

LECTURE PRESENTATIONS

For CAMPBELL BIOLOGY, NINTH EDITION

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Chapter 5 (continued)

The Structure and Function of Proteins

Lectures modified by Garrett Dancik

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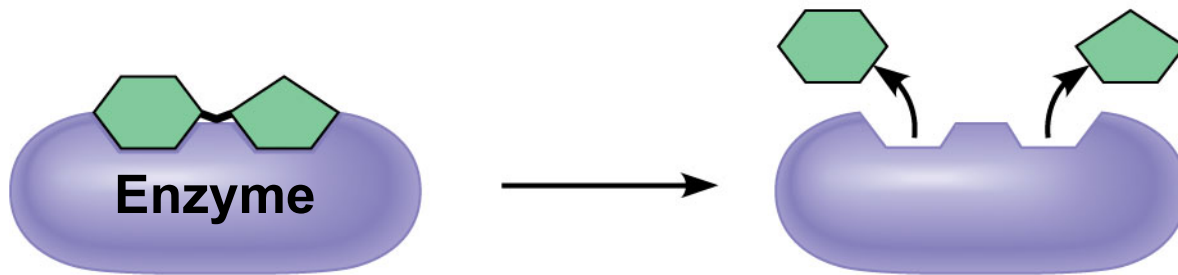
Concept 5.4: Proteins include a diversity of structures, resulting in a wide range of functions

- Proteins account for more than 50% of the dry mass of most cells
- Protein functions include structural support, storage, transport, cellular communications, movement, and defense against foreign substances

Enzymatic proteins

Function: Selective acceleration of chemical reactions

Example: Digestive enzymes catalyze the hydrolysis of bonds in food molecules.



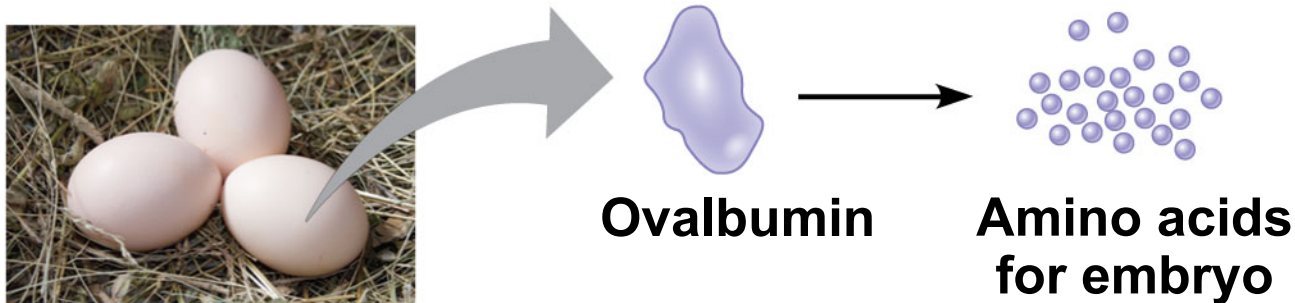
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- **Enzymes** are a type of protein that acts as a **catalyst** to speed up chemical reactions
- Enzymes can perform their functions repeatedly, functioning as workhorses that carry out the processes of life
- <http://www.biotopics.co.uk/other/morinf.html>

Storage proteins

Function: Storage of amino acids

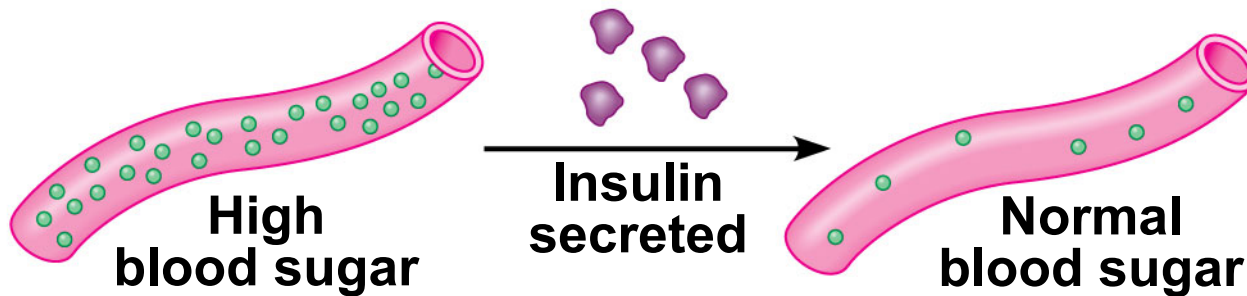
Examples: Casein, the protein of milk, is the major source of amino acids for baby mammals. Plants have storage proteins in their seeds. Ovalbumin is the protein of egg white, used as an amino acid source for the developing embryo.



Hormonal proteins

Function: Coordination of an organism's activities

Example: Insulin, a hormone secreted by the pancreas, causes other tissues to take up glucose, thus regulating blood sugar concentration



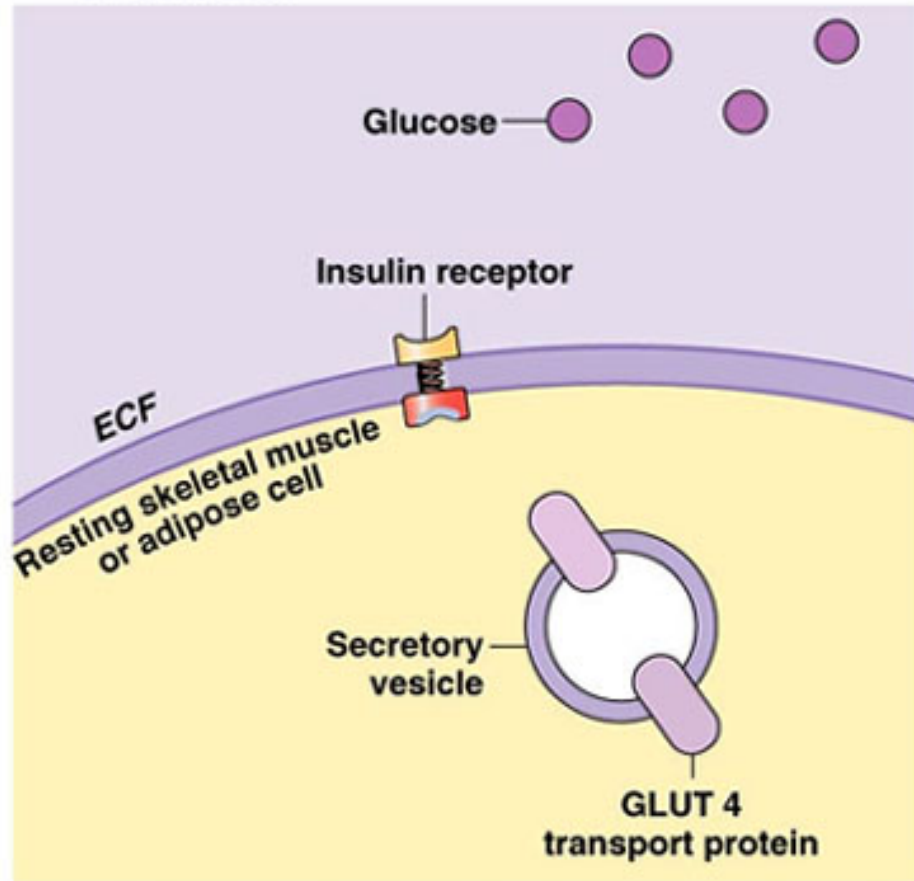
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Insulin protein entry:

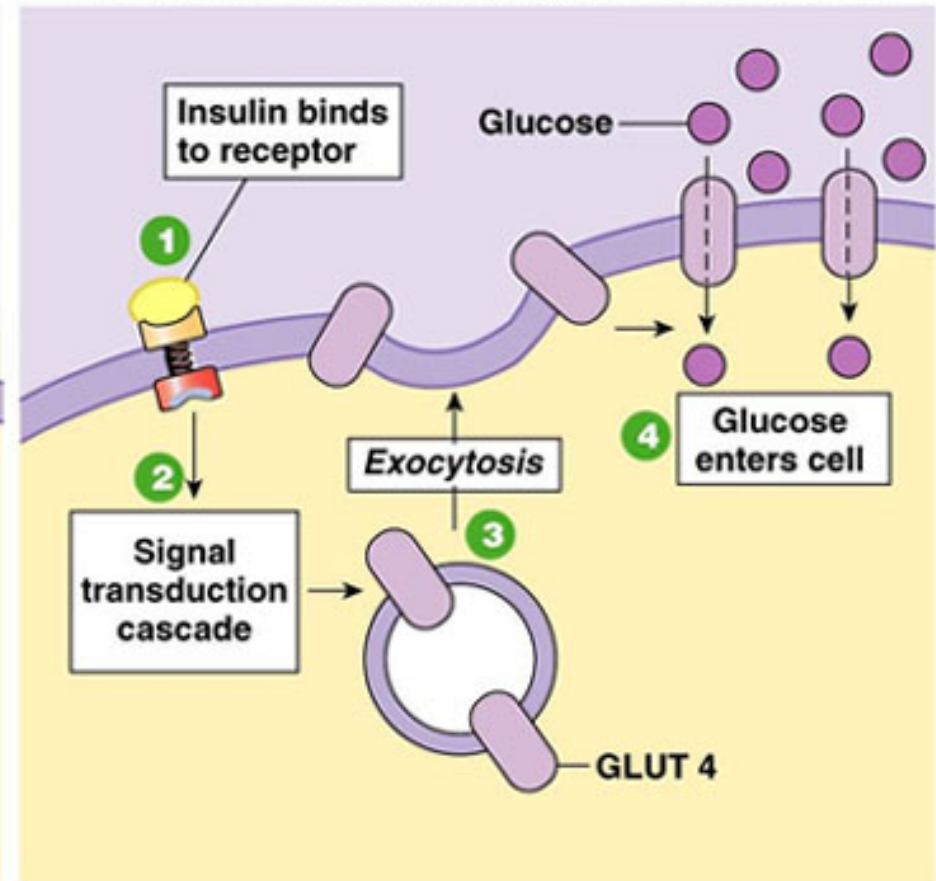
<https://www.ncbi.nlm.nih.gov/protein/AAA59172.1>

Insulin and Glucose transport

(a) In the absence of insulin, glucose cannot enter the cell.



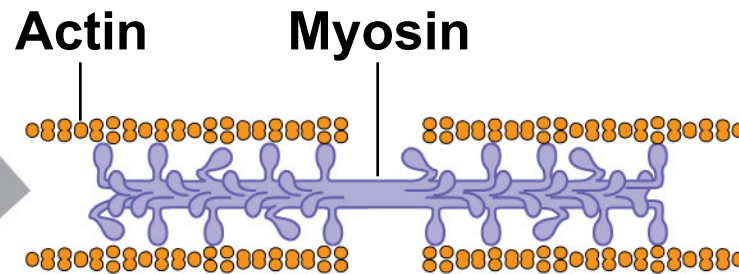
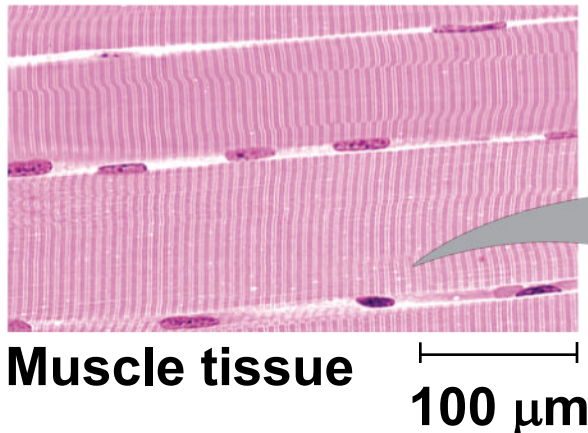
(b) Insulin signals the cell to insert GLUT 4 transporters into the membrane, allowing glucose to enter cell.



Contractile and motor proteins

Function: Movement

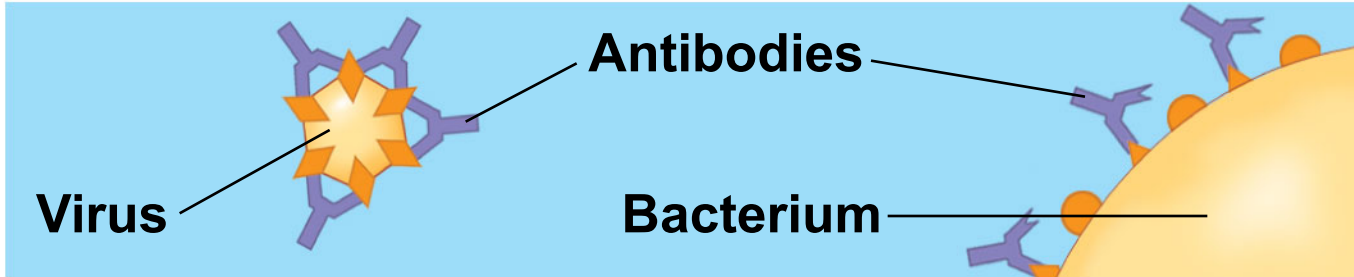
Examples: Motor proteins are responsible for the undulations of cilia and flagella. Actin and myosin proteins are responsible for the contraction of muscles.



Defensive proteins

Function: Protection against disease

Example: Antibodies inactivate and help destroy viruses and bacteria.

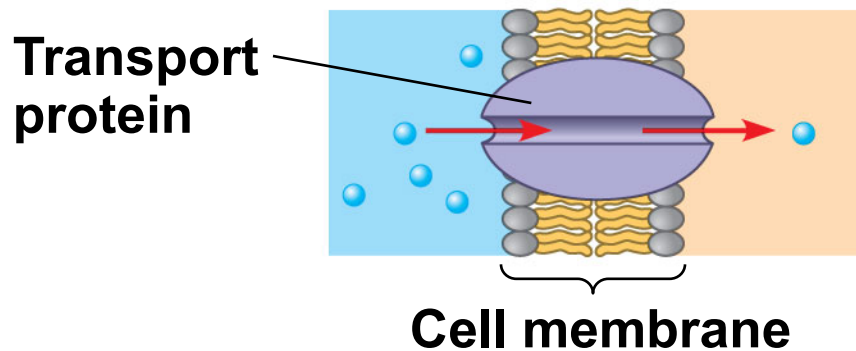


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Transport proteins

Function: Transport of substances

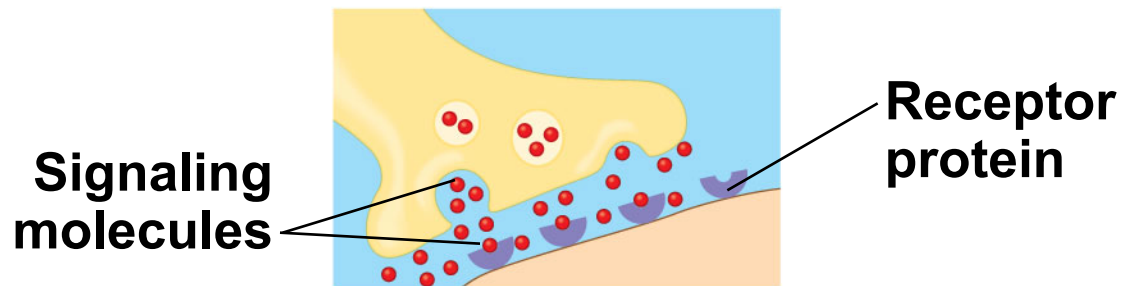
Examples: Hemoglobin, the iron-containing protein of vertebrate blood, transports oxygen from the lungs to other parts of the body. Other proteins transport molecules across cell membranes.



Receptor proteins

Function: Response of cell to chemical stimuli

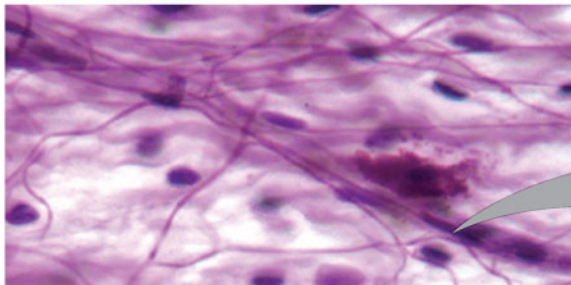
Example: Receptors built into the membrane of a nerve cell detect signaling molecules released by other nerve cells.



Structural proteins

Function: Support

Examples: Keratin is the protein of hair, horns, feathers, and other skin appendages. Insects and spiders use silk fibers to make their cocoons and webs, respectively. Collagen and elastin proteins provide a fibrous framework in animal connective tissues.



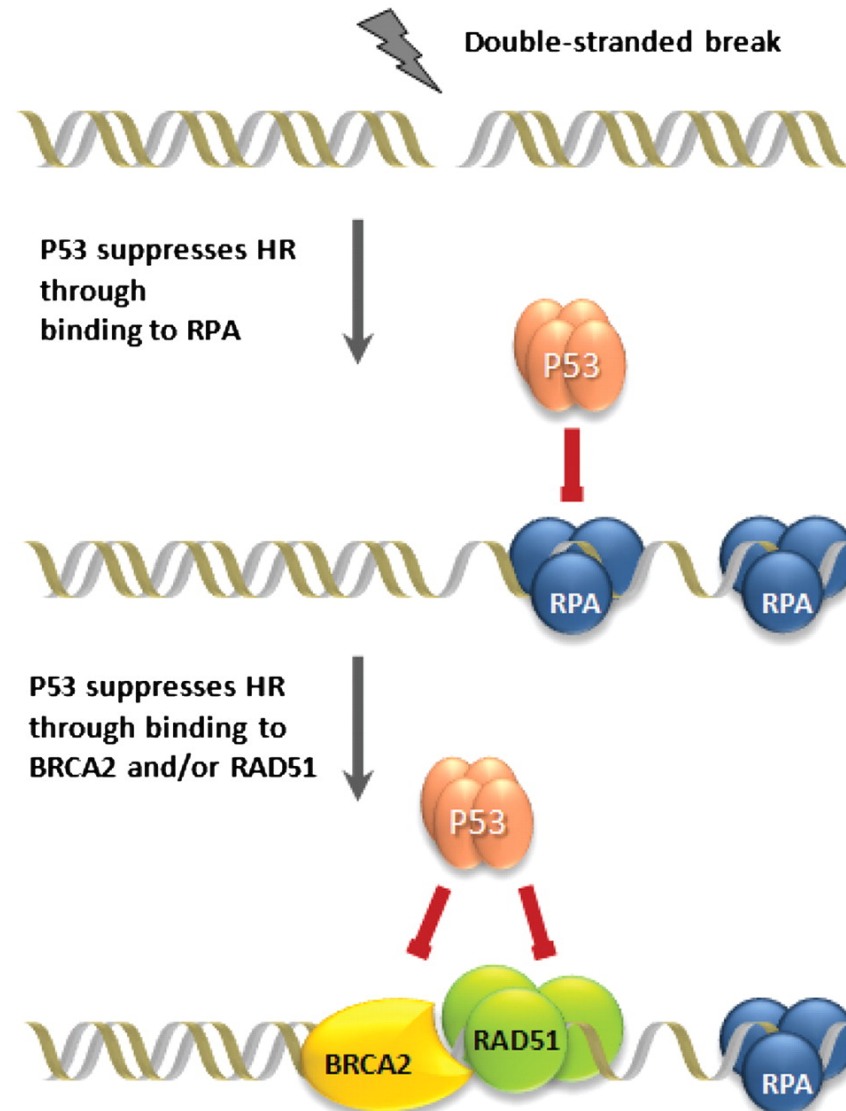
**Connective
tissue**

60 μm



DNA repair proteins

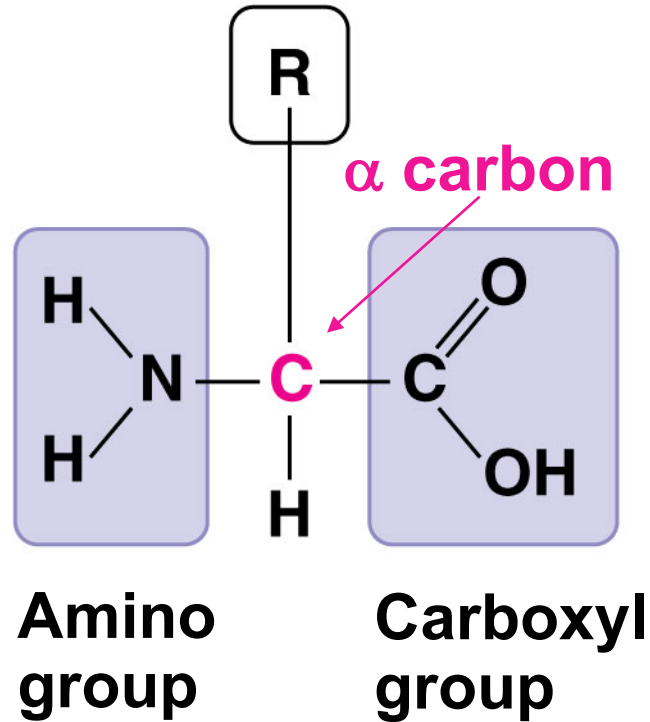
Examples include p53 and BRCA2



Proteins

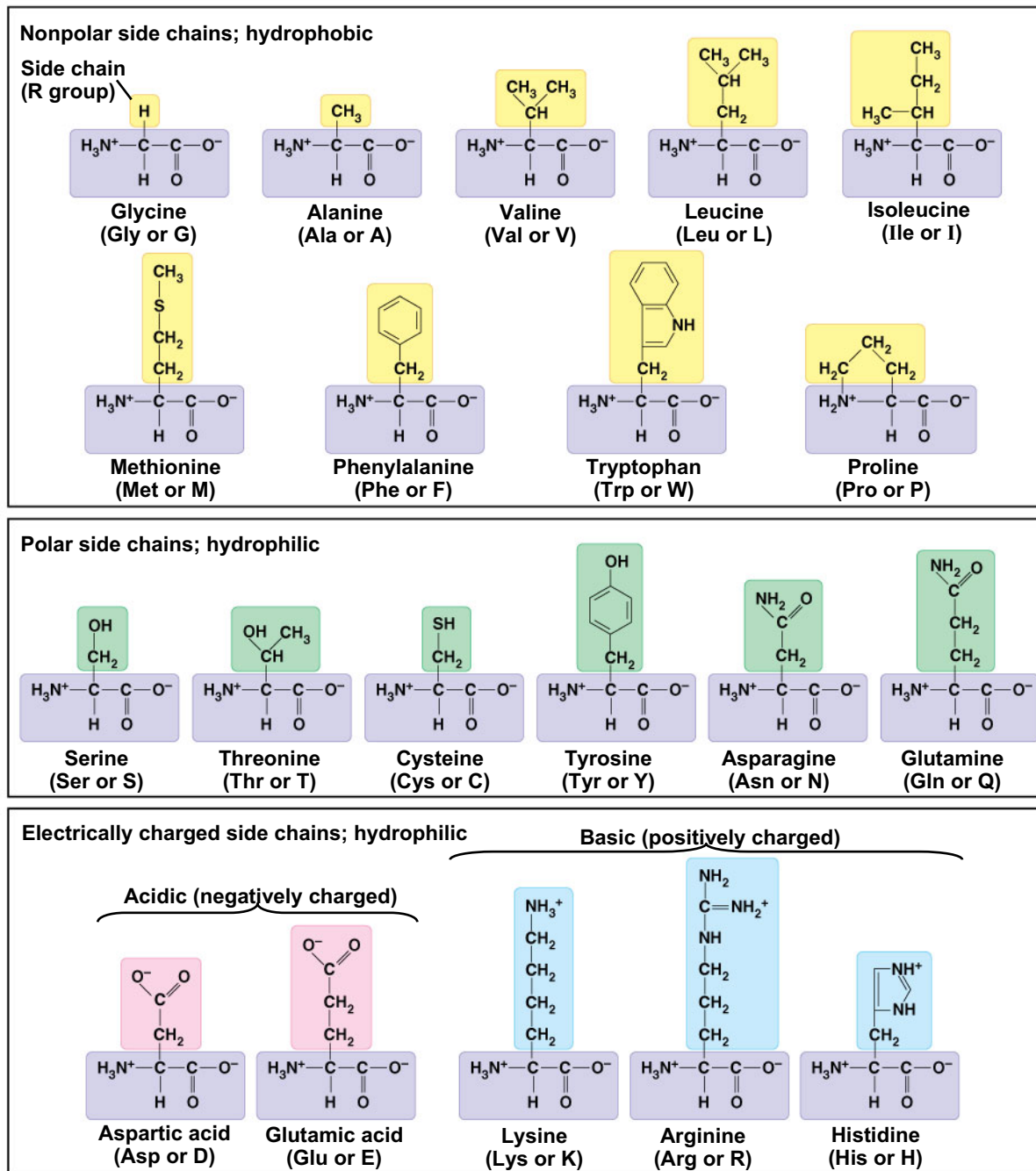
- **Amino acids** are the building blocks (monomers) of proteins
 - Amino acids are organic molecules with carboxyl and amino groups
 - Amino acids differ in their properties due to differing side chains, called R groups (see next slide)
- **Polypeptides** are unbranched polymers built from the same set of 20 amino acids
- A **protein** is a biologically functional molecule that consists of one or more polypeptides

Side chain (R group)



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Figure 5.16

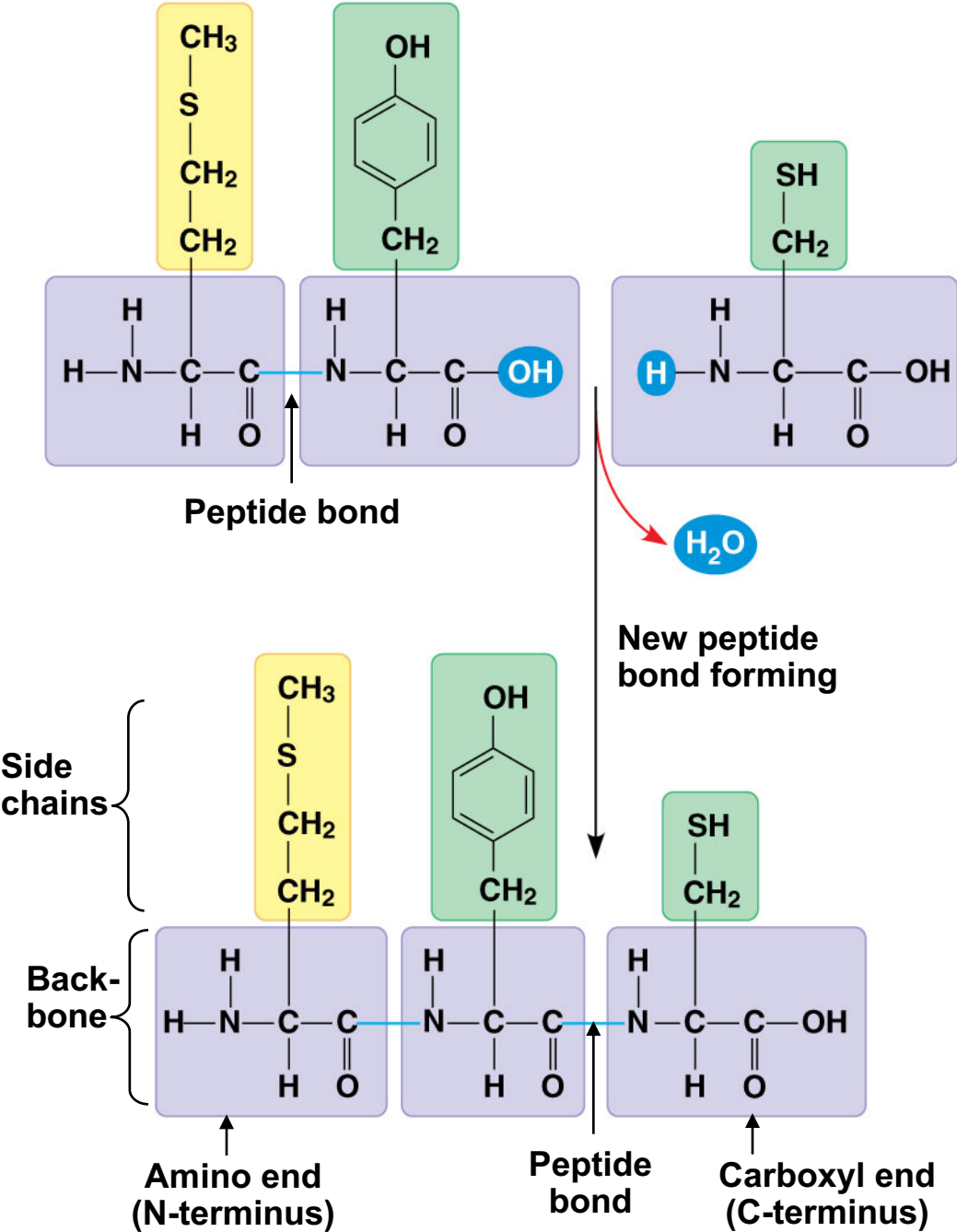


Amino Acid Polymers

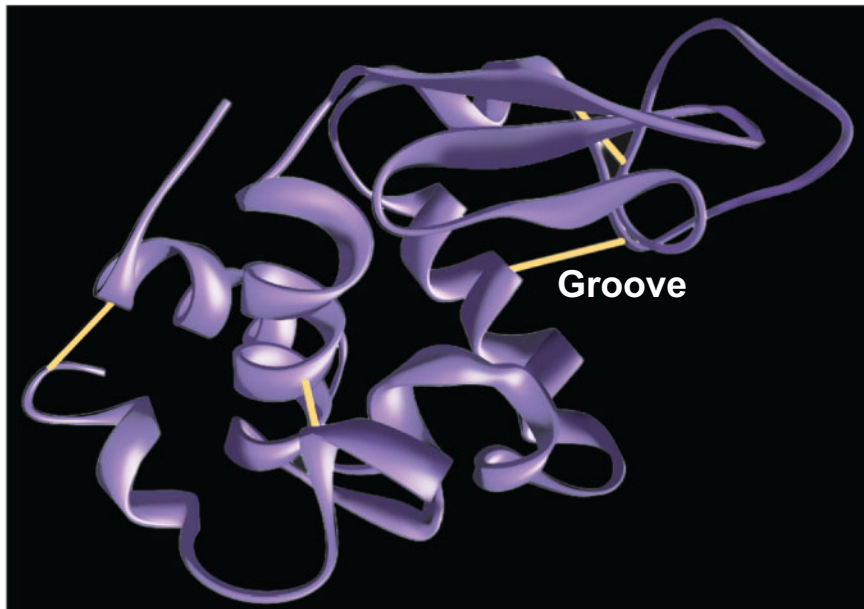
- Amino acids are linked by **peptide bonds**
- A polypeptide is a polymer of amino acids
- Polypeptides range in length from a few to more than a thousand monomers (amino acids)
- Each polypeptide has a unique linear sequence of amino acids, with a carboxyl end (C-terminus) and an amino end (N-terminus)

Figure 5.17

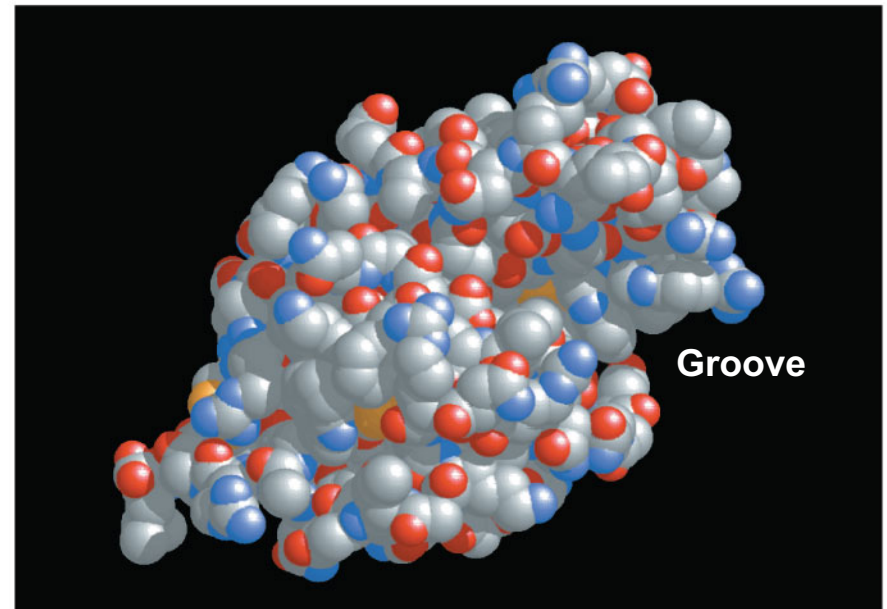
How are peptide bonds formed?



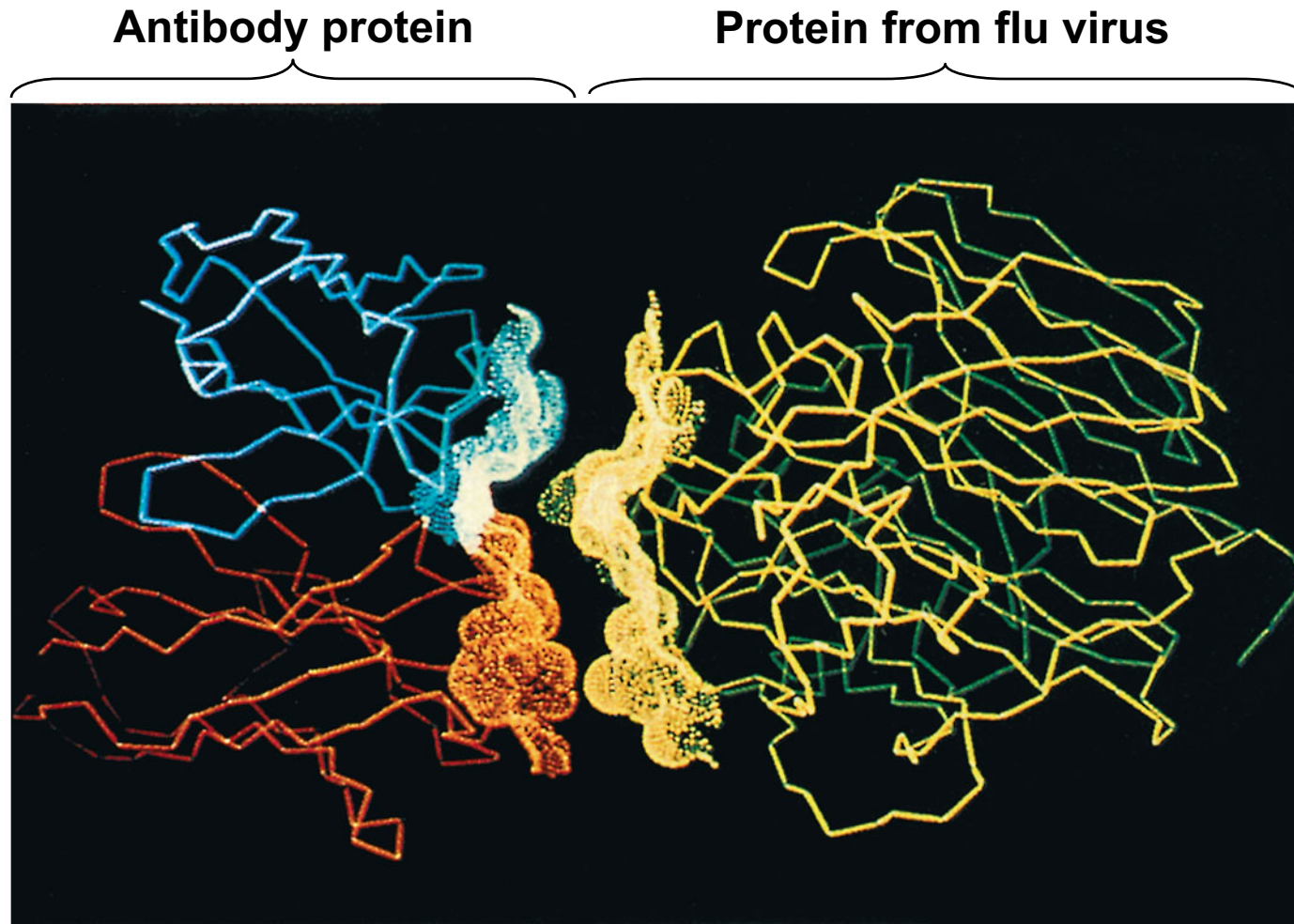
- A functional protein consists of one or more polypeptides precisely twisted, folded, and coiled into a unique shape
- The sequence of amino acids determines a protein's three-dimensional structure
- A protein's structure determines its function
- Bioinformatics uses computer programs to predict protein structure and function from amino acid sequences



(a) A ribbon model



(b) A space-filling model

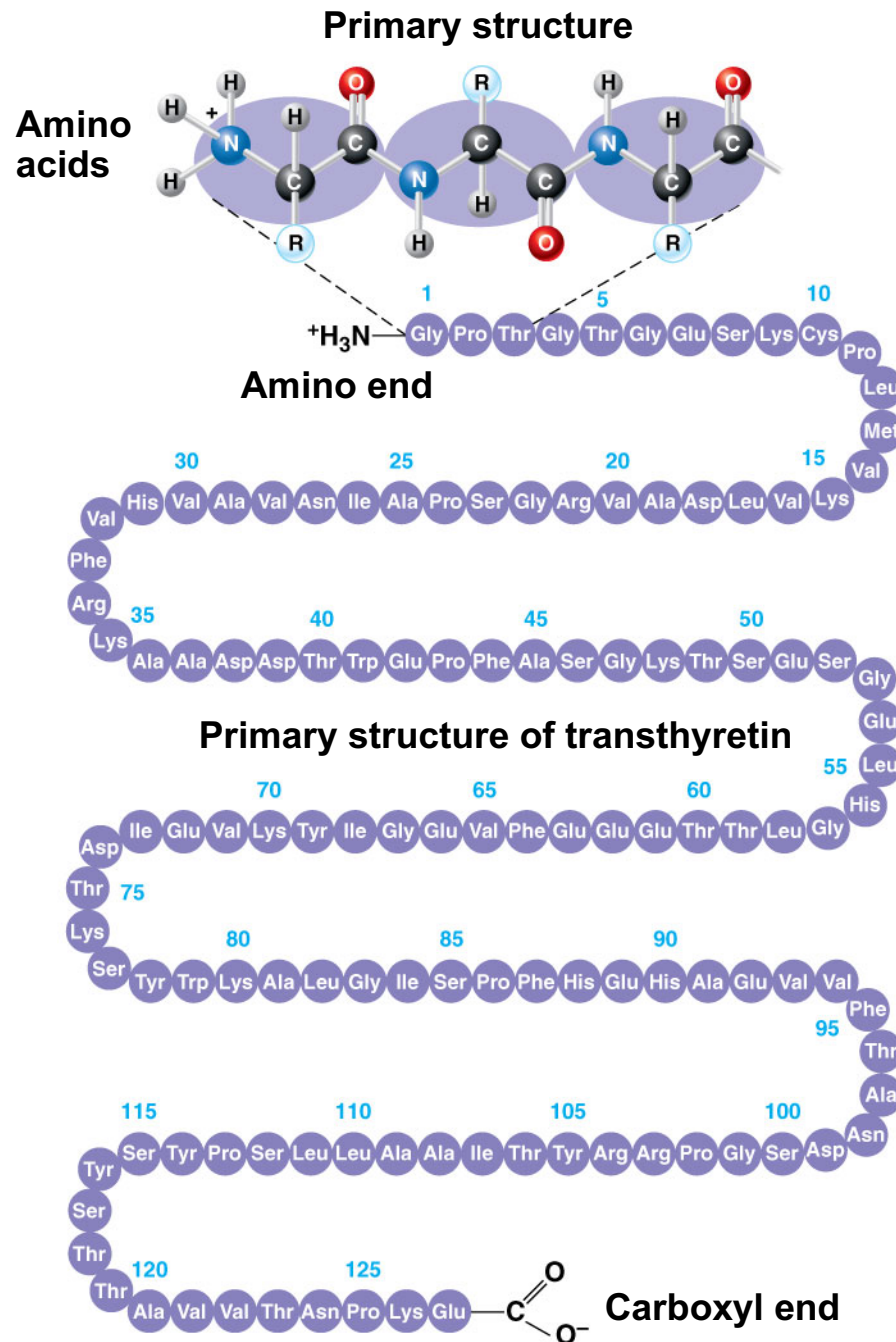


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Four Levels of Protein Structure

- The primary structure of a protein is its unique sequence of amino acids
- Secondary structure, found in most proteins, consists of coils and folds in the polypeptide chain
- Tertiary structure is determined by interactions among various side chains (R groups)
- Quaternary structure results when a protein consists of multiple polypeptide chains

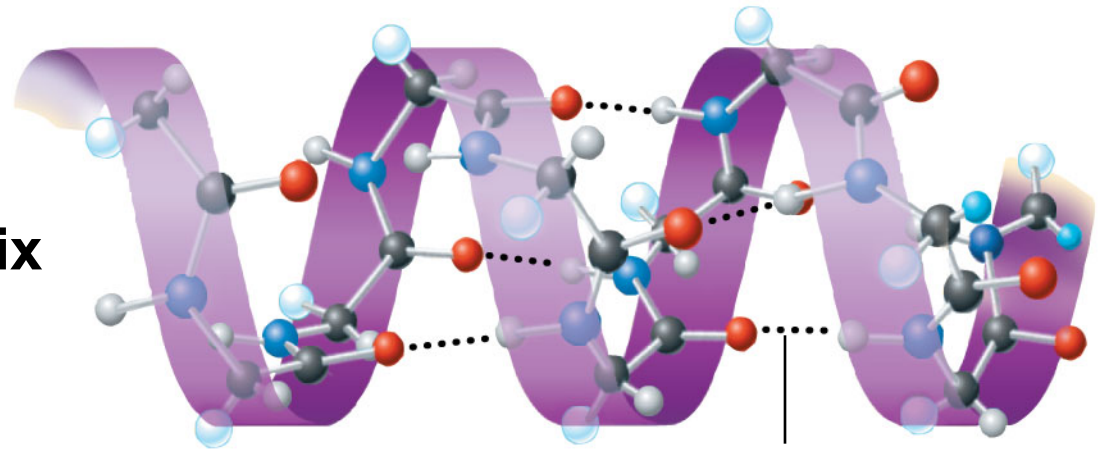
- **Primary structure**
 - The sequence of amino acids in a protein
 - Determined by inherited genetic information



- **Secondary structure** results from hydrogen bonds parts of the polypeptide backbone
- Includes the α **helix** and a called a β **pleated sheet**

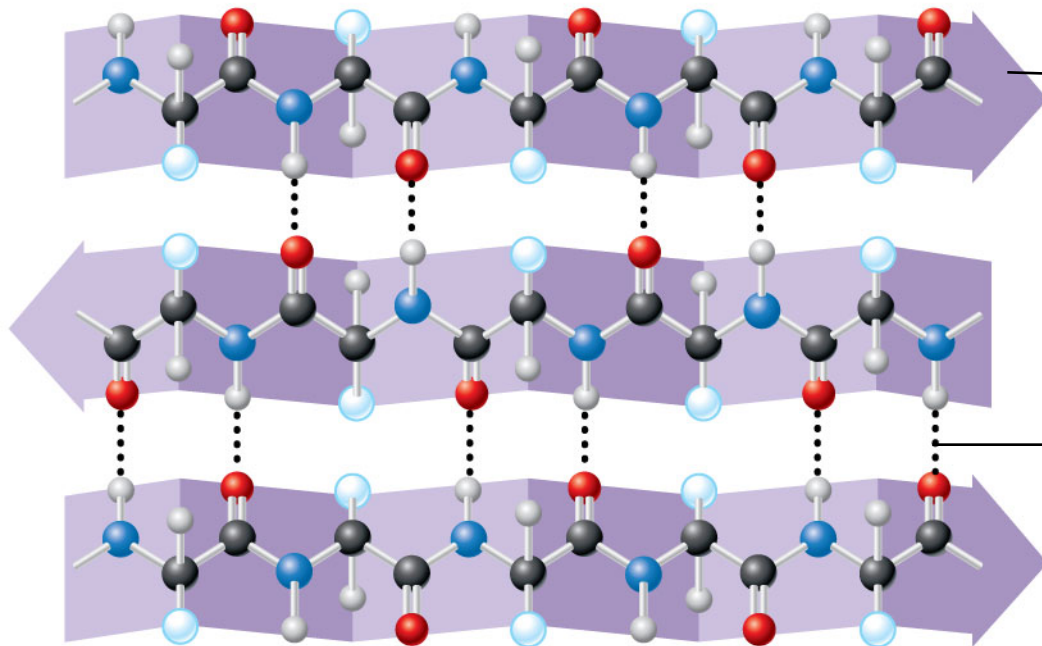
Secondary structure

α **helix**



Hydrogen bond

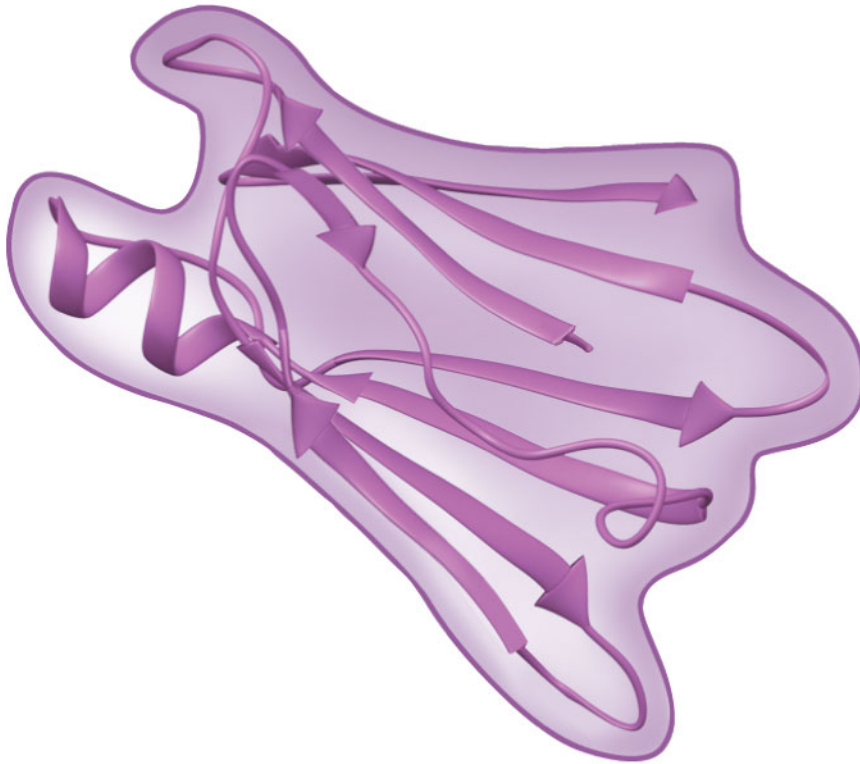
β **pleated sheet**



β **strand**, shown as a flat arrow pointing toward the carboxyl end

Hydrogen bond

- **Tertiary structure** is the shape of a polypeptide in three dimensions



**Transthyretin
polypeptide**

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- **Quaternary structure** results when two or more polypeptide chains form one macromolecule

α subunit

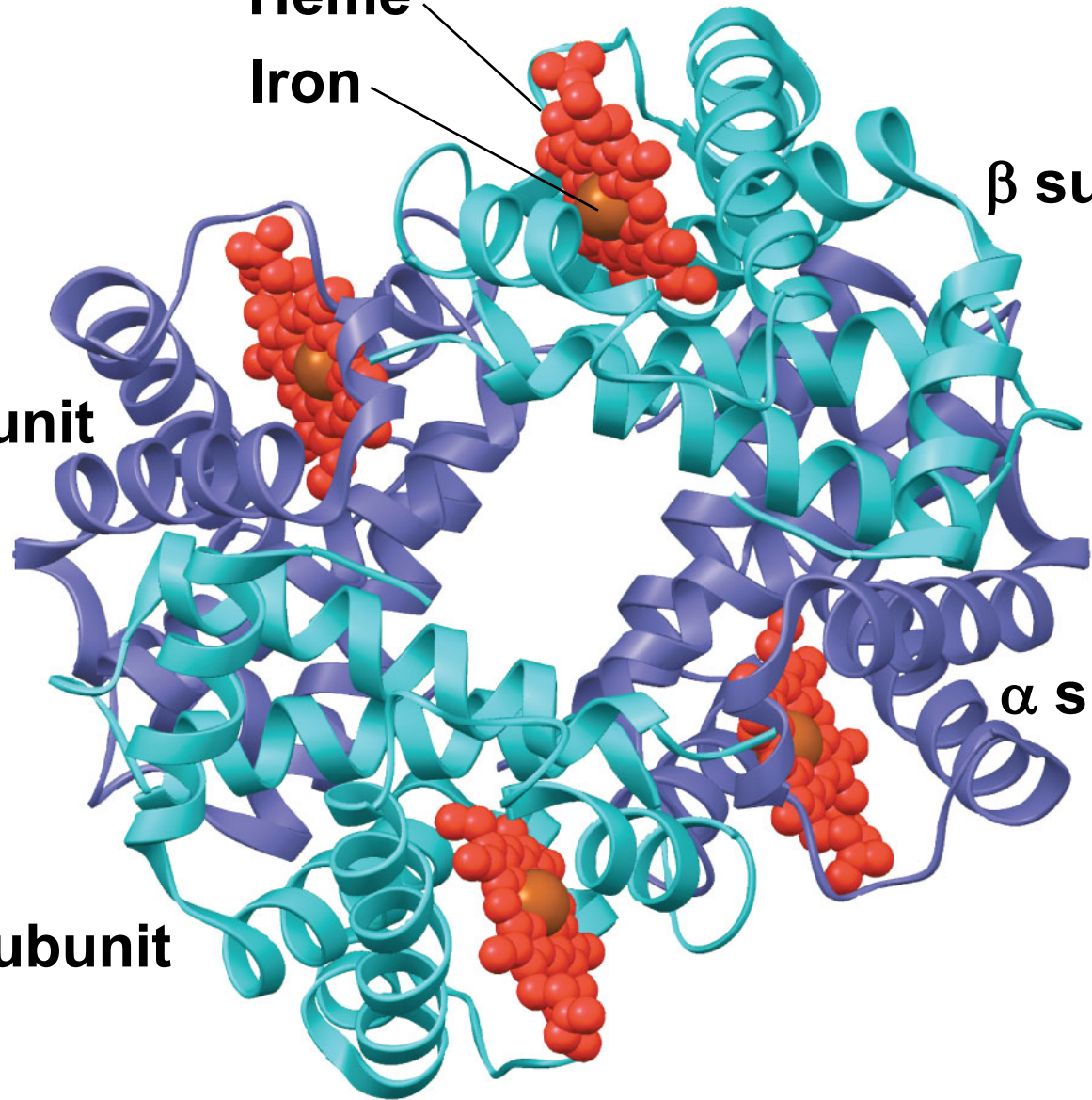
β subunit

Heme

Iron

β subunit

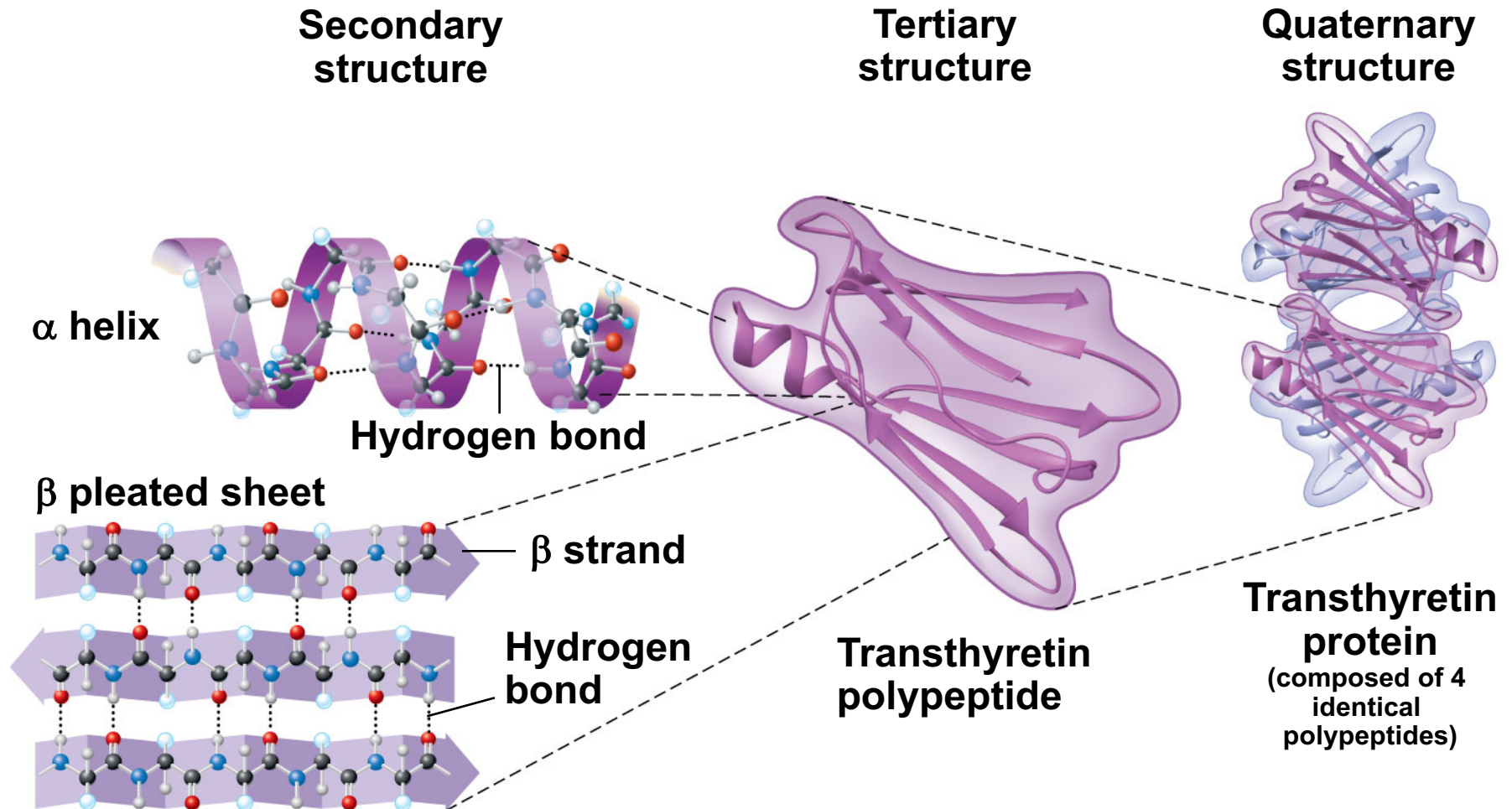
α subunit



Hemoglobin

Putting it all together...

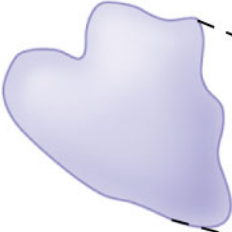
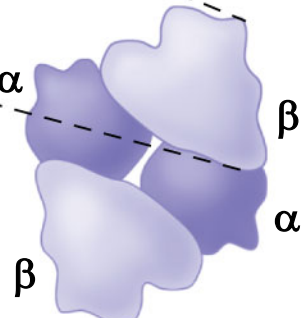
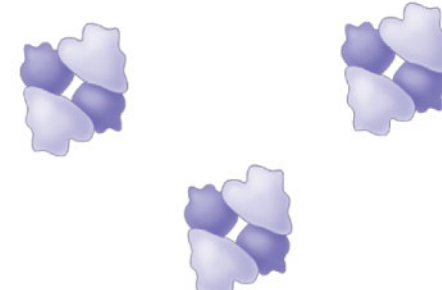
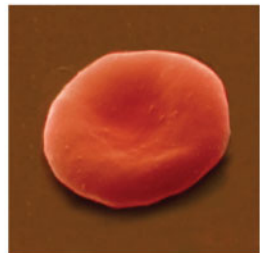
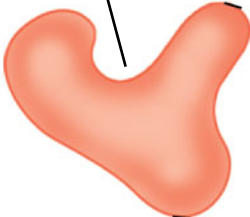
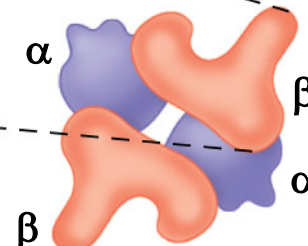
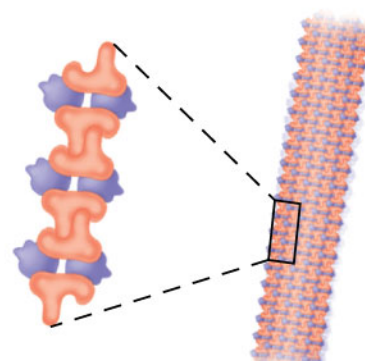

(but primary structure is not shown)



Sickle-Cell Disease: A Change in Primary Structure

- A slight change in primary structure can affect a protein's structure and ability to function
 - How does the primary structure change?
- **Sickle-cell disease**, an inherited blood disorder, results from a single amino acid substitution in the protein hemoglobin
- Genpept:
 - <https://www.ncbi.nlm.nih.gov/protein/4504349>

Figure 5.21

	Primary Structure	Secondary and Tertiary Structures	Quaternary Structure	Function	Red Blood Cell Shape
Normal hemoglobin	1 Val 2 His 3 Leu 4 Thr 5 Pro 6 Glu 7 Glu	 <p>β subunit</p>	<p>Normal hemoglobin</p> 	<p>Molecules do not associate with one another; each carries oxygen.</p> 	 <p>10 μm</p>
Sickle-cell hemoglobin	1 Val 2 His 3 Leu 4 Thr 5 Pro 6 Val 7 Glu	<p>Exposed hydrophobic region</p>  <p>β subunit</p>	<p>Sickle-cell hemoglobin</p> 	<p>Molecules crystallize into a fiber; capacity to carry oxygen is reduced.</p> 	 <p>10 μm</p>