

Macromolecules

Biochemistry

What is Organic?

- ▶ Organic Chemistry – branch of chemistry dealing with carbon.
- ▶ Organic Molecules- Molecules that have carbon.

Versatile building blocks

- ▶ Carbon forms four bonds
 - ▶ Why?
- ▶ Can effect three dimensional shape of molecules.
- ▶ Variations on carbon skeletons
 - ▶ Length
 - ▶ Shape
 - ▶ Number and location of bonds
 - ▶ Other elements

Hydrocarbons

- ▶ Bonds between C-C and C-H are all hydrophobic because they are non-polar.

▶

Functional Groups

- ▶ OH
 - ▶ Hydroxyl
- ▶ -CO
 - ▶ Carbonyl
 - ▶ Aldehyde
 - ▶ Ketone
- ▶ -COOH
 - ▶ Carboxyl

▶

Functional Groups

- ▶ -NH₂
 - ▶ Amino
- ▶ -SH
 - ▶ Sulfhydryl
 - ▶ Thiols
- ▶ -PO₄
- ▶ CH₃
 - ▶ Methyl

▶

Macromolecules

- ▶ Four Main large organic polymers
 - ▶ What is a polymer?
 - ▶ Made of repeating units
 - ▶ What are the repeating units called?
 - ▶ Monomer



Macromolecules

- ▶ What are they?
 - ▶ Carbohydrates
 - ▶ Lipids
 - ▶ Proteins
 - ▶ Nucleic Acids



Polymers

- ▶ Polymer- Large molecule made of many parts
 - ▶ Monomer- Subunit or building block for Polymer
 - ▶ Macromolecules are large organic polymers.



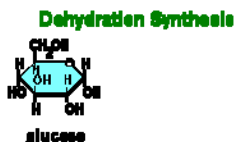
Macromolecules

- ▶ 4 classes
 - ▶ Carbohydrates
 - ▶ Example: Sugar or Sucrose
 - ▶ Lipids
 - ▶ Example: Oil
 - ▶ Proteins
 - ▶ Example: Muscle
 - ▶ Nucleic Acids
 - ▶ Example: DNA

Polymerization Reactions

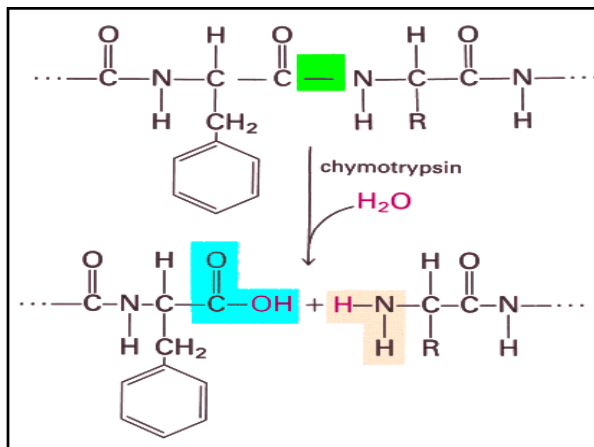
- ▶ Condensation Reactions
 - ▶ Linking molecules by the removal of water.
 - ▶ Examples

Dehydration Synthesis or Condensation Reactions



Hydrolysis

- ▶ Hydrolytic Enzymes work by reversing the condensation reactions. They add water back to break the bonds.
- ▶ Digestive enzymes work this way
- ▶ Example



Carbohydrates

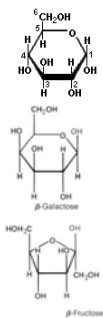
- ▶ Carbohydrates
 - ▶ Organic molecules made of sugars and their polymers.
 - ▶ Monomers are simple sugars called Monosaccharides
 - ▶ Examples: Glucose, Galactose, Fructose.

Monosaccharides

- ▶ Single Sugars
- ▶ CH_2O is empirical formula
- ▶ Can be produced (glucose) by photosynthesis with CO_2 , light, and H_2O
- ▶ Can be made into more complex structures
- ▶ Characteristics

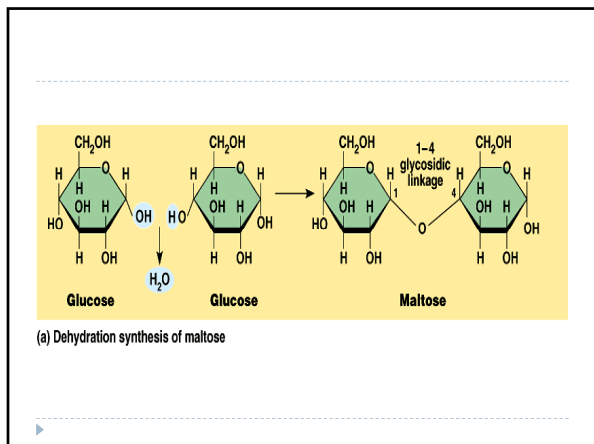
Types of Monosaccharides

- ▶ **Glucose**
 - ▶ Used for energy production in animals
- ▶ **Galactose**
 - ▶ Used with Glucose to form Lactose.
- ▶ **Fructose**
 - ▶ Linked to Glucose to form Sucrose.



Disaccharides

- ▶ Two Sugars linked together by a condensation reaction (dehydration synthesis)
- ▶ Glucose and fructose make Sucrose
- ▶ 1,4 Glycosidic linkage



Disaccharides

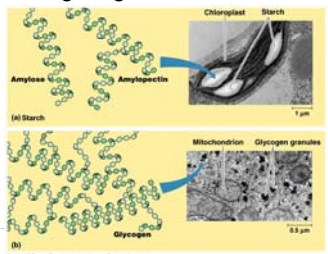
- ▶ **Maltose**
 - ▶ Glucose and Glucose
- ▶ **Lactose: Transport Sugar in Milk**
 - ▶ Glucose and Galactose
- ▶ **Sucrose: Transport Sugar in Plants.**
 - ▶ Glucose and Fructose

Polysaccharides

- ▶ **Made of a few hundred or thousand monosaccharides.**
 - ▶ Made of enzyme mediated condensation reactions
- ▶ **Energy Storage**
 - ▶ Starch
 - ▶ Glycogen
- ▶ **Structural Support**
 - ▶ Cellulose and Chitin

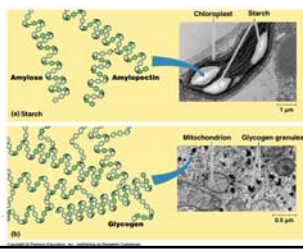
Storage Polysaccharides

- ▶ Cells hydrolyze storage polysaccharides for sugar.
- ▶ Two main forms in living things



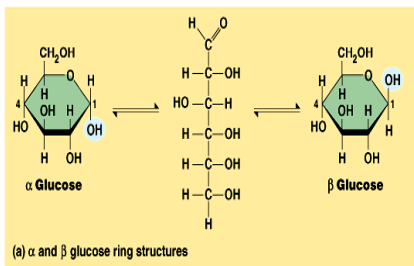
Storage Polysaccharides

- ▶ Glycogen
 - ▶ Glucose polymer
 - ▶ branched by 1-4 and 4-6 linkages
 - ▶ Stored in Muscle and Liver

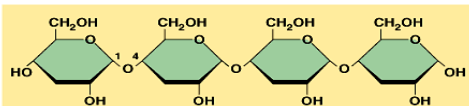


Structural Polysaccharides

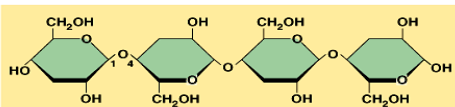
- ▶ Cellulose and Chitin



Structural and Storage



(b) Starch: 1-4 linkage of α glucose monomers



(c) Cellulose: 1-4 linkage of β glucose monomers

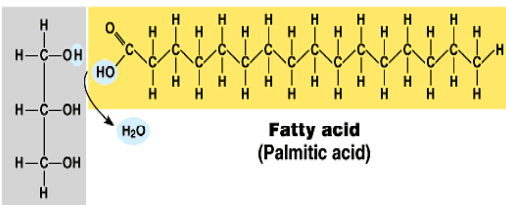
Structural Polysaccharides

- ▶ Chitin – Polymer of an amino sugar.
- ▶ Forms exoskeleton of arthropods
- ▶ Monomer is an amino sugar like beta glucose, but has a nitrogen containing group on the #2 carbon.

Lipids

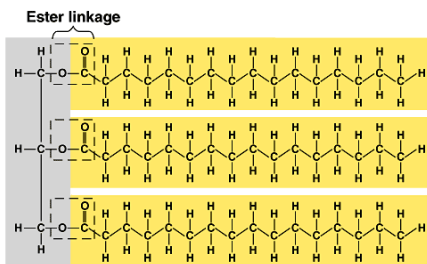
- ▶ Diverse group of organic compounds that are insoluble in water, but will dissolve in non-polar solvents.
 - ▶ Fats, oils, phospholipids, steroids.
- ▶ Fats store large amounts of energy.
 - ▶ Made of Glycerol
 - ▶ Fatty Acids
 - ▶ Ester Linkages

Formation of Triglyceride



Glycerol
(a) Dehydration synthesis

Triglyceride



(b) Fat molecule (triacylglycerol)

Characteristics of Fats

- ▶ Not soluble in water
- ▶ Source of variation is the fatty acids
 - ▶ Can all be same
 - ▶ Or all three different
 - ▶ Vary in length
 - ▶ Vary in number and location of double bonds.

Saturated vs Unsaturated

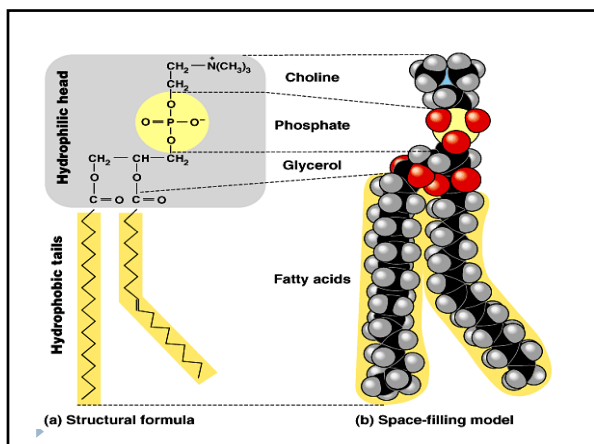
- ▶ No Double bonds
- ▶ Carbon has max H
- ▶ Usually solid at room temp.
- ▶ Most animal fats
- ▶ Bacon grease, lard, butter
- ▶ One or more present
- ▶ Tails kink at double bonds. Can't pack close enough to solidify at room temp.
- ▶ Usually liquid at room temp.
- ▶ Most plant fats.
- ▶ Corn oil, olive oil, peanut oil

Fats Functions

- ▶ Energy Storage
 - ▶ More energy less weight than other molecules.
- ▶ Cushions vital organs
- ▶ Insulation

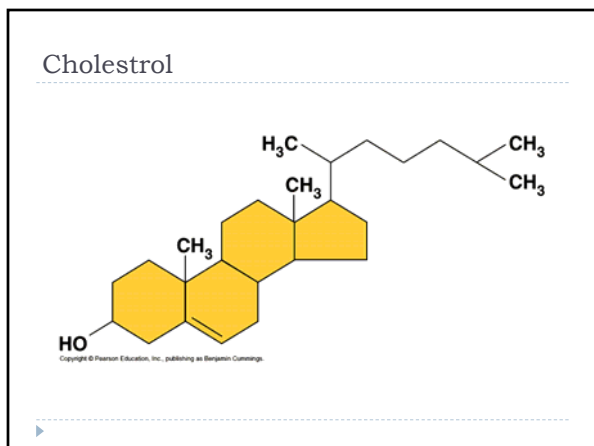
Phospholipids

- ▶ Glycerol and two fatty acids with a phosphate on the third. They usually have a third group as well.
- ▶ Make up the major component of cell membrane.
- ▶ Show differing interaction with water.
- ▶ Micelle formation



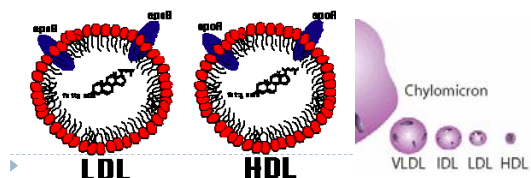
Steroid

- ▶ Lipids that have four fused carbon rings with various functional groups.
- ▶ Cholesterol is an important steroid
 - ▶ Precursor to many other steroid molecules
 - ▶ Testosterone, Estrogen etc...
 - ▶ Major component of cell membranes.
 - ▶ Contributes to Athlerosclerosis.



How are fats moved?

- ▶ Chylomicrons-
- ▶ LDL vs HDL



Proteins

- ▶ Polypeptide
 - ▶ made of amino acids linked by condensation reactions.
 - ▶ Protein = is a macromolecule consisting of one or more polypeptide chains folded into a specific conformation.
 - ▶ More than 50% of dry weight

▶

Proteins

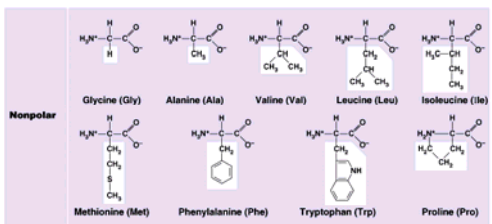
- ▶ Functions
 - ▶ Structural support (Keratin)
 - ▶ Transport
 - ▶ Storage
 - ▶ Signaling
 - ▶ Movement (Actin and Myosin)
 - ▶ Defense (Immunoglobulins)
 - ▶ Catalysts (Lactase)
 - ▶ Made of 20 amino acid monomers

▶

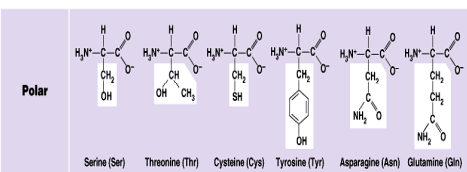
Amino Acid

- ▶ Review Structure
- ▶ Show how linked
- ▶ 20 common amino acids are grouped by their properties
 - ▶ Hydrophobic, acids, bases.
 - ▶ Polar and Non-polar help proteins stay oriented in membranes, create channels, and active site binding.

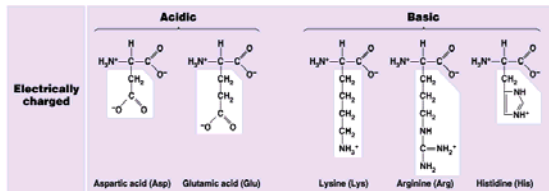
Amino Acids



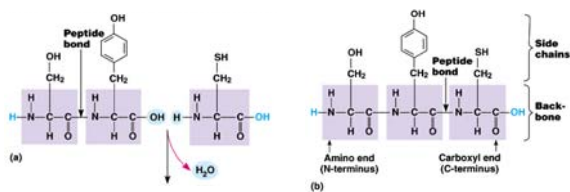
Amino Acids



Amino Acids



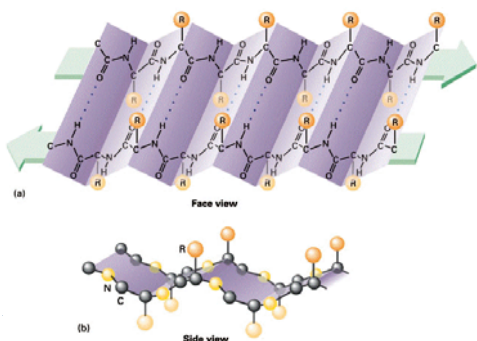
How Peptide Bond Forms



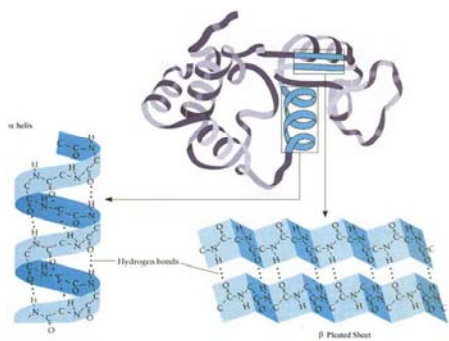
Conformation

- ▶ Shape determines function.
- ▶ Native conformation
 - ▶ found under normal biological conditions.
- ▶ Four Levels of Protein Structure

Secondary Structure: Beta Pleated Sheet

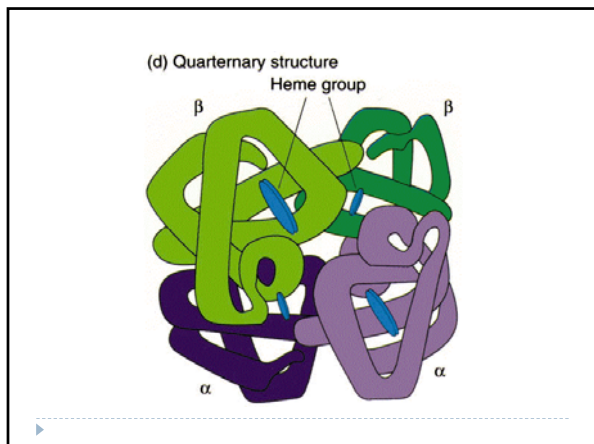


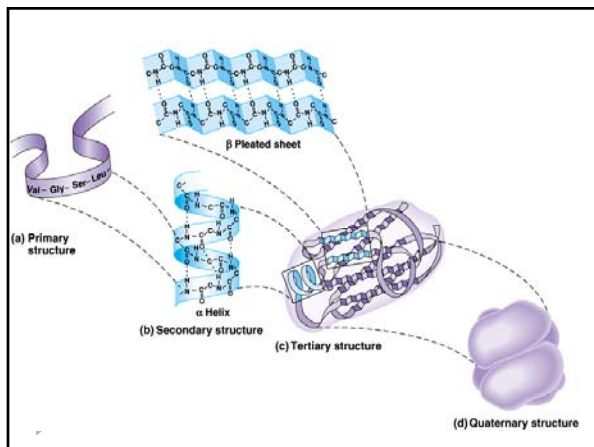
Secondary Structure: Helix



Uses of Beta Pleated Sheet







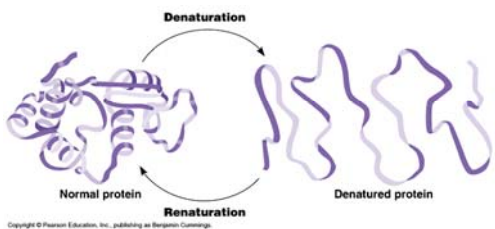
Fibrous vs Globular

- ▶ **Fibrous:**
 - ▶ Keratin- hair and feathers
 - ▶ Elastin- ligaments and blood vessels
 - ▶ Collagen- Most abundant in body. Connective tissue and cartilage.
- ▶ **Globular:**
 - ▶ Enzymes- Catalyze reactions
 - ▶ Hormones- signal (insulin)
 - ▶ Antibodies- bind/recognize invaders

Conformation

- ▶ Denaturation
 - ▶ Hydrophobic vs Hydrophilic solvent
 - ▶ Chemical agents
 - ▶ pH
 - ▶ Heat
 - ▶ Ionic strength

Denature (Like Cooking Egg White)



Nucleic Acids

- ▶ Transmit hereditary information
- ▶ Protein conformation is determined by the primary structure. Primary structure is determined by genes. Genes consist of segments of DNA that code for a particular series of amino acids.

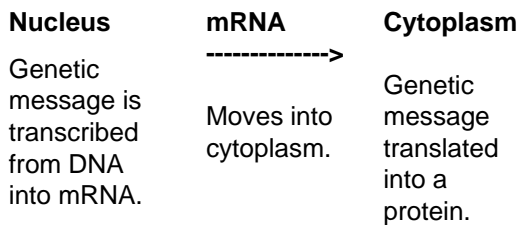
DNA

- ▶ Contains coded information
- ▶ Directs It's own replication
- ▶ Passed on from one generation to another.
- ▶ Found primarily in the nucleus
- ▶ Makes up genes. Codes for the production of proteins with RNA intermediate.

RNA

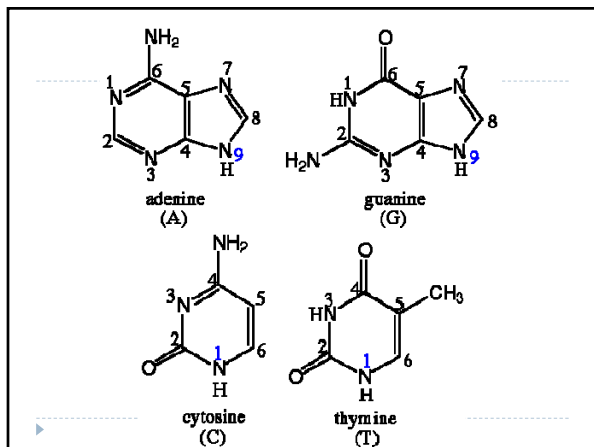
- ▶ Functions in protein synthesis
- ▶ Sites of protein synthesis is on the ribosomes(RNA and protein).
- ▶ mRNA carries coded info from nucleus to cytoplasm(in eukaryotes).
- ▶ Flow of genetic information
 - ▶ DNA-->RNA-->Protein

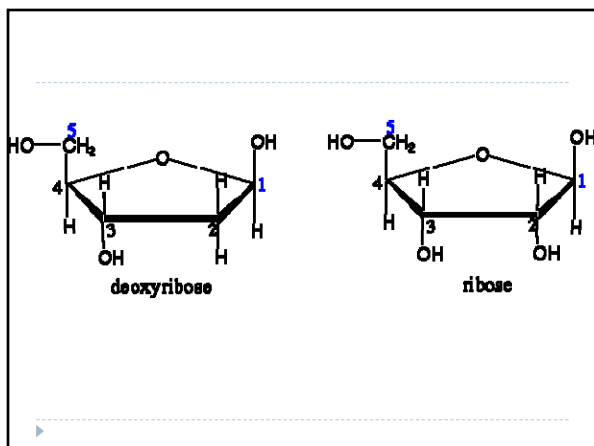
DNA to protein

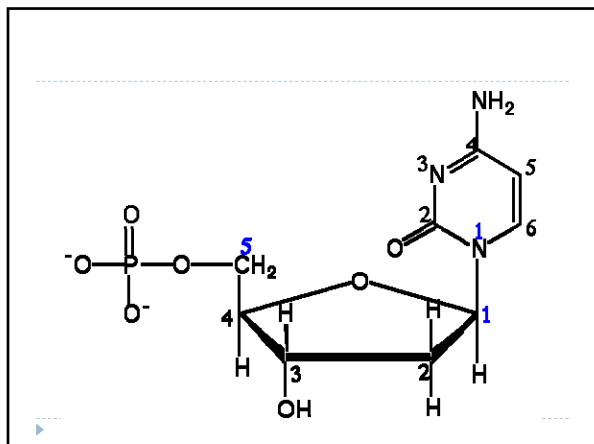


Nucleotide Structure

- ▶ Nucleotide
 - ▶ Sugar
 - ▶ Phosphate
 - ▶ Nitrogenous bases
 - ▶ Adenine = Purine
 - ▶ Guanine = Purine
 - ▶ Cytosine = Pyrimidine
 - ▶ Thymine = Pyrimidine







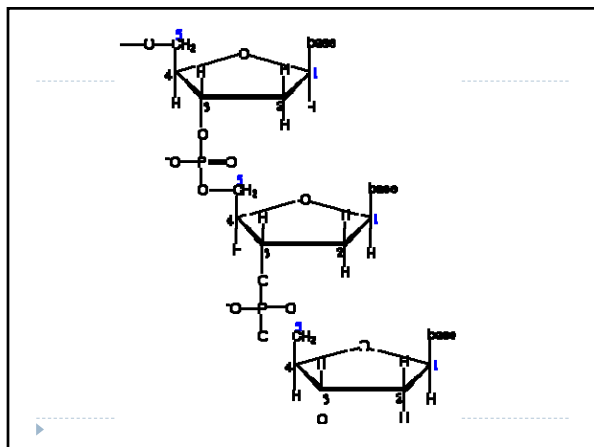


Table 5.2 Polypeptide Sequence as Evidence for Evolutionary Relationships

Number of Amino Acid Differences in the β Chain of Hemoglobin, Compared to Human Hemoglobin (Total Chain Length = 146 Amino Acids)

Species	Number of Amino Acid Differences
Human	0
Gorilla	1
Gibbon	2
Rhesus monkey	8
Mouse	27
Frog	67
