LAB #5
MOLECULAR MODELS OF BIO-MOLECULES - PART 2
AMINO ACIDS, PEPTIDES, & PROTEINS

OBJECTIVES

- Be able to recognize models of the following bio-molecules: amino acids, a dipeptide, a tripeptide, the R-group of an amino acid, and peptide bonds
- Define the following terms: amino acid, R-group, peptide bond, dehydration reaction, hydrolysis reaction, polar, non-polar, hydrophilic, hydrophobic, peptide, dipeptide, tripeptide, polypeptide, protein, subunit, multi-subunit protein, primary structure, secondary structure, tertiary structure, quaternary structure

MATERIALS

- 4 Molecular Model kits per lab group
- colored pencils

Molecular Model Kit Color Key

<table>
<thead>
<tr>
<th>Color</th>
<th>Substance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Black</td>
<td>Carbon</td>
</tr>
<tr>
<td>White</td>
<td>Hydrogen</td>
</tr>
<tr>
<td>Red</td>
<td>Oxygen</td>
</tr>
<tr>
<td>Blue</td>
<td>Nitrogen</td>
</tr>
</tbody>
</table>

NOTES TO STUDENTS

- Work in groups of 3-5 people.
- Once you construct a molecule, do not disassemble it. You will use it throughout the lab.
- Use the rigid connectors to indicate the electron pairs in a single covalent bond.
- Use flexible connectors to indicate each electron pair in a double- or triple-covalent bond.
**AMINO ACIDS**

**INTRODUCTION:**

Amino acids are nitrogen containing organic compounds that are the building blocks for proteins. There are 20 different amino acids. The basic structure of an amino acid is shown in figure 5.1

![Figure 5.1: Basic amino acid structure](image)

Each of the 20 amino acids contains a unique **R-group**. The only difference between the 20 amino acids is the R-group. The type of R-group determines the type of amino acid. The R-groups differ in their size and structure and vary with respect to their hydrophilic/hydrophobic character.

In figure 5.1, the location of the R-group is indicated with an “R”. The “R” is not a designated group but a place-saver used to indicate that an R-group is attached at this location.

Circle the R-group in figure 5.1

**Table 5.1** The structural formulas for several of the R-groups and the names of the amino acid they form.

<table>
<thead>
<tr>
<th>R-group structural formula</th>
<th>Name of amino acid with R-group</th>
</tr>
</thead>
<tbody>
<tr>
<td>-CH₂OH</td>
<td>Serine</td>
</tr>
<tr>
<td>-CH₂CH₂COOH</td>
<td>Glutamate</td>
</tr>
<tr>
<td>O</td>
<td>Glutamine</td>
</tr>
<tr>
<td>(-CH₂CH₂-C-NH₂)</td>
<td></td>
</tr>
<tr>
<td>CH₃</td>
<td>Valine</td>
</tr>
<tr>
<td>(-C-H)</td>
<td></td>
</tr>
<tr>
<td>CH₃</td>
<td></td>
</tr>
<tr>
<td>-CH₂SH</td>
<td>Cysteine</td>
</tr>
</tbody>
</table>
Amino acids can be joined together (amino end to carboxylic end) by covalent bonds. The bond formed between two covalently bonded amino acids is called a peptide bond.

![Peptide bond diagram](image)

On figure 5.2, circle the amino group in blue and the carboxylic group in red.

The number of amino acids joined end to end can vary greatly. In some molecules only two amino acids are joined together. Other molecules may contain hundreds of amino acids joined end to end.

The number, type, and order of amino acids that join together determine the type of peptide or protein that is formed. The sequence of amino acids in a protein is referred to as the protein’s primary structure. The amino acids in the primary structure then interact with each other to form a secondary structure composed of coiled and pleated regions called α-helix (alpha-helix) and β-sheet (beta-sheet) respectively. The interaction of the different R-groups in the chain causes further folding and bending of the molecule to occur, resulting in the tertiary structure of the peptide or protein. Some proteins are composed of a grouping of tertiary structures that interact with each other to form a final quaternary structure. Hemoglobin in red blood cells is protein with a quaternary structure.

**Exercise 1: Constructing Amino Acids**

1. Using the molecular model kit, construct the following amino acids.

![Amino acids](image)

Use a green colored pencil to circle the R-groups of the amino acids above.

**NOTE:** Do NOT disassemble any of the models you construct until you are finished with the lab.
2. Using the amino acid models you just constructed, simulate the reaction below.
   a. Remove a H from the amino group of Alanine.
   b. Remove a –OH from the carboxyl group of Glycine.
   c. Join the two amino acids by attaching the carboxyl end of Glycine to the amino end of Alanine.

   ![Chemical structures](image)

   d. Connect the H from Alanine to the OH from Glycine. What is this molecule?

   ![Draw an arrow pointing to the newly formed peptide bond.]

3. Perform the same reaction as in #2, this time connecting the amino end of Leucine to the carboxyl end of the Glycine-Alanine dipeptide that you made.

   ![Chemical structures](image)

   a. You have just made a tripeptide.

4. Play with this tripeptide by twisting the different parts. Is the molecule flexible? ______
REVIEW QUESTIONS

1. Is the formation of a peptide bond a hydrolysis reaction or a dehydration synthesis reaction?

2. Can a peptide bond be formed by joining two carboxylic acid groups together? ____
   Can a peptide bond be formed by joining two amino groups together? ____________
   Explain your answers.

3. Circle the peptide bond in the structural formula below.

4. Based on your observations of the tripeptide model you constructed in the lab, do you think a protein made of 75 amino acids would be flexible or rigid? __________
   Could part of the protein bend and make turns? ____________
   Explain your answer.

5. Based on the information in Table 5.1:

   a. What is the name of this amino acid? ________________

   b. Calculate this amino acid’s molecular weight? _________