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

Proteins: Basically polyamides
Carbonhydrates: 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 monosaccarides 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 acids, so called because the amino group is in the alpha position of the molecule.

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

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

### 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.

<table>
<thead>
<tr>
<th>Nonpolar</th>
<th>Polar, Neutral</th>
<th>Acidic</th>
<th>Basic</th>
</tr>
</thead>
<tbody>
<tr>
<td>Alanine*</td>
<td>Asparagine</td>
<td>Aspartic acid*</td>
<td>Arginine</td>
</tr>
<tr>
<td>Glycine*</td>
<td>Cysteine*</td>
<td>Glutamic acid*</td>
<td>Lysine*</td>
</tr>
<tr>
<td>Isoleucine</td>
<td>Glutamine</td>
<td></td>
<td>Histidine*</td>
</tr>
<tr>
<td>Leucine</td>
<td>Serine*</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Methionine</td>
<td>Threonine*</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Phenylalanine</td>
<td>Tyrosine*</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Proline*</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Tryptophan*</td>
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<td></td>
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</tbody>
</table>
Note that the bonds in AAs are noncovalent bonds, except for disulfide bonds w/ cysteine.

The non-polar AAs are:
- Hydrophobic
- Like to segregate themselves (think of oil drops connecting)
- In the body these are micelles that can encapsulate 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
- Histidine 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.