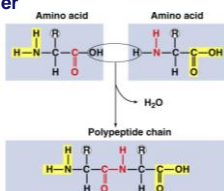


Proteins

- Most structurally & functionally diverse group of biomolecules
- Functions:
 - ◆ involved in almost everything
 - enzymes
 - structure (keratin, collagen)
 - carriers & transport (membrane channels)
 - receptors & binding (defense)
 - contraction (actin & myosin)
 - signaling (hormones)

Proteins

- Structure:
 - ◆ monomer = **amino acids**
 - 20 different amino acids
 - ◆ polymer = **polypeptide**
 - protein can be 1 or more polypeptide chains folded & bonded together
 - large & complex molecules
 - complex 3-D shape

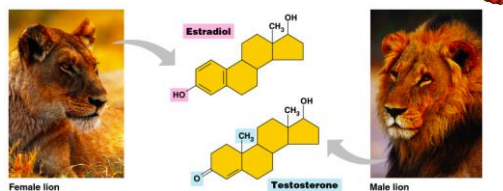


Types of functional groups

- 6 functional groups most important to chemistry of life:
 - ◆ hydroxyl
 - ◆ carbonyl
 - ◆ carboxyl
 - ◆ amino
 - ◆ sulfhydryl
 - ◆ phosphate
- Affect reactivity
 - ◆ hydrophilic
 - ◆ increase solubility in water

Viva la difference!

- Basic structure of male & female hormones is **identical**
 - ◆ identical C skeleton
 - ◆ attachment of different functional groups
 - ◆ interact with different targets in the body



Hydroxyl

- **-OH**
 - ◆ organic compounds with OH = **alcohols**
 - ◆ names typically end in **-ol**
 - ethanol

Functional Group	Formula	Name of Compounds	Example
Hydroxyl	-OH	Alcohols	$\begin{array}{c} \text{H} & \text{H} \\ & \\ \text{H}-\text{C}-\text{C}-\text{OH} \\ & \\ \text{H} & \text{H} \end{array}$ Ethanol (the drug of alcoholic beverages)

Carbonyl

▪ C=O

♦ O double bonded to C

- if C=O at end molecule = **aldehyde**
- if C=O in middle of molecule = **ketone**



Table 4.1 Functional Groups of Organic Compounds

Functional Group	Formula	Name of Compounds	Example
Carbonyl		Aldehydes	 Propanal
		Ketones	 Acetone

Carboxyl

▪ -COOH

♦ C double bonded to O & single bonded to OH group

- compounds with COOH = **acids**
 - ♦ fatty acids
 - ♦ amino acids

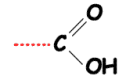


Table 4.1 Functional Groups of Organic Compounds

Functional Group	Formula	Name of Compounds	Example
Carboxyl	 (non-ionized)	Carboxylic acids	 Acetic acid* (the acid of vinegar)
	 (ionized)		

Amino

▪ -NH₂

♦ N attached to 2 H

- compounds with NH₂ = **amines**
 - ♦ amino acids
- NH₂ acts as base
 - ♦ ammonia picks up H⁺ from solution



Table 4.1 Functional Groups of Organic Compounds

Functional Group	Formula	Name of Compounds	Example
Amino	 (non-ionized)	Amines	 Glycine*
	 (ionized)		

Sulfhydryl

▪ -SH

♦ S bonded to H

- compounds with SH = **thiols**
- SH groups stabilize the structure of proteins



Table 4.1 Functional Groups of Organic Compounds

Functional Group	Formula	Name of Compounds	Example
Sulfhydryl	-SH	Thiols	 Ethanethiol

Phosphate

▪ -PO₄

♦ P bound to 4 O

- connects to C through an O
- PO₄ are anions with 2 negative charges
- function of PO₄ is to transfer energy between organic molecules (ATP)

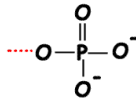


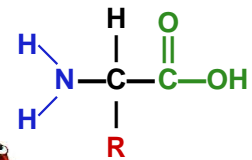
Table 4.1 Functional Groups of Organic Compounds

Functional Group	Formula	Name of Compounds	Example
Phosphate		Organic phosphates	 Glycerol phosphate

Amino acids

▪ Structure:

- ♦ central carbon
- ♦ amino group
- ♦ carboxyl group (acid)
- ♦ R group (side chain)
 - variable group
 - confers unique chemical properties of the amino acid



Oh yeah...
the inner nerd
is coming out
baby!



Nonpolar amino acids

- nonpolar & hydrophobic

Glycine (Gly)	Alanine (Ala)	Valine (Val)	Leucine (Leu)	Isoleucine (Ile)
Methionine (Met)	Phenylalanine (Phe)	Tryptophan (Trp)	Proline (Pro)	

Why are these nonpolar & hydrophobic?

Polar amino acids

- polar or charged & hydrophilic

Serine (Ser)	Threonine (Thr)	Cysteine (Cys)	Tyrosine (Tyr)	Asparagine (Asn)	Glutamine (Gln)
Acidic		Basic			
Aspartic acid (Asp)	Glutamic acid (Glu)	Lysine (Lys)	Arginine (Arg)	Histidine (His)	

Why are these polar & hydrophilic?

Building proteins

- Peptide bonds: dehydration synthesis
 - linking NH₂ of 1 amino acid to COOH of another
 - C-N bond

Peptide bond

Building proteins

- Polypeptide chains
 - N-terminal = NH₂ end
 - C-terminal = COOH end
 - repeated sequence (N-C-C) is the polypeptide backbone
 - grow in one direction

Side chains
Backbone
Amino end (N-terminus) | Carboxyl end (C-terminus)

Protein structure & function

- function depends on structure
 - 3-D structure
 - twisted, folded, coiled into unique shape

hemoglobin, pepsin, collagen

Protein structure & function

- function depends on structure
 - all starts with the order of amino acids
 - what determines that order of amino acids?

lysozyme: enzyme in tears & mucus that kills bacteria

the 10 glycolytic enzymes used to breakdown glucose to make ATP

Primary (1°) structure

- Order of amino acids in chain
 - amino acid sequence determined by DNA
 - slight change in amino acid sequence can affect protein's structure & it's function
 - even just one amino acid change can make all the difference!

Tell 'em about the Colonie Youth in a lineup!

Primary (1°) structure: Sickle cell anemia

(a) Normal red blood cells and the primary structure of normal hemoglobin

Val | His | Leu | Thr | Pro | Glu | Glu | ...

1 2 3 4 5 6 7

(b) Sickled red blood cells and the primary structure of sickle-cell hemoglobin

Val | His | Leu | Thr | Pro | Val | Glu | ...

1 2 3 4 5 6 7

Just one "letter" change in the DNA causes a different amino acid to be positioned... Valine instead of Glutamic Acid.

Secondary (2°) structure

- "Local folding"
 - folding along short sections of polypeptide
 - interaction between adjacent amino acids
 - H bonds in backbone
 - α -helix
 - β -pleated sheet

Tertiary (3°) structure

- "Global (whole molecule) folding"
 - determined by interactions between R groups
 - hydrophobic interactions
 - effect of water in cell
 - anchored by disulfide bridges (H & ionic bonds)

2° Hydrogen bonding

3°

- Electrostatic attraction (NH_3^+ and COO^-)
- Hydrophobic interaction
- Metal-Ion coordination (M^{2+})

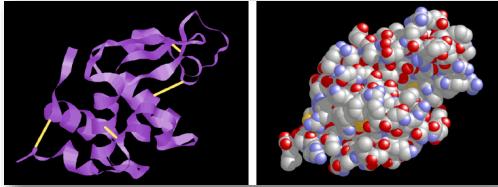
Quaternary (4°) structure

- Joins together more than 1 polypeptide chain
 - only then is it a functional protein

(a) Collagen (b) Hemoglobin

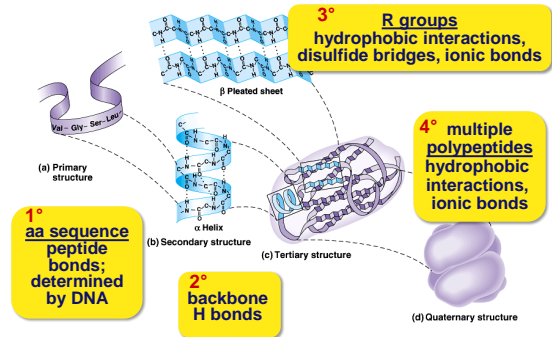
Protein models

- Protein structure visualized by
 - ◆ X-ray crystallography
 - ◆ extrapolating from amino acid sequence
 - ◆ computer modelling



lysozyme

Protein structure (review)



Denature a protein

- Disrupt 3° structure

- pH
- temperature
- salt

- ◆ unravel or denature protein
- ◆ disrupts H bonds, ionic bonds & disulfide bridges

- Some proteins can return to their functional shape after denaturation, many cannot!

