Lesson 2: DNA Transcription and Translation

Introduction

This lesson is designed build on students' knowledge of DNA and RNA structure to teach students about DNA transcription and translation. Students will connect these processes to the formation of a functional protein, and how DNA mutations that affect protein structure, like the structure of hemoglobin in sickle cell anemia, can have a large affect on the body.

Student Background Knowledge

Before this lesson, students should have a solid grasp of DNA and RNA base pairing, and the differences in DNA and RNA structure. Students should also understand the function of cell organelles like the nucleus and ribosome. A basic knowledge of the circulatory system is also necessary.

Teacher Background Knowledge

DNA transcription occurs in the nucleus. Messenger RNA (mRNA) makes a complimentary strand to the section of DNA coding for the protein. In mRNA, adenine compliments with uracil instead of thymine, the compliment in DNA. The messenger RNA carries the complimentary strand out of the nucleus to the ribosome, the organelle where proteins are manufactured. This is where translation occurs. Transfer RNA (tRNA) brings the appropriate amino acids to the ribosome where they are attached together like beads on a string to form the protein. tRNA reads a three base pair section (called a codon) of mRNA at a time. Each amino acid has a set of codons that code for that particular molecule.

Each protein has a specific shape; determined by the sequence of amino acids that it consists of. A protein's structure determines its function. Hemoglobin is the protein that is responsible for carrying oxygen in red blood cells. In healthy cells, hemoglobin molecules remain separate both when they are carrying oxygen to the body tissues and when their oxygen supply is depleted and they are returning to the lungs. Individuals with sickle cell anemia have one amino acid substitution; exchanging a valine for the normal glutamic acid. This subtle change causes drastic problems. The hemoglobin protein in sickle cell anemia polymerizes, or sticks to itself, when the oxygen has been transferred to body tissues. This causes the cell to snap into the sickle shape that is characteristic of the disease, instead of remaining plump and round on its journey back to the lungs. Sickle shaped cells easily lodge in the tiniest capillaries, depriving the surrounding tissues of oxygen and causing damage. Sickle cells that return to the lungs can snap back into shape once oxygenated, but the constant popping into and out of shape makes the cells brittle and shortens their life span.

TEKS Objectives:

BIOL.1.05 Organize, analyze, evaluate, make inferences, and predict trends from data.
BIOL.2.02 Interpret the functions of systems in organisms including circulatory, digestive, nervous, endocrine, reproductive, integumentary, skeletal, respiratory, muscular, excretory and immune.
BIOL.2.10 Compare the structures and functions of different biomolecules including carbohydrates, lipids, proteins, and nucleic acids.

BIOL.2.23 Relate cellular functions and processes to specialized structures within cells.
BIOL.2.25 Investigate and identify cellular parts and processes including homeostasis, permeability, energy production, transportation of molecules, disposal of wastes, and synthesis of new molecules.
BIOL.2.35 Describe the components and structure of DNA and illustrate how it carries the information for traits
BIOL.2.38 Compare genetic variations observed in plants and animals
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Materials
Paper
Pencils
Hemoglobin DNA Code Worksheet
Say It With DNA Worksheet

Lesson Plan

OPENING:
Warm Up: List all of the people and materials needed to design and build a house. Have students share answers. Use this opportunity to connect structure and function. A house doesn't need to be several stories tall with multi-stall restrooms, but an office building might. An office building does not need a bathtub, but a house might etc.

CONCEPT DEVELOPMENT:
Compare DNA transcription and translation to building a house. Be sure to review the base pairing rules and differences between DNA and RNA. The DNA is the blueprint. Have students brainstorm how to get a blueprint from the architect's office (nucleus) to the construction site (ribosome). Email or fax is an option to represent mRNA because each puts the original blueprint in a different form (electronic messages, not paper) just like mRNA is different from DNA. That is transcription. During translation, the construction workers read the faxed blueprint (as tRNA "reads" mRNA). The building materials – bricks, support beams, shingles, etc – are like the amino acids. After reading the blueprint, the construction workers take the appropriate materials and put them together in the right order to make a house. tRNA brings amino acids to the ribosome in the right order to make a protein.
Stress the importance of structure determining function in a protein using sickle cell anemia as an example.

GUIDED PRACTICE:
Say It With DNA worksheet. Students will work as you show them how to decode a phrase from a DNA sequence.

STUDENT PRACTICE:
Students will transcribe and translate the DNA sequence of the first 7 amino acids in sickle cell hemoglobin into the amino acid sequence that determines the protein. They

will compare the sickle cell amino acids to normal hemoglobin amino acids to diagnose the DNA mutation.

CLOSURE:
Exit Ticket: Give students a small amino acid sequence to decode backwards into the DNA sequence.