Chemistry
Chapter 18

Introduction to Biochemistry

Each of the principle classes of biochemistry has a basis in what we have learned so far.

Proteins:	Basically polyamides
Charbohydrates:	Hemiacetals and acetals with –OH groups
Lipids:	Mainly triesters of glycerol
Nucleic Acids:	Hemiacetals and acetals

Here is a listing of the functional groups and the type of biomolecules they are in:

- Amino group: AAs and Proteins
- Hydroxyl group: CHOs and glycrol, a component of lipids
- Carbonyl group: CHOs
- Carboxyl group: AAs, proteins, fatty acids
- Amide group: Links AAs in proteins
- CA ester: Triacylglycerols (and other lipds)
- Phosphates: ATP and many metabolism intermediaries
- Hemiacetal group: Cyclic monosaccharides
- Acetal group: Connects monosaccharides in disaccharides and larger CHOs

Protein Structure and Function

Proteins are large polymers made up of many Amino Acids (AAs). The AAs are alpha-amino acides, so called because the amino group is in the alpha position of the molecule.

2 AAs = dipeptide
3 AAs = tripeptide

peptide bonds are catalyzed by enzymes!

Every amino acid in a protein contains an amine group, a carboxyl group and an R group all bonded to a central carbon atom…this is the alpha carbon. The R group may be hydrocarbons, or it may be a functional group. The functional groups determine the behavior of the molecule…imagine that! More on that in a bit!

Proteins have four levels of structure, which you already know about from A&P!

- Primary: amino acid sequence….basically just a chain
- Secondary: regular and repeating spatial organization of neighboring segments of single chains. These are the alpha-helix and beta-pleated sheets
- Tertiary: the overall shape of the protein molecule, produced by folding of secondary structures…3-D shape!
- Quaternary: overall structure of proteins composed of more than one chain

Proteins by Function

Type	Function	Example
Enzymes	Catalysts	Amylase (begins digestion of CHOs)
Hormones	Carries messages	Insulin
Storage proteins	Makes things available when needed	Myoglobin (stores oxygen in muscles)
Transport proteins	Carries stuff	Serum albumin
Structural proteins	Provides mechanical shape and support	Collagen
Protective proteins	Defense	Immunoglobulin
Contractile proteins	Do mechanical work	Myosin and actin

Amino Acids

Nature uses 20 alpha-Amino Acids…there are actually 21 total but for some reason our book only talks about 20 of them. Anyway, 19 of these 20 differ only in the R group. The other one is a cyclic AA (proline). Each AA is classified as nonpolar, neutral, acidic or basic…this is all based on the side chain.

Nonpolar	Polar, Neutral	Acidic	Basic
Alanine*	Asparagine	Aspartic acid*	Arginine
Glycine*	Cysteine*	Glutamic acid*	Lysine*
Isoleucine	Glutamine		Histidine*
Leucine	Serine*		
Methionine	Threonine		
Phenylanaline	Tyrosine*		
Proline*			
Tryptophan*			

Note that the bonds in AAs are noncovalent bonds, except for disulfide bonds w/ cysteine.

So, this 21st amino acid is Hydroxyproline…it is not found in food and is in collagen. The body does not hydroxylate proline to make this AA…it only hydroxylates proline that is part of a protein chain, and this reaction requires Vitamin C….so this is why you have to take Vitamin C. If not, you get scurvy which is a break-down of collagen.

The non-polar AAs are:

- Hydrophobic
- Like to segregate themselves (think of oil drops connecting)
- In the body these are micelles that can encapuslate things
- Capable of folding back upon themselves to squeeze out water (cyclize in water!)

The polar acidic AAs:

- Are found at the surface of proteins and active sites
- Are on the outside of transport proteins

Some examples of side-group functionality:
Serine has a free –OH group. If this AA is part of the protein backbone, then the –OH group can H-bond with itself. It can also form esters with CA, and can react with aldehydes and ketones to form hemiacetals and acetals.

The amide on glutamine means this molecule can H-bond

Cysteine has a thiol group –SH. It can oxidize to a disulfide, and enables the protein to fold or bond with others.

Threonine has an –OH group, so it can also H-bond

Tyrosine is a phenol…if you treat it with base you get a phenoxide ion.

Acidic side chains: Can form ionic/salt bonds
Help make the protein soluble
Histadine and lysine are most prevalent

A little note about the strength of the bonds.

- C-C have a disassociation E of 80-100 kCals/mole
- H-bonds are at about 2-7 kCals/mole. This isn't a lot, but when you get a lot of them together it really adds up
- Ionic bonds are at about 50 kCal/mole

Acid-Base properties of Amino Acids

Amino acids contain both an acidic group (-COOH) and a basic group (-NH_2). These two groups undergo intermolecular acid-base reactions, which transfers the hydrogen from the –COOH group to the NH_2 group, making it an NH_3…overall, the entire AA is a dipolar ion…it has one positive charge and one negative charge. Dipolar ions are called zwitterions…isn't that cute?

In acidic solutions, zwitterions accept protons to protonate the carboxyl group.

In basic solutions, zwitterions lose protons.

The isoelectric point is the pH at which a sample of an amino acid has equal numbers of positive and negative charges (overall zero charge). Amino acids with acidic side chains have isoelectric points that are more acidic than those with neutral side chains.

Handedness/Chirality

When the mirror image of a molecule is not superimposable then the molecule has chirality. This occurs when the central Carbon has four different substituent groups:

When molecules exist in two different mirror images (enantiomers), then one is the "right-handed" form and one is the "left-handed" form. The right handed one is denoted with a D, and the left one with an L. Note that the body is efficient at making "left-handed" chiral compounds. If you were to make these in the lab, you would get a mixture of D & L.

The enantiomers are also called "optical isomers" because of the effect they have on polarized light. They are also a kind of stereoisomer…compounds that have the same formula and atoms with the same connections, but different spatial arrangements. Though they reflect polarized light differently, the enantiomers have many of the same physical properties (boiling point, density, isoelectric point, solubility in water, etc…)

Note that 19 of the 20 amino acids are chiral…only glycine is achiral.