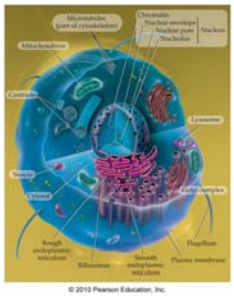
Biochemistry

- Biochemistry is the science deals with chemical composition and reactions in living organisms
- At some level, all biological processes have a component that is chemical in nature
  - Energy conversion
  - Neurotransmission
  - Genetics

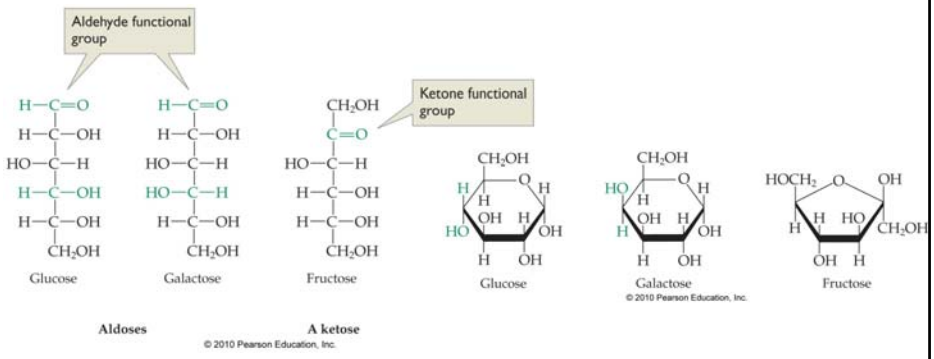


- Biochemists typically focus on understanding the structure and function of cellular components
  - biomolecules such as proteins, carbohydrates, lipids, nucleic acids, etc.

Carbohydrates

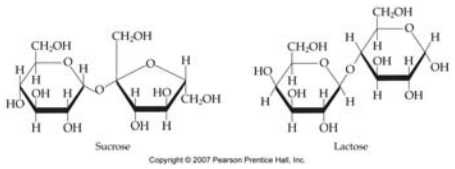
- polyhydroxy aldehydes or ketones or compounds that can be hydrolyzed to form such compounds

- ***Monosaccharides***: Carbohydrates that cannot be hydrolyzed into simpler compounds.

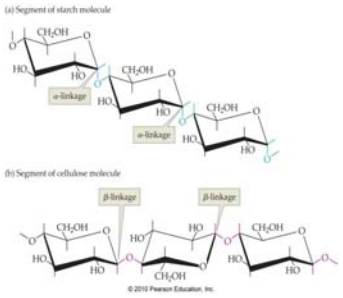


Carbohydrates

- disaccharides – can be converted to monosaccharides by hydrolysis



- polysaccharides – starch and cellulose…subtle, but critical differeces



Fats and Lipids

- **Lipids**: biological molecules that are insoluble in water, but are soluble in nonpolar organic solvents.

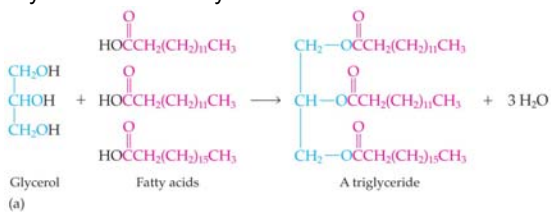
- **Fats**: esters of long-chain fatty acids and glycerol. (*triglycerides*)

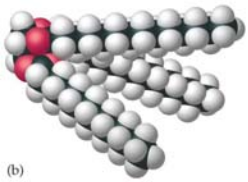
Table 16.1 Some Fatty Acids in Natural Fats

Number of Carbon Atoms	Condensed Structural Formula	Name	Source
4	$CH_3CH_2CH_2COOH$	Butyric acid	Butter
6	$CH_3(CH_2)_4COOH$	Caproic acid	Butter
8	$CH_3(CH_2)_6COOH$	Caprylic acid	Coconut oil
10	$CH_3(CH_2)_8COOH$	Capric acid	Coconut oil
12	$CH_3(CH_2)_{10}COOH$	Lauric acid	Palm kernel oil
14	$CH_3(CH_2)_{12}COOH$	Myristic acid	Oil of nutmeg
16	$CH_3(CH_2)_{14}COOH$	Palmitic acid	Palm oil
18	$CH_3(CH_2)_{16}COOH$	Stearic acid	Beef tallow
18	$CH_3(CH_2)_7CH{=}CH(CH_2)_7COOH$	Oleic acid	Olive oil
18	$CH_3(CH_2)_4CH{=}CHCH_2CH{=}CH(CH_2)_7COOH$	Linoleic acid	Soybean oil
18	$CH_3CH_2(CH{=}CHCH_2)_3(CH_2)_6COOH$	Linolenic acid	Fish oils
20	$CH_3(CH_2)_4(CH{=}CHCH_2)_4CH_2CH_2COOH$	Arachidonic acid	Liver

Fats and Lipids

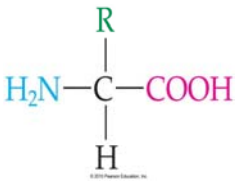
- **Saturated** fatty acids have no carbon-to-carbon double bonds.
  - **Monounsaturated** fatty acids have one carbon-to-carbon double bond.
  - **Polyunsaturated** fatty acids have two or more carbon-to-carbon double bonds.
  - Solid fats have a high proportion of saturated fatty acids while liquid oils have primarily unsaturated fatty acids.

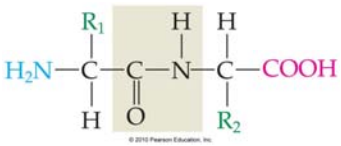


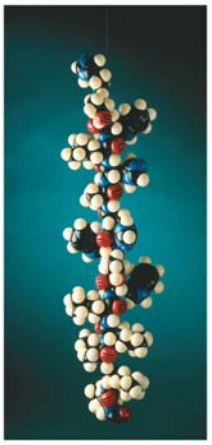


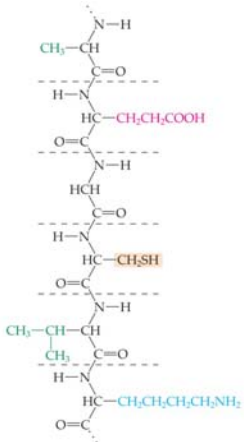
Amino Acids and Proteins

- Polymers of amino acids, linked by amide functional groups
  - aka peptide bonds





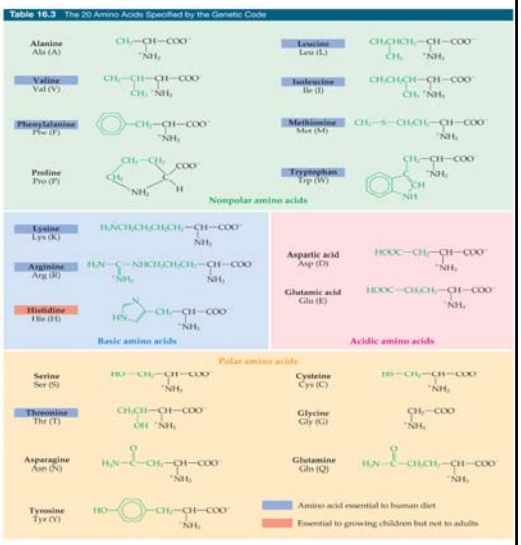




(a) (b)

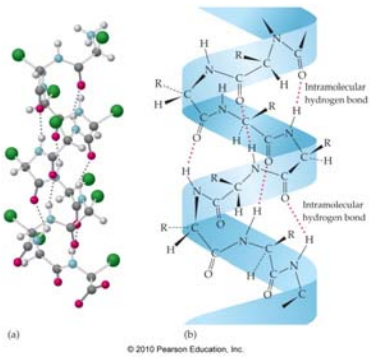
Amino Acids and Proteins

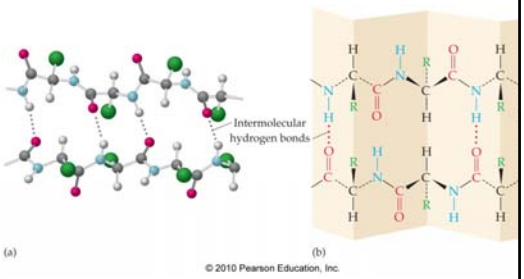
- **Dipeptide** is formed when two amino acids are joined.
- **Tripeptides** contain three amino acid units.
- **Polypeptides** contain ten or more amino acid units.
- **Proteins** may contain 10,000 or more amino acid units.
- The sequence of the amino acids in a protein is critical. The sequence is denoted from the free amino group (N-terminal) to the free carboxyl group (C-terminal).



Protein Structure

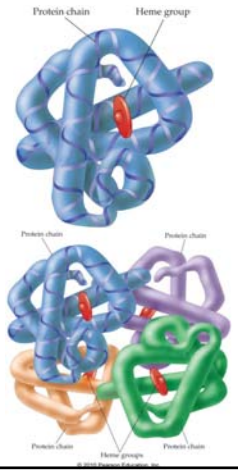
- Proteins are complex compounds, many things contribute to their function
- **Primary Structure** – order of amino acids
- **Secondary Structure** – folding and coiling of chain due to hydrogen bonding

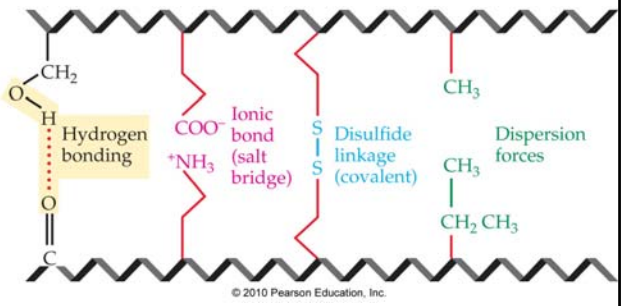




Protein Structure

- **Tertiary Structure** – 3D shape due to IM forces between groups that are far apart in the chain
- **Quaternary Structure** – Interaction of more than one protein chain
- *Denaturing*



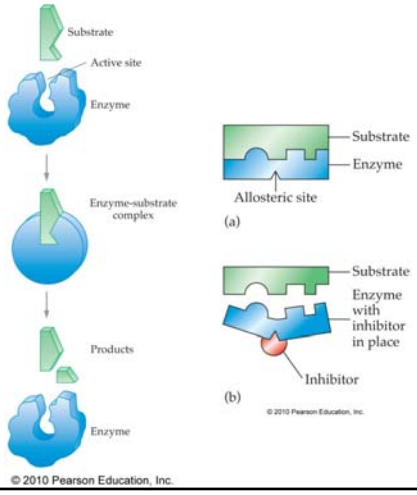


Enzymes

- Biochemical catalysts, often highly specific. Most are proteins

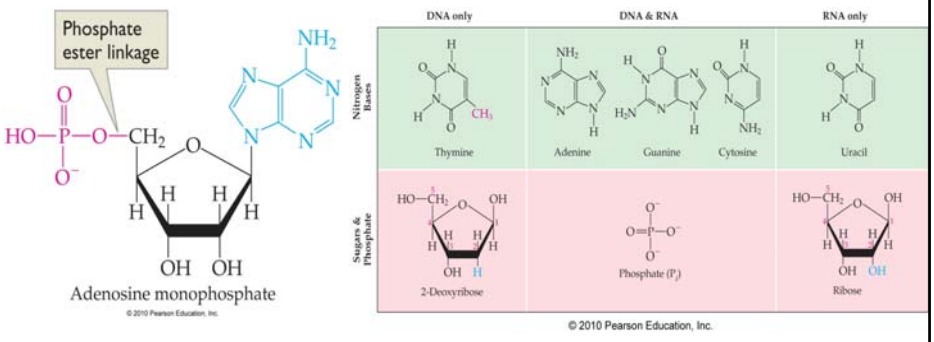
Enzyme + Substrate → Enzyme-substrate complex ↔ Enzyme + Products

- Substrate interacts with enzyme at the **active site**, often through IM forces and shape specificity.
  - Disrupting shape can lead to **inhibition** of enzyme function
- Some enzymes require **cofactors**
  - another species to be present for proper functioning of the enzyme. (ion or small molecule)



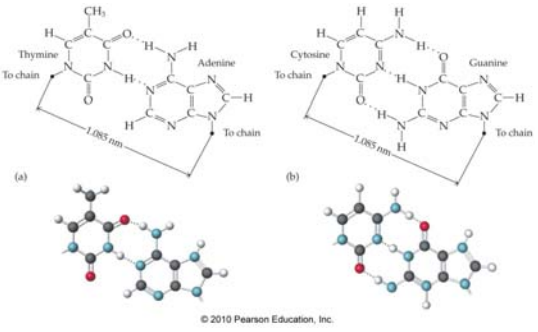
Nucleic Acids

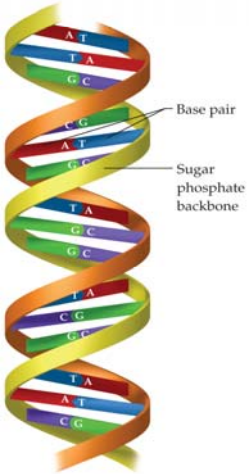
- Information and control centers of the cell.
- Two major forms: deoxyribonucleic acid (**DNA**) and ribonucleic acid (**RNA**)
  - consist of long chains called ***nucleotides***.
- Each nucleotide is composed of a sugar unit, phosphate unit, and a heterocyclic amine base.



DNA

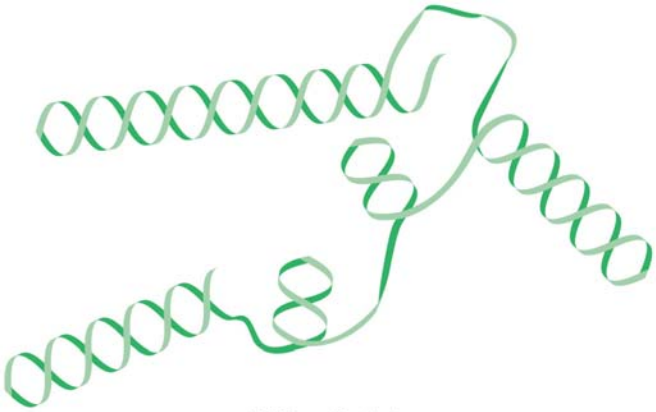
- The double helix of DNA is held together by **base-pairing**.
- **Complimentary bases** are thymine and adenine, and cytosine and guanine.
  - Interact by hydrogen bonding.





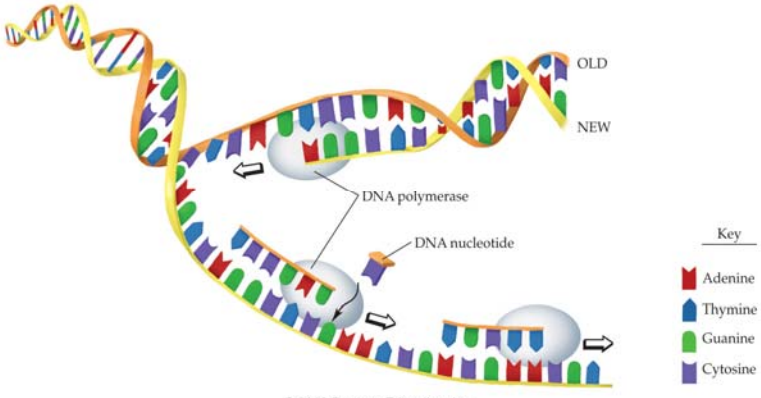
RNA

- RNA consists of single strands of nucleic acid.



DNA Synthesis and Replication

- DNA occurs as *chromosomes*.
  - 46 in humans, containing ~3 billion base pairs!
  - Describes synthesis of proteins and other molecules. *Genes* are sections of DNA that code for a specific protein.
  - DNA replicates during cell division



RNA and Protein Synthesis

- The genetic code is carried in a three-base sequence known as a ***codon***.
- The ***codon*** codes for a specific protein by base-pairing the **anticodon** with a specific messanger RNA (mRNA) during **transcription** and transfer RNA (tRNA) through a process known as **translation**.

Table 16.5 The Genetic Code

FIRST BASE	SECOND BASE: U	SECOND BASE: C	SECOND BASE: A	SECOND BASE: G	THIRD BASE
U	UUU=Phe	UCU=Ser	UAU=Tyr	UGU=Cys	U
	UUC=Phe	UCC=Ser	UAC=Tyr	UGC=Cys	C
	UUA=Leu	UCA=Ser	UAA=Termination	UGA=Termination	A
	UUG=Leu	UCG=Ser	UAG=Termination	UGG=Trp	G
C	CUU=Leu	CCU=Pro	CAU=His	CGU=Arg	U
	CUC=Leu	CCC=Pro	CAC=His	CGC=Arg	C
	CUA=Leu	CCA=Pro	CAA=Gln	CGA=Arg	A
	CUG=Leu	CCG=Pro	CAG=Gln	CGG=Arg	G
A	AUU=Ile	ACU=Thr	AAU=Asn	AGU=Ser	U
	AUC=Ile	ACC=Thr	AAC=Asn	AGC=Ser	C
	AUA=Ile	ACA=Thr	AAA=Lys	AGA=Arg	A
	AUG=Met	ACG=Thr	AAG=Lys	AGG=Arg	G
G	GUU=Val	GCU=Ala	GAU=Asp	GGU=Gly	U
	GUC=Val	GCC=Ala	GAC=Asp	GGC=Gly	C
	GUA=Val	GCA=Ala	GAA=Glu	GGA=Gly	A
	GUG=Val	GCG=Ala	GAG=Glu	GGG=Gly	G

Transcription and Translation

Table 16.4 DNA Bases and Their Complementary RNA Bases

DNA Base	Complementary RNA Base
Adenine (A)	Uracil (U)
Thymine (T)	Adenine (A)
Cytosine (C)	Guanine (G)
Guanine (G)	Cytosine (C)