Teacher Notes

Contents

Activity Guide

This activity guide for the Flow of Genetic Information Field Test Kit© will help you consider different ways you may use these materials. We encourage you to modify these lessons and activities to meet the learning objectives and needs of your specific students.

Replication Activity

Objectives

Students will

- **Identify** the directionality of a DNA strand.
- **Explain** the implications of the anti-parallel structure of DNA as it relates to replication.
- **Model** the replication of the leading and lagging strands of DNA.
- **Describe** the semiconservative nature of DNA replication.
- **Describe** the semi-discontinuous process of DNA replication.
- **Explain** how a change in the DNA code may result in a change in the encoded protein.

Prerequisite Knowledge and Skills

- Hydrogen bonding and covalent bonding
- Cell structure
- DNA structure
- Cell cycle basics
- Prokaryotic and eukaryotic cell structure

Teacher Notes Continued

Kit Materials Needed

- DNA Replication Placemat (recommended one placemat per group of four students)
- Polymerase
- Foam nucleotides (You may wish to use the gray pieces to emphasize parent and daughter DNA strands.)

Other Materials Suggested

- DNA Discovery Kit© DNA-12 *(available from 3D Molecular Designs at http://www.3dmoleculardesigns.com/Education-Products/DNA-Discovery-Kit.htm),* DNA Starter Kit© DNASK-01 *(available from 3D Molecular Designs at http://www.3dmoleculardesigns.com/Education-Products/DNA-Starter-Kit.htm)* or other DNA models or kits
- 2 Modeling Mini Toobers MTBR-01 *(available from 3D Molecular Designs at http://www.3dmoleculardesigns.com/Education-Products/Modeling-Mini-Toobers.htm)* Please note that 2 Modeling Mini Toobers (3') are included in every DNA Discovery Kit© classroom set ***(DNA-12***).

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Note: The 3' OH group is essential for adding a new nucleotide to the growing DNA strand. If this group is not present — for example, if there is a 3' H instead of a 3' OH — then DNA synthesis cannot continue. This is the basis for the Sanger sequencing method used in determining the sequence of nucleotides.

In order to call student attention to the newly-synthesized DNA, teachers may opt to use the gray foam DNA nucleotides to make the new "daughter" strands.

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Use the gray foam DNA nucleotides to model the different patterns that emerge in the Meselson and Stahl experiment that determined how the process of DNA replication occurs. Students will discover that the patterns will vary between conservative, semi-conservative and dispersive replication after only one or two rounds of replication.

Online Resources

Visit 3dmoleculardesigns.com/Teacher-Resources/Flow-of-Genetic-Information-Kit/Additional-Online-Resources.htm for:

- Detailed descriptions suitable for IB or AP Biology

Visit 3dmoleculardesigns.com/Teacher-Resources/Flow-of-Genetic-Information-Kit/Animations-and-Videos.htm for:

- A general overview animation of continuous and discontinuous replication
- A group of videos on DNA replication

Teacher Notes Continued

Transcription Activity

Objectives

Students will

- **Identify** different types of RNA.
- **Demonstrate** how a molecule of messenger RNA is created from the template of DNA using the model.
- **Compare** and contrast the structures of RNA and DNA.
- **Explain** the structure and function of codons and anticodons in the formation of proteins.
- **Model** the flow of genetic information from DNA →RNA→ protein (also known as the **central dogma**).
- **Explain** how changing the DNA code — a mutation — may ultimately change the sequence of amino acids in the protein.

Prerequisite Knowledge and Skills

- Hydrogen bonding and covalent bonding
- Cell structure
- DNA structure
- Structure of amino acids and proteins
- Prokaryotic and eukaryotic cell structure

Kit Materials Needed

- One Transcription Placemat (recommended one placemat per group of four students)
- Foam nucleotides, including uracil

Other Materials Suggested

- DNA Discovery Kit© *(available from 3D Molecular Designs at http://www.3dmoleculardesigns.com/Education-Products/DNA-Discovery-Kit.htm)*

Transcription page 2

Note: If you choose to pursue a more rigorous lesson, you may elect to introduce pre-mRNA, introns, exons, splicing and post transcriptional modification. The details of these processes are shown on 3D Molecular Designs' Map of the Human β-Globin Gene©*(available from 3D Molecular Designs at http://www.3dmoleculardesigns.com/Education-Products/Map-of-the-Human-Globin-Gene.htm).*

Transcription page 7

Note: Caution students about the limitations of models! RNA polymerase doesn't start on the "end" of the DNA and work its way to the opposite end. There are specific nucleotide sequences directing the RNA polymerase where to begin and where to end on the DNA. These sequences are NOT included in this kit.

Teacher Notes Continued

Translation Activity

Objectives

Students will

- **Identify** different types of RNA.
- **Demonstrate** how a molecule of messenger RNA is translated into a protein.
- **Explain** the structure and function of codons and anticodons in the formation of proteins.
- **Model** the flow of genetic information from DNA→ RNA→ protein (also known as the **central dogma**).
- **Explain** how changing the DNA code, a mutation, may ultimately change the sequence of amino acids in the protein.

Prerequisite Knowledge and Skills

- Hydrogen bonding and covalent bonding
- Cell structure
- DNA structure
- Structure of amino acids and proteins
- Prokaryotic and eukaryotic cell structure

Kit Materials Needed

- One Translation Placemat (recommended one placemat per group of four students)
- Foam nucleotides, including uracil
- tRNA, stop codon and amino acids

Other Materials Suggested

- DNA Discovery Kit© *(available from 3D Molecular Designs at http://www.3dmoleculardesigns.com/Education-Products/DNA-Discovery-Kit.htm)*

Page 2

Note: Translation may also be thought of in three stages: (1) initiation, (2) elongation, and (3) termination

Translation page 3

Note: You may elect to include the following interesting note: If one tRNA anticodon variety existed for each mRNA codon specifying an amino acid, there would be 61 tRNAs. In fact, there are only about 45, implying that some tRNAs must be able to bind to more than one codon. Such flexibility is possible because the rules for base pairing between the third nucleotide base of the mRNA codon and the corresponding tRNA anticodon are relaxed. Flexible base pairing at this codon position is referred to as wobble. For example, a tRNA with the anticodon 3'-CGU-5' can base pair with either the mRNA codon 5'-GCA-3' or 5'-GCG-3' both of which code for alanine.

Note: Moving from 5'to 3', all tRNAs end in the sequence CCA. Amino acid tRNA synthetases are enzymes that add specific amino acids to the appropriate tRNA.

Teacher Notes Continued

Translation page 4

Note: There are two histidines and two cysteines in the amino acid sequence of the polypeptide. Each of the histidines has it's own tRNA to illustrate the redundancy in the code. The tRNA for the cysteine is reused.

Note: If you think your students need a "refresher" on the chemical properties of amino acids **(hydrophobic, hydrophilic, acidic and basic)**, our Amino Acid Starter Kit© has a helpful explanation. *Visit 3dmoleculardesigns.com/Teacher-Resources/Amino-Acid-Starter-Kit/Student-Handout-1.htm.*

National Framework

Connections to: A Framework for K-12 Science Education

Practices, Crosscutting Concepts, and Core Ideas*

Dimension 1: Scientific and Engineering Practices

1. Asking Questions (for science) and Defining Problems (for engineering)
2. Developing and Using Models
4. Analyzing and Interpreting Data
5. Using Mathematics and Computational Thinking
6. Constructing Explanations (for science) and Designing Solutions (for engineering)

Dimension 2: Cross Cutting Concepts

1. Patterns
2. Cause and Effect: Mechanism and Explanation
3. Scale, Proportion, and Quantity
4. Systems and System Models
6. Structure and Function
7. Stability and Change

Dimension 3: Disciplinary Core Ideas

Life Sciences

LS1: From Molecules to Organisms: Structures and Processes

LS1.A: Construct an explanation based on evidence for how the structure of DNA determines the structure of proteins which carry out the essential functions of life through systems of specialized cells.

LS3: Heredity: Inheritance and Variation of Traits

LS3.A: Ask questions to clarify relationships about the role of DNA and chromosomes in coding the instructions for characteristic traits passed from parents to offspring.

LS3.B: Make and defend a claim based on evidence that inheritable genetic variations may result from (1) new genetic combinations through meiosis, (2) viable errors occurring during replication, and/or (3) mutations caused by environmental factors. Apply concepts of statistics and probability to explain the variation and distribution of expressed traits in a population.

Engineering, Technology and Applications of Sciences

ETS1: Engineering Design

ETS1.B: Use a computer simulation to model the impact of proposed solutions to a complex real-world problem with numerous criteria and constraints on interactions within and between systems relevant to the problem.