Name: *Period:*

2 The Science of Biology
Modeling Protein Structure

Introduction

Proteins are one type of macromolecule that are found in living things. They are constructed through the joining, by the process of dehydration synthesis, of smaller monomers called amino acids. There are 20 amino acids that are used by living things to construct proteins. All amino acids share certain characteristics, yet each differs structurally, and therefore can have different properties, which effect how they interact with other molecules. The order of amino acids is directed by the DNA in the cell.

Objective

To relate the structure of an object with its function.

Demonstrate that the primary structure of a protein relates directly to the secondary, tertiary, and quarternary structure of a protein.

Comprehend that the final structure of a protein relates directly to its function.

Materials

Wire toober

Pipe cleaners (6 yellow, 3 white, 2 red, 2 blue, and 2 green)

Procedure

1. With your partner, use a toober to construct an apparatus that will carry a pencil and three pieces of paper across the room. You cannot use anything but the toober. You may use loops, folds, and twists, but no part of the toober can be cut and the outer coating must remain on the wire inside without any of it being visible.

2. Exchange your apparatus with another group's. Is your apparatus the same? Name one difference and one similarity between the design of your apparatus and that of the other group's.

3. What type of fold worked best to hold the pencil? What type of fold worked best to hold the paper?

4. Using the other group's toober, change one bend of the apparatus. Does this change have any affect on the function of the apparatus? Can you change a bend of the apparatus without changing the function?

5. Describe in your own words how the structure of an object affects its function.

6. Now you will make a structure with the toobers that has specific bends and twists based on some design rules. Each group now gets fifteen pieces of pipe cleaner according to the following colors: 6 yellow, 3 white, 2 red, 2 blue, and 2 green. Mix up the colors and randomly place the pipe cleaners on the toober by twisting them around the toober. Space them so they take up the entire toober and are roughly equally spaced (about every three inches). When twisting them on the tube, align all the twisted ends to face the same direction.

7. Starting at one end of the toober, begin bending the toober according to the following rules:

   Yellow pipe cleaners need to be on the interior of the structure as close together as you can.
   White pipe cleaners need to be on the outside of your structure and away from any yellows.
   Red and blue pipe cleaners pair with each other - red to blue - so they are touching.

Green pipe cleaners pair together and need to be touching.

The twisted ends of the pipe cleaner represent the reactive region of the pipe cleaner and, when folding the tube, should pair with other twisted ends. Do not twist them on the tube.

8. When you have reached the end, you should have a toober that has been folded into some three-dimensional shape. Compare your shape with another groups. Are they the same? Name one characteristic that is the same and one characteristic that is different.

9. If you both followed the same rules of bending, why were the two shapes different?

10. Recalling that the structure of an object relates directly to its function, could both of the shapes perform the same task?

11. Would the toober fold the same way if the order of pipe cleaners was different?

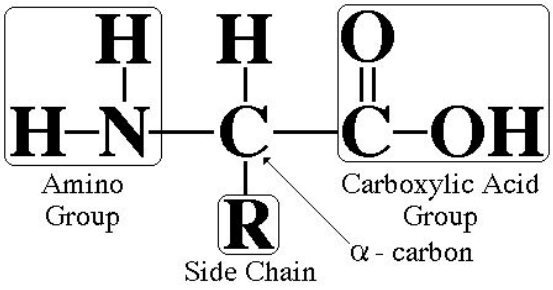
12. Explain in your own words how the order of the colored pipe cleaners determined the three dimensional shape of the final model.

13. Describe how a change in the order of pipe cleaners could result in two shapes that perform different functions.

14. Make sure your teacher has seen your model.

15. The pipe cleaners represent amino acids. There are twenty different amino acids, yet they all share some basic characteristics. All are formed by a central carbon, amino arm, carboxyl arm, hydrogen head, and R-group.

The specific properties of the R-group determines whether the amino acid is polar (hydrophilic), nonpolar (hydrophobic), charged (positive or negative), or can form bonds with other amino acids. The twisted end of the pipe cleaner represented this R-group. The different colors of pipe cleaners relate to these properties:



yellow are nonpolar (hydrophobic)
white are polar (hydrophilic)
blue are positively charged
red are negatively charged
green have sulfhydryl groups, which bond to each other to form a strong bond called a disulfide bridge.

The order of amino acids (primary structure) determines the order of the R-groups, and therefore the pattern of bending. This pattern of bending determines the shape of the protein. As structure relates to function, the shape of the protein relates directly to its function. If the shape of the protein is changed, the function it performs will also change.

16. To model the change in protein shape, replace any red pipe cleaner with a yellow one. Bend the toober to reflect the new bonding pattern according to the previous rules. Describe how this change of a single amino acid affects the shape of the protein.

17. Predict what effect the change in protein shape would have on the function of the protein.

18. The change you have modeled is a representation of a real condition called sickle cell anemia. Red blood cells have on them a protein called hemoglobin, which carries oxygen, and results in red blood cells normally having a shape that resembles a doughnut without the hole in the middle. In sickle cell anemia, a single mutation occurs in a subunit of hemoglobin at amino acid #6 in which a glutamic acid (negative charge) is replaced with a valine (nonpolar). This single change in amino acid sequence results in red blood cells that form a sickle shape, and look like the letter C. This sickle shape impairs the ability of the red blood cells to carry oxygen, causes them to clump together, and can become trapped in capillaries, which impedes blood flow through the body.

Teacher Notes

Engage

Relate structure to function. Pick any object that has a function (water bottle holds water) and ask the students to describe its function. Discuss how the structure of the bottle relates to its function. What if you changed the bottle (tube with no bottom)? Would it function the same? (wouldn't hold water) Does the structure have to be identical to this water bottle to work (coffee cup also holds water, yet is not identical). Structure and function are directly related. The water bottle has a lid that seals, and is effective for holding liquids sealed tightly. The coffee cup does not, yet is insulated to ensure that hot water does not burn the hand.