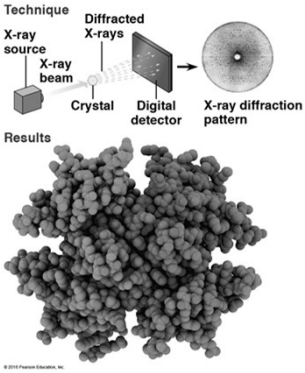
- Protein **structure and function** are sensitive to chemical and physical conditions
- Unfolds or **denatures** if **pH** and **temperature** are not optimal



change in structure = change in function



X-ray crystallography used to determine the 3-D structure of proteins



Genomics: Analysis of genes and genomes

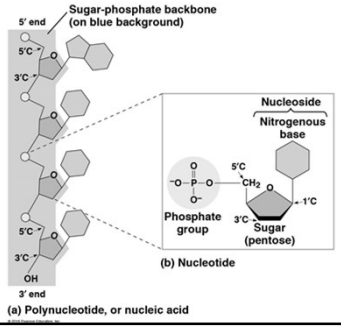
II. Nucleic Acids

Function: store hereditary info

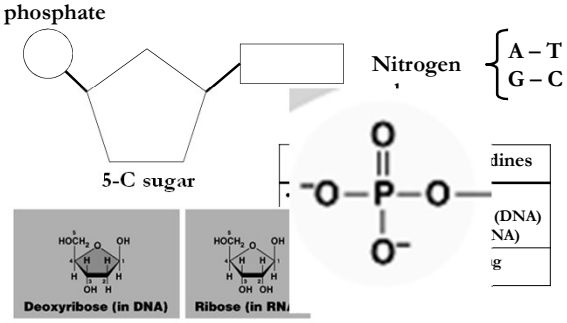
DNA	RNA
• Double-stranded helix • N-bases: A, G, C, *Thymine* • Stores hereditary info • Longer/larger • Sugar: deoxyribose	• Single-stranded • N-bases: A, G, C, *Uracil* • Carry info from DNA to ribosomes • tRNA, rRNA, mRNA, RNAi • Sugar: ribose

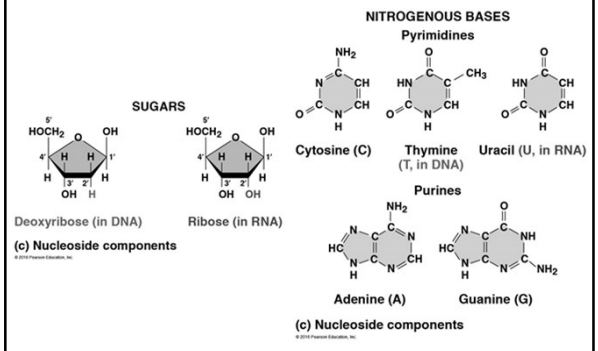
Nucleotides: monomer of DNA/RNA

Nucleotide = Sugar + Phosphate + Nitrogen Base

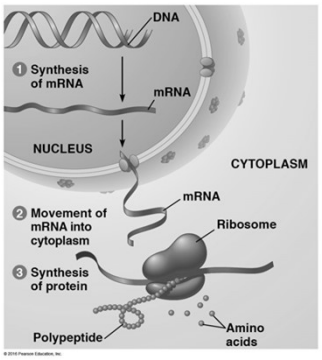


Nucleotide





Information flow in a cell:
DNA → RNA → protein

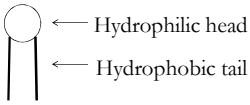


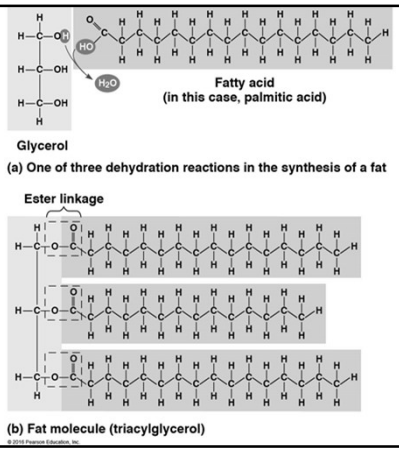
IV. Lipids

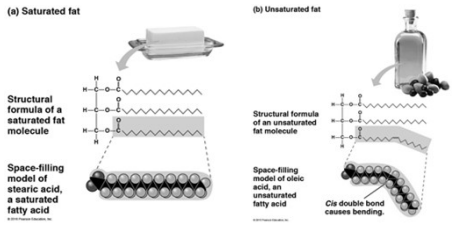
A. Fats (triglyceride): store energy
- Glycerol + 3 Fatty Acids
- saturated, unsaturated, polyunsaturated

B. Steroids: cholesterol and hormones

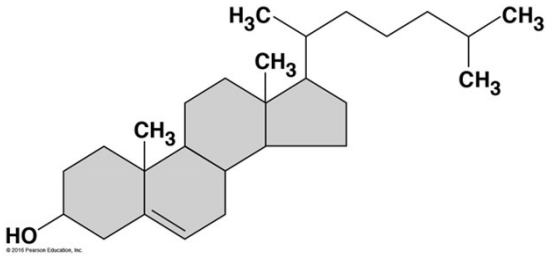
C. Phospholipids: lipid bilayer of cell membrane
- **<u>hydrophilic head</u>**, **<u>hydrophobic tails</u>**



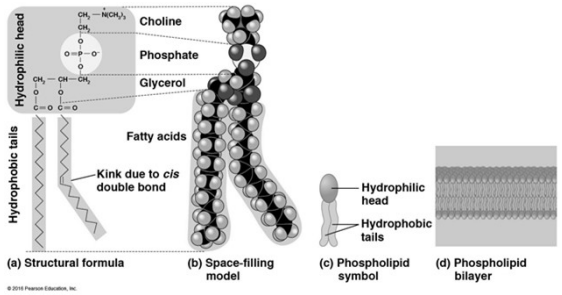




Saturated	Unsaturated	Polyunsaturated
"saturated" with H	Have some C=C, result in kinks	
In animals	In plants	
Solid at room temp.	Liquid at room temp.	
Eg. butter, lard	Eg. corn oil, olive oil	

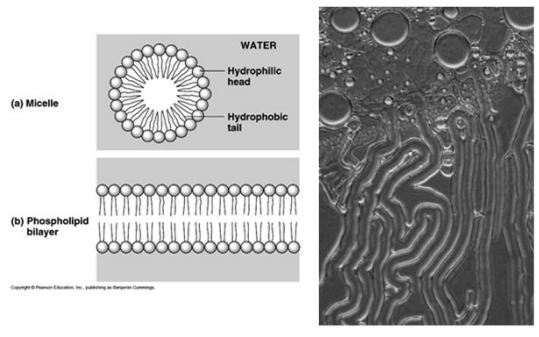


Cholesterol, a steroid



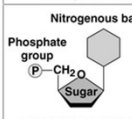
The structure of a phospholipid

Hydrophobic/hydrophilic interactions make a **phospholipid bilayer**

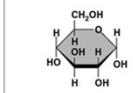


Components	Examples	Functions
 Amino acid monomer (20 types)	• Enzymes • Structural proteins • Storage proteins • Transport proteins • Hormones • Receptor proteins • Motor proteins • Defensive proteins	• Catalyze chemical reactions • Provide structural support • Store amino acids • Transport substances • Coordinate organismal responses • Receive signals from outside cell • Function in cell movement • Protect against disease

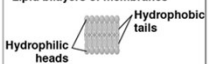
© 2016 Pearson Education, Inc.

Components	Examples	Functions
 Nucleotide monomer	DNA:  • Sugar = deoxyribose • Nitrogenous bases = C, G, A, T • Usually double-stranded	Stores hereditary information
	RNA: • Sugar = ribose • Nitrogenous bases = C, G, A, U • Usually single-stranded	Various functions in gene expression, including carrying instructions from DNA to ribosomes

© 2016 Pearson Education, Inc.

Components	Examples	Functions
 Monosaccharide monomer	Monosaccharides: glucose, fructose	Fuel; carbon sources that can be converted to other molecules or combined into polymers
	Disaccharides: lactose, sucrose	
	Polysaccharides: • Cellulose (plants) • Starch (plants) • Glycogen (animals) • Chitin (animals and fungi)	 • Strengthens plant cell walls • Stores glucose for energy • Stores glucose for energy • Strengthens exoskeletons and fungal cell walls

© 2016 Pearson Education, Inc.

Components	Examples	Functions
	Triacylglycerols (fats or oils): glycerol + three fatty acids	Important energy source 
	Phospholipids: glycerol + phosphate group + two fatty acids	Lipid bilayers of membranes 
 Steroid backbone	Steroids: four fused rings with attached chemical groups	• Component of cell membranes (cholesterol) • Signaling molecules that travel through the body (hormones)

© 2016 Pearson Education, Inc.