Lesson 4: The Code for Building Proteins

Introduction

In the last two lessons, you saw that many of an organism's traits are the result of proteins. The structure and function of these proteins results from the specific order of amino acids joined together in the protein. What determines the specific order of amino acids in a protein? That question will focus our work in this lesson.

Process and Procedure

Lesson Focus Question

1. Write the focus question for this lesson in the box below. Write your best ideas about the question below the box. Be sure to leave space to revise your ideas in a different color as the class discusses the focus question.

Proteins Do the Work of the Body

2. Read the information about proteins. As you read each paragraph, annotate the text to show science ideas that you and your classmates already wrote on a sticky note and ideas that you could add to a chart. Use the space below to record ideasthat should be added to a chart on a new sticky note.

Proteins Have Many Jobs

You may think a protein is just something you find in meat, nuts, and dairy products. There are proteins in those foods. However, in a living organism, proteins are much more than that. Proteins play a role in almost all of life's processes. For example, enzymes are proteins that help chemical reactions take place. Some enzymes in your stomach help break down the food you eat. Insulin is another protein. It is a type of protein hormone that aids in controlling the level of sugar in your body. Other proteins, like melanin, produce pigments that determine the color of your eyes and hair. Collagen is a protein that helps make your skin and bones strong. Proteins such as hemoglobin help move oxygen around your body. Antibody proteins help your body fight off illness. Proteins help give cells their structure and shape. Those are just a few examples of the variety of proteins and what they do. As you saw in the jaguar example, there can be different amounts of each protein in cells.

What Are Proteins Made Of?

Regardless of the type of protein, all of them are made up of a chain of building blocks, or subunits, called amino acids. In the cytoplasm of a cell, amino acids are first put together in a long, linear molecule. Proteins fold into particular shapes based on the order of amino acids. Proteins will function properly only when they have folded into a very specific shape. But what determines the order in which amino acids are put together?

DNA is the Code of Life

Even though proteins are responsible for many jobs in cells, there is another molecule that has the instructions to make proteins. Those instructions are found in deoxyribonucleic acid, or DNA. People sometimes say that DNA has the instructions for all of life. DNA is found in every living thing, from bacteria to sunflowers to humans to whales. It contains the blueprints to assemble amino acids in the proper order to make all the different types of proteins in your body. DNA is found in the nucleus of your cells. But how can a molecule contain instructions? Just as the structure of a protein determines its job, or function, in a cell, the structure of DNA holds the information needed to make proteins.

3. Imagine that you are on a team of research scientists trying to describe the structure of the DNA molecule. You have decided to tackle the problem by constructing a physical model. As new information becomes available, you will change your model to reflect the new information, much like Watson and Crick did.

Model 1

- Like proteins, DNA is a polymer. A polymer is a long, chainlike molecule composed of smaller parts or subunit molecules. Subunit molecules are like the links in a chain. They are attached to each other by chemical bonds.
- There are four different types of DNA subunit molecules.

Model 2

- DNA consists of two long chains of subunits twisted around each other to form a double helix. A helix is a spiral. This of the shape of a pipe cleaner wrapped around a pencil.

- The two helical chains are weakly bonded together. The subunits of one strand bond to subunits on the other strand.
- The diameter of the DNA molecule is the same along its length. It does not get wider or thinner from one end of the molecule to the other.

Model 3

- The order of subunits in one strand of DNA determines the order of the subunits on the other strand.
- The subunits are not paired with those of the same type on the other strand. For example, a red pop bead on one strand would not be paired with a red pop bead on the other strand.

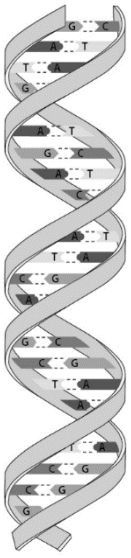
4. Read the information about DNA structure. As you read each paragraph, annotate the text to show ideas that are represented in your model and ideas that are new.

DNA Structure Suggests it is a Code

Sometimes a very simple code can provide complex information. For example, information in a computer is sent using only the numbers 0 and 1. The order of these two numbers provides very complex information to the computer. We propose that DNA is a code that provides the complex information for producing every kind of protein.

This report is based on our research about the structure of DNA. The building blocks of DNA are smaller molecules called nucleotides. There are four different nucleotides in DNA: adenine (A), cytosine (C), guanine (G), and thymine (T). DNA is a double-stranded molecule. Two long strands of DNA are connected by weak bonds between nucleotides on each strand. The two strands twist into a double helix shape that looks like a twisted ladder.

We have found that the nucleotides on one strand pair with nucleotides on the other strand in predictable ways. Adenine (A) always pairs with thymine (T), and cytosine (C) always pairs with guanine (G). This means the order of the nucleotides on each strand is complementary, not identical. For example, if nucleotides on one strand are in the order A-T-C, the nucleotides on the complementary strand will be in the order T-A-G.



We found that the four nucleotides *within* a strand are bonded together in any order. This suggests that the nucleotides are like the letters in a word. Consider how the order of letters in a word conveys information to someone who is reading. For example, placing the three letters A, T, and C in the order C-A-T is the "code" for "CAT", meaning a small, furry mammal. Placing the same letters in the order A-C-T is code for the verb "ACT" that means to behave. Similarly, the nucleotides in a DNA strand may stand for specific amino acids. This means that the order of the nucleotides in DNA gives the information for the order of amino acids in a protein. The order of the amino acids in a protein give it a unique structure and function.

Our idea also indicates what a gene is. Earlier research describes the "gene" as the basic unit of heredity. However, this research has little to say about the physical nature of the gene. We suggest that a gene is a segment of DNA that contains the code for assembling amino acids in the correct order to make a specific protein. This definition of a gene is based on the structure of DNA and the idea that DNA is a code. Each gene in DNA has a unique sequence of nucleotides that codes for a specific protein. We encourage further research for collecting evidence that supports or contradicts our hypothesis that DNA is a code.

5. DNA Analogy Map

Part of Model	Represents…	What the part represents	They are alike because:
one pop bead			
four different colors of pop beads			
		double helix	
		complementary base pairing	
What are the strengths and limitations of this model?			

Summarize Key Science Ideas

6. The focus question for this lesson was: *How does a cell assemble amino acids in the correct sequence to make a protein that can do its job in the cell?* Return to your original answer and revise your ideas in a different color. Your goal is to give the most accurate answer that includes all the information you have learned.