Proteins

3. **Proteins** are very important in biological systems as control and structural elements. Control functions of proteins are carried out by enzymes and proteinaceous hormones. Enzymes are chemicals that act as organic catalysts (a catalyst is a chemical that promotes but is not changed by a chemical reaction).

The building block of any protein is the amino acid, which has an amino end (NH_2) and a carboxyl end (COOH). The structure of a generalized amino acid, as well as the specific structures of the 20 biological amino acids are shown in Figure 18 and 19 respectively. The R indicates the variable component (R-group) of each amino acid. Alanine and Valine, for example, are both nonpolar amino acids, but they differ, as do all amino acids, by the composition of their R-groups. All living things (and even viruses) use various combinations of the same twenty amino acids.

Figure 18. Structure of an amino acid. Image from Purves et al., Life: The Science of Biology, 4th Edition, by Sinauer Associates (www.sinauer.com) and WH Freeman (www.whfreeman.com), used with permission.

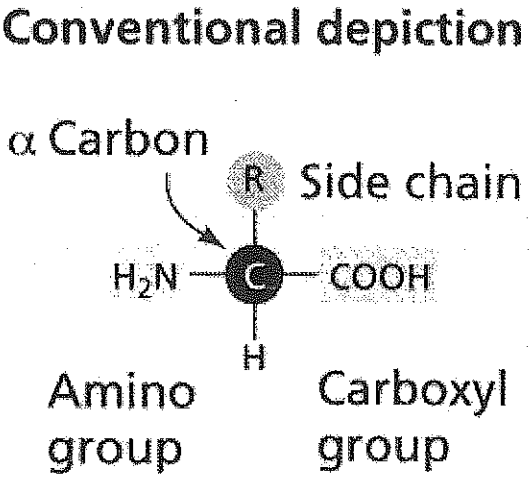
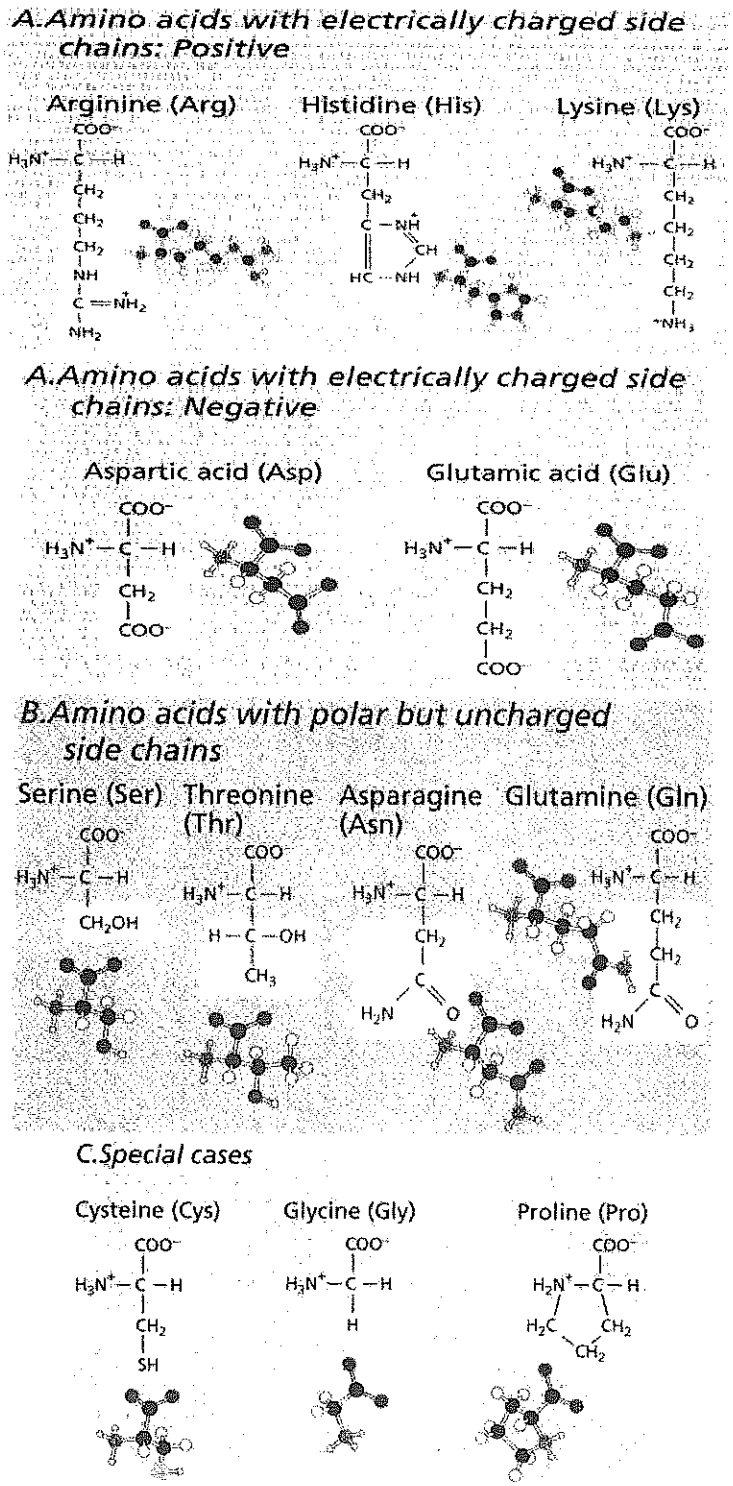
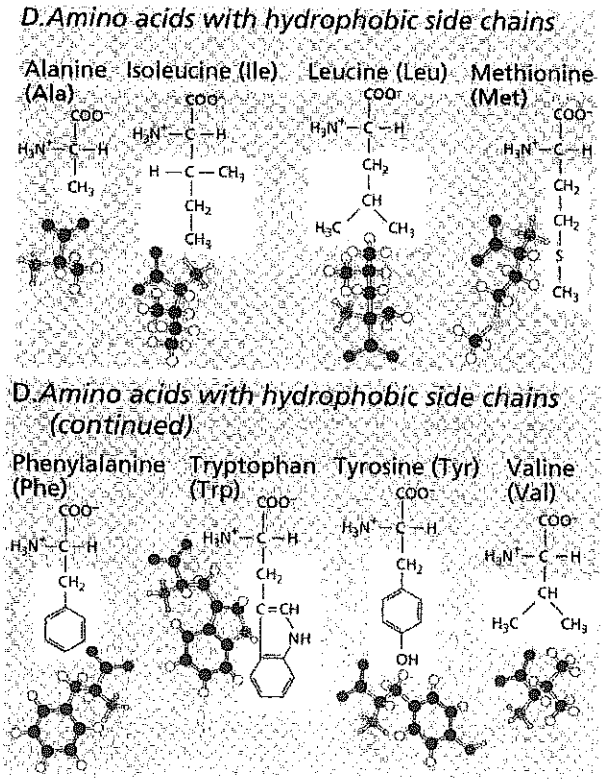


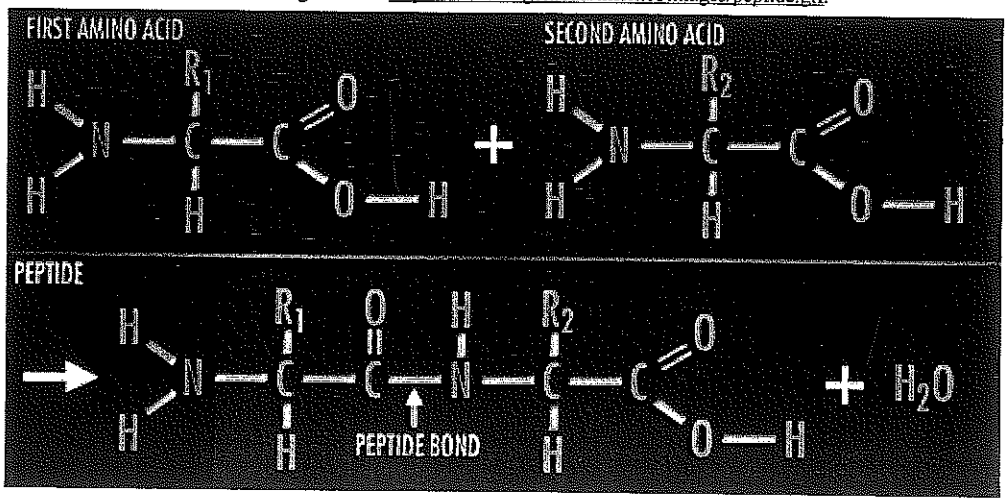
Figure 19. Structures in the R-groups of the twenty amino acids found in all living things. Images from Purves et al., Life: The Science of Biology, 4th Edition, by Sinauer Associates (www.sinauer.com) and WH Freeman (www.whfreeman.com), used with permission.





Amino acids are linked together by joining the amino end of one molecule to the carboxyl end of another. Removal of water allows formation of a type of covalent bond known as a peptide bond.

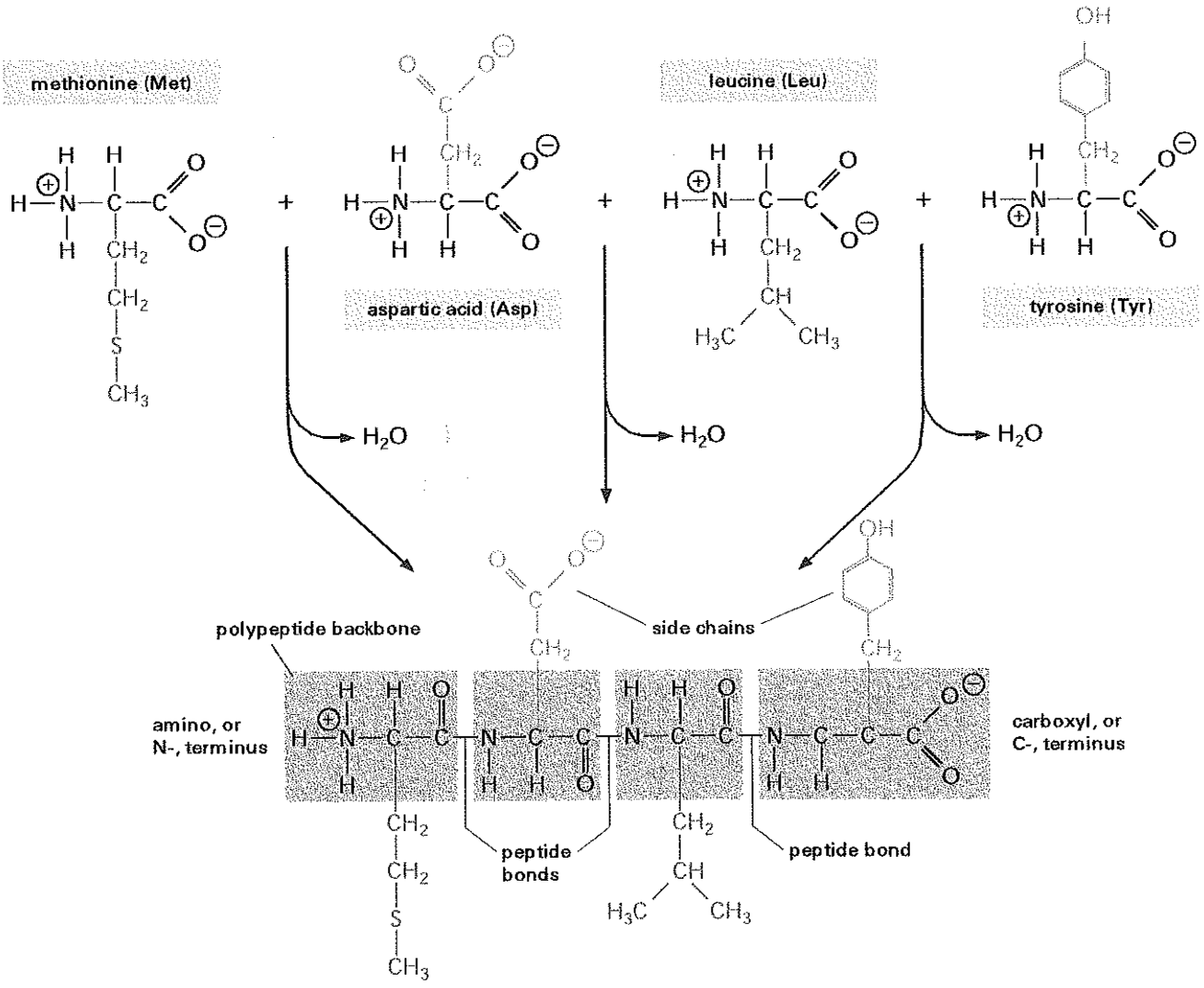
Figure 20. Formation of a peptide bond between two amino acids by the condensation (dehydration) of the amino end of one amino acid and the acid end of the other amino acid. The above image is from http://zebu.uoregon.edu/internet/images/peptide.gif.



- Amino acids are linked together into a polypeptide, the primary structure in the organization of proteins. The primary structure of a protein is the sequence of amino acids, which is directly related to the sequence of information in the RNA molecule, which in turn is a copy of the information in the DNA molecule.
- The secondary structure is the tendency of the polypeptide to coil or pleat due to H-bonding between R-groups.
- The tertiary structure is controlled by bonding (or in some cases repulsion) between R-groups.
- Many proteins, such as hemoglobin, are formed from one or more polypeptides. Such structure is termed quaternary structure.

NOTES:

Protein Structure



SCHEMATIC

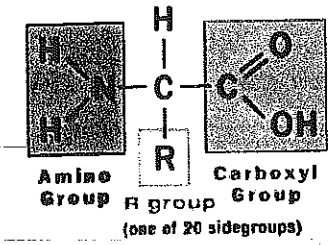
SEQUENCE Met — Asp — Leu — Tyr

Biology Lecture Notes

Proteins: Amino Acids and the Peptide Bond

>> Key Concepts:

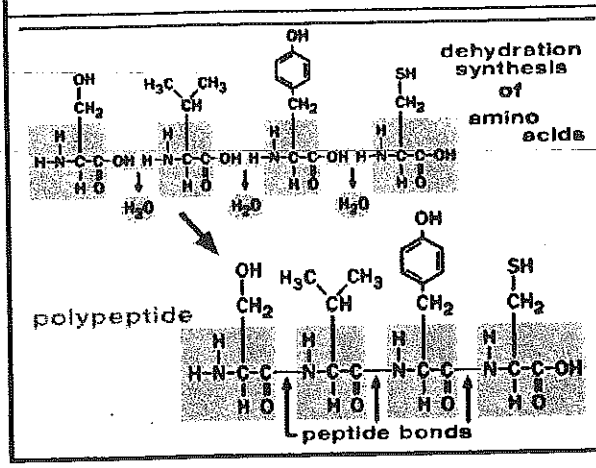
- **Proteins** consist of polymers of amino acids and have a specific **conformation**, or shape.
- **Amino acids** have an amine group on one end and a **carboxyl** group on the other.
- There are 20 amino acids, each with a different **R group.**
- A **peptide bond** can be formed between two amino acids through **dehydration synthesis.**



Proteins consist of long chains of **amino acids.**

Amino acids consist of a central carbon that has an **amine group, a carboxyl group,** a hydrogen, and an **R group** attached.

R groups have different properties that, in turn, give the amino acid different properties.



A **peptide bond** is the carbon-nitrogen bond between two amino acids. Peptide bonds are formed through **dehydration synthesis** between the carboxyl group of one amino acid and the amine group of the other.

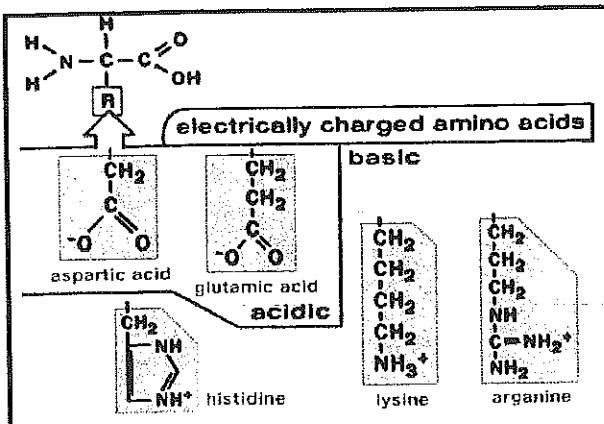
A **polypeptide** is a chain of amino acids bonded together. One or several can make up a protein. A polypeptide will have an amine group on one end and a carboxyl group on the other.

Biology Lecture Notes

Amino Acids: The R Groups

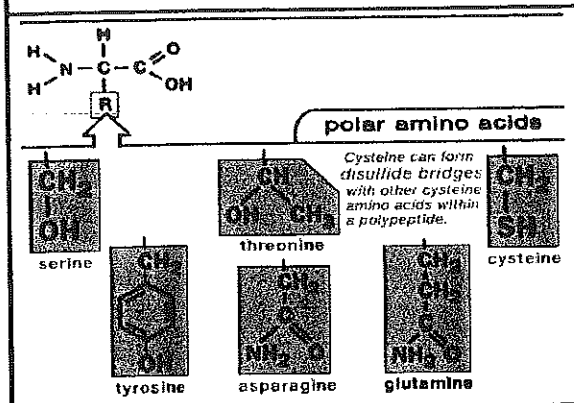
>> Key Concepts:

- There are 20 **amino acids**, each with a different **R group.**
- The properties of the different R groups lead to interactions between R groups within a protein, which in turn determines the **conformation,** or shape, of the protein.
- Amino acids can be placed into one of three general categories based on their R groups: **charged, polar,** and **nonpolar.**



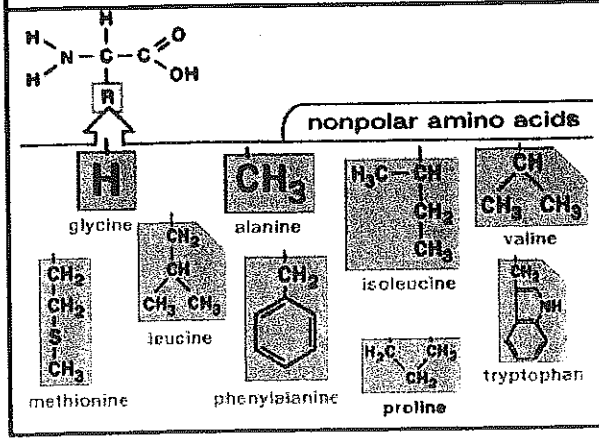
The **charged amino acids** include:

Aspartic acid
Glutamic acid
Lysine
Arginine
Histidine



The **polar amino acids** include:

Threonine
Cysteine
Tyrosine
Asparagine
Glutamine
Serine



The **nonpolar amino acids** include:

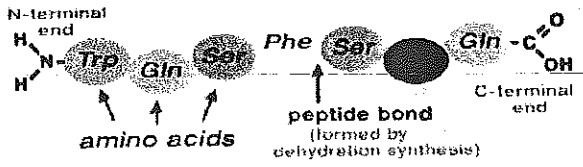
Glycine
Alanine
Valine
Leucine
Isoleucine
Methionine
Phenylalanine
Tryptophan
Proline

Biology Lecture Notes

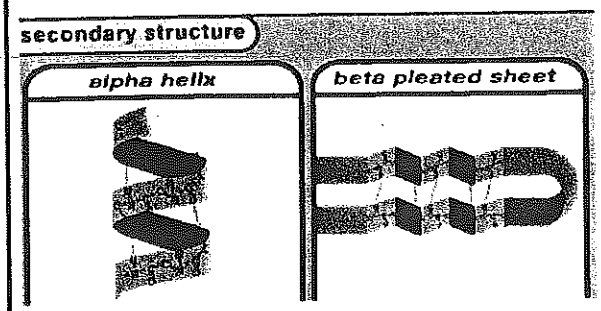
Primary and Secondary Structure

>> Key Concepts:

- Proteins are macromolecules that do much of the work of the cell.
- The shape of a protein determines its function. The order and arrangement of amino acids within a polypeptide chain determine the shape of a protein. **RNA**, in turn, instructs the amino acids to bond in a particular sequence.
- The **primary structure** of a protein is the specific sequence of the amino acids in a polypeptide. A single change in primary structure can significantly change the shape of a polypeptide.
- The **secondary structure** of a protein is the regular pattern of local hydrogen bonding within the polypeptide chain. Examples of secondary structure within a polypeptide include the **alpha helix** and **beta pleated sheet.**



The order and arrangement of amino acids within a polypeptide chain determines the shape of a protein. The order or sequence of amino acids within a polypeptide is referred to as its **primary structure.** Amino acids are joined together by a **peptide bond.**



The **alpha helix** is one type of **secondary structure.** The polypeptide twists into a helix that is supported by hydrogen bonds between the amine group hydrogen and the carboxyl oxygen.

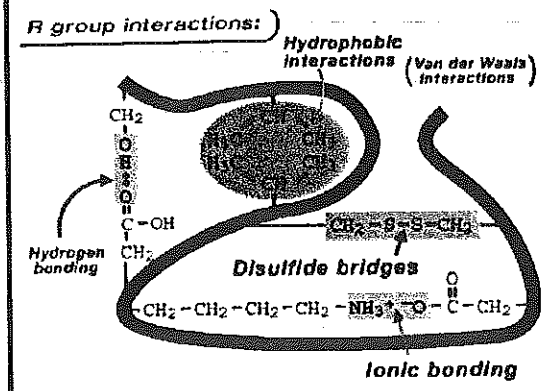
The **beta pleated sheet** is another type of secondary structure. It is formed when the polypeptide chain folds, placing two chains next to each other. Hydrogen bonding occurs between the chains, forming a sheet-like region within the polypeptide.

Biology Lecture Notes

Tertiary Structure

>> Key Concepts:

- The **tertiary structure** of a protein is the three-dimensional folding that results from interactions between R groups.
- Several major interactions take place between R groups: **hydrophobic interactions, Van der Waals interactions, ionic bonding,** and formation of **disulfide bridges.**



Four main types of interactions give a polypeptide its **tertiary structure.**

- **Hydrophobic interactions** take place when amino acids with hydrophobic (nonpolar) R groups come together into the interior of a molecule to minimize contact with water.
- As the hydrophobic R groups pack together, **Van der Waals interactions** between reinforce their interactions.
- **Ionic bonding** takes place between charged R groups because of the attraction between positive and negative charges.
- **Disulfide bridges** are strong covalent bonds that form between two cysteine molecules. Cysteine has a **sulfhydril group** that can form a disulfide bond when placed next to another sulfhydril group.