

## **5E Integrated STEM Lesson Plan – Unit Gene Action**

**Lesson Title:** *Unit- Gene Action: DNA Structure and DNA Replication*

**Author:** *Preeti Jain (Lesson adapted from Biology a Human Approach 5th Edition)*

**Topic:**

1. Decoding the Message - Simple codes can convey complex information.
2. The Stuff of Life -DNA; genetic information in different organisms
3. Modeling DNA -DNA structure; DNA replication; base pairing as a mechanism for information storage and transmission; modeling a scientific process; mutations
4. Effects of Mutations - DNA replication; protein synthesis; mutations

**Targeted Grade Level:** Grades 10-12

**Time Needed:** *12 class periods of 42 minutes each*

**Subject Integration:** Science, Math, Engineering, Technology, and **ARTS (art standards will be added later)**

**Justification:** I have adapted this lesson from my school's Biology textbook and added some parts from the Teach Engineering lesson. I will finish this in 2 weeks based on how students are progressing. This lesson integrates all tenets as well as the ideas of the natures of science, technology, engineering, and ethics (examples are specified in the 5Es).

**Science-** Students will gain knowledge of how the structure of DNA allows information to be stored in cells, transferred to a new generation, and expressed in ways that are useful for an organism. Using investigations and research, students will isolate and extract DNA and then perform a modeling DNA activity.

**Technology and Engineering:** Students will study DNA technologies that scientists have developed, especially in terms of manipulating and analyzing DNA models and genetic engineering. DNA modeling based on video segments exemplifies the functional integration of science, engineering, mathematics, and technology. With these technologies, scientists can alter agricultural products and engineer the production of new or rare medicines.

**Math-** Students will be using mathematical pattern recognition to decipher the code depending on several variables. Then, students will work on collecting data by isolating and extracting DNA from various organisms and following a protocol using abstract and quantitative reasoning.

**Art Integration: Will complete as the course progresses.**

**Standards:**

*In this unit students have the opportunity to learn using all three dimensions of NGSS, see the description below.*

NGSS Performance Expectations

*HS-LS1-1. 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. (Grades 9 - 12)*

*HS-LS1-2 Construct an explanation based on valid and reliable evidence obtained from a variety of sources (including students' own investigations, models, theories, simulations, peer review) and the assumption that theories and laws that describe the natural world operate today as they did in the past and will continue to do so in the future.*

*HS-LS3-1: Ask questions to clarify relationships about the role of DNA and chromosomes in coding the instructions for characteristic traits passed from parents to offspring.*

Science and Engineering Practices

Disciplinary Core Ideas

Crosscutting Concepts:

<p><i>SEP 2: Developing and Using Models</i></p> <p><i>SEP 8: Obtaining, Evaluating, and Communicating Information.</i></p> <p><i>SEP 4: Analyzing and Interpreting Data.</i></p> <p><i>Construct an explanation based on valid and reliable evidence obtained from a variety of sources (including students' own investigations, models, theories, simulations, peer review) and the assumption that theories and laws that describe the natural world operate today as they did in the past and will continue to do so in the future.</i></p>	<p><i>LS1.A: Structure and Function, Grades 9–12, element 2: All cells contain genetic information in the form of DNA molecules. Genes are regions in the DNA that contain the instructions that code for the formation of proteins, which carry out most of work of cells.</i></p> <p><i>LS3.A: Inheritance of Traits, Grades 9–12, element 1: Each chromosome consists of a single very long DNA molecule, and each gene on the chromosome is a particular segment of that DNA. The instructions for forming species' characteristics are carried in DNA. All cells in an organism have the same Genetic content, but the genes used (expressed) by the cell may be regulated in different ways. Not all DNA codes for a protein; some segments of DNA are involved in regulatory or structural functions, and some have no as-yet known function.</i></p>	<p><i>This unit focuses on CCC 4: Systems and System Models.</i></p> <ul style="list-style-type: none"> <li><i>• Grades 9–12, element 2: When investigating or describing a system, the boundaries and initial conditions of the system need to be defined and their inputs and outputs analyzed and described using models.</i></li> <li><i>• Grades 9–12, element 3: Models can be used to simulate systems and interactions—including energy, matter, and information flows—within and between systems at different scales.</i></li> </ul> <p><i>CCC 6: Structure and Function.</i></p> <p><i>Grades 9–12, element 1: Investigating or designing new systems or structures requires a detailed examination of the properties of different materials, the structures of different components, and connections of components to reveal their function and/or solve a problem.</i></p>
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*Common Core State Standards:*

*MP.2 Reason abstractly and quantitatively. (HS-LS3-1), (HS-LS3-2)*

*MP.4 Model with Mathematics (HS-LS1-4)*

*Math: CCSS.MATH.CONTENT.HSN.Q.A.1*

*Use units as a way to understand problems and to guide the solution of multi-step problems; choose and interpret units consistently in formulas; choose and interpret the scale and the origin in graphs and data displays.*

*CCSS.MATH.CONTENT.HSN.Q.A.2*

*Define appropriate quantities for the purpose of descriptive modeling.*

*CCSS.MATH.CONTENT.HSG.MG.A.1*

*Use geometric shapes, their measures, and their properties to describe objects*

*ELA: Integration of Knowledge and Ideas:*

*CCSS.ELA-LITERACY.RST.9-10.7*

*Translate quantitative or technical information expressed in words in a text into visual form (e.g., a table or chart) and translate information expressed visually or mathematically (e.g., in an equation) into words.*

*CCSS.ELA-LITERACY.RST.9-10.8*

*Assess the extent to which the reasoning and evidence in a text support the author's claim or a recommendation for solving a scientific or technical problem.*

*CCSS.ELA-LITERACY.RST.9-10.9*

*Compare and contrast findings presented in a text to those from other sources (including their own experiments), noting when the*

*findings support or contradict previous explanations or accounts.*

Range of Reading and Level of Text Complexity:

CCSS.ELA-LITERACY.RST.9-10.10

*By the end of grade 10, read and comprehend science/technical texts in the grades 9-10 text complexity band independently and proficiently.*

**ART Standards** To be added later

**Measurable Student Learning Objectives:** By end of this unit “students will be able to understand that”

- Structure of DNA allows information to be stored in cells, transferred to new generations, and expressed in ways that are useful to an organism.
- Models are a useful way of visualizing structures and processes that are hard to observe.
- Describe general techniques used by genetic engineers to modify DNA.
- Analyze the benefits and drawbacks of manipulating an organism's DNA.

### **Engage: Day 1” Decoding the Message”**

#### **Key Idea-Complex information can be transferred using a simple code.**

In this Decoding the message engage activity students will decipher a code to get a message. This activity introduces students to the efficiency and use of codes as a bridge to understanding DNA as a code of life. They will see how codes with just 2 symbols can carry so much information. The students each have different words in the coded message that is associated with proteins. The codes that students will be working on is binary code using 0s and 1s .This activity gets students thinking about how codes can store information and later in the chapter they will relate this activity to their study of DNA.

I have attached a video from a teaching channel which enhances my anchoring activity that students will watch at home as homework before the next lesson that also is enhancing this anchoring activity and linking to the next activity.

**Analysis:** Students will work individually to answer these questions. Record your answers in your science notebook.

1. Digital coding uses only 2 symbols (0s and 1s). How many different words are on the class list? Could the same code be used to make more words? Explain how only 2 symbols can be used to make so many words.
2. This activity showed that a simple code could transmit complex information. How do you think that idea might relate to genetic information?

**HW-**Students will watch the video from Kyla burns after Decoding the message students activity for introducing DNA <https://www.youtube.com/watch?v=1fdn0ZVRgPY> (link posted in online platform that students can access) They have to think about the connection/linking question of decoding activity and example of code used by organisms

**Resources and Materials** - *Coded message, Need to Know Digital coding, analysis questions*

**Engage Resources: Decoding the message**

[Coded message](#) , [Digital coding](#) , [Modeling a double helix](#)

Materials- Coded message per student, Need to know Digital Coding

### **Explore Day 2-3 “The stuff of life”**

**Key idea:** DNA is a simple code that is used to make complex organisms.

In this exploration activity, they will work with a partner to search for the substance that carries the code of life in the cells of some common organisms. Students will be divided into groups and will investigate a common thread of life. Students will begin thinking that a code could be used to store and transmit all the unique characteristics that organisms display and the code would be one way to store this information, and then pass it to the next generation.

Students extract and compare DNA from different organisms utilizing a protocol. They will explore the genetic information inside bananas, peas and chickens. Students will observe that DNA looks similar in different organisms. Students will follow the process and procedures and protocols outlined step by step. They will observe and record the data and appearance of DNA in the alcohol layer (Cloudy).

#### **Analysis questions:**

Complete the following tasks individually in your science notebook s HW. Students' answers may vary depending on their extraction.

1. Does DNA appear to be the same for all organisms?
2. What is your evidence?
3. What could you do to be more certain of your answers?
4. How could you investigate the idea that DNA is found only in living or once-living things?

5. What features do you think DNA might need to have in order to contain a code that directs the processes of life?  
How do you think DNA allows genetic information to be passed to new generations?

**Materials: (team of 2)**

- 2 pairs of safety goggles
- 2 lab aprons
- 1 5-mL graduated cylinder
- 1 10-mL graduated cylinder
- 1 large test tube
- 1 test-tube rack
- 1 wooden splint or metal spatula
- 1 50-mL beaker containing 20-mL of filtered material (from your teacher)
- Woolite liquid detergent
- Meat tenderizer
- Cold ethanol or isopropanol
- Bleach solution
- Dark-colored sheet of paper (optional)
- Clock or timer
- Supplies for additional investigations (optional)

**Modifications:** For my ELL students it is important that they understand directions when conducting the investigation, for helping them further you can draw pictures or take pictures of each step in protocol to show them.

**Explore Resources**

[Extracting the Substance of Life Protocol](#)

[Landmark discovery DNA may be stuff of life](#)

### **Explore-Explain Day 3-5: Modeling DNA**

**Major Topics:** DNA structure; DNA replication; base pairing as a mechanism for information storage and transmission; modeling a scientific process; mutations.

**Key Idea-**DNA is a simple code that is used to make complex organisms.

**Part A: Modeling DNA Structure.** –Students will build physical representations of a variety of structures which they will modify as they gather information. Models 1,2 and 3 are exploratory. The teacher can watch for patterns in the way they set up the pop beads and ask guiding questions. These patterns will be clues for their understanding.

**Part B: Analyzing a DVD Model.** – Students will watch a video segment [chapter 11 DNA structure.mp4](#) and learn more about the structure of DNA. This video segment shows the four nucleotides that compose DNA and reveals the nature of their complementary base pairing. This information should allow students to add to their complementary information storage, and the transfer of genetic material. Students will also begin to understand the importance of this structure to the replication of DNA molecules.

**Part C: Modeling DNA replication-** in this part students use models, essays, and Optional video segment [DNA Replication video.mp4](#) as resources to answer two questions that helps illustrate the process of replication and mutation. This video segment animates DNA replicating.

**Materials:**

Part A (team of 4)

pop beads or paper clips

twist ties

rubber bands

double-sided tape

wire

Copy master – Modeling a double helix

**Part B (team of 4) - “DNA Structure video (watch as a class), copy master - Messages for [Messages for testing information transfer](#)**

**Part C (team of 8 and 2) - “DNA Replication video (optional pop beads)-students work on information transfer game**

To learn more about the original modeling of DNA, read the article/essay [Landmark Discovery: Why the Fuss about Watson and Crick](#)

***Part D Modeling DNA Replication***

As you saw in part A of this activity, one reason that scientists develop models is to help them picture structures that are difficult to observe directly. This helps them better understand these structures. Models also can help scientists picture and better understand complex processes.

1. come up with ideas, read the essay, [DNA Structure and Replication](#)
2. .As you read, list any information that you think might help you answer the first research question.  
You may also want to watch the video segment, [DNA Replication video.mp4](#)
3. Return to your team of 2. Use the pop beads and the key in below figure 11.4 to build a model of a molecule of DNA.  
Although you will work as a team to share information, each of you should build and manipulate your own model.  
You will need to demonstrate to your teacher your *own* understanding of replication.



Figure 11.1

What components of DNA do these pop beads represent?

4. Manipulate your pop-bead model to illustrate the process of replication.
5. Analyze your work in steps 5–6. Then individually develop an answer to research question 1. Record your answer in your science notebook.

**Explore - Explain Resources: Modeling DNA**

Analyzing a video Model -DNA structure

[chapter 11 DNA structure.mp4](#)

[Modeling DNA](#)

[Modeling a double helix](#)

[Messages for testing information transfer](#)

[DNA Replication video.mp4](#)

[Landmark Discovery: Why the Fuss about Watson and Crick](#)

[DNA Structure and Replication](#)

[Replication Errors and Mutation](#)

**Explain: Day 6-7 Expression of Genetic Information**

In this Explain activity, Expression of Genetic Information,

**Topics-** Expression of genetic information; transcription; protein synthesis; genetic code; mutations.

**Key idea-** Cells are able to use information in DNA to synthesize other types of molecules.

In this Explain activity, Expression of Genetic Information, **students will develop** their own explanation of the relationship between genetic information and physical characteristics. Students will work in pairs and by tracing the series of events that lead to sickle cell disease. Sickle cell disease is a potentially fatal condition caused by a mutation that affects a person's blood cells. Students **will create a poster** that illustrates the molecular basis of sickle cell disease.

This explain activity is designed to help students develop a conceptual understanding of the complex phenomenon of gene expression. Students should now be able to explain how genetic information maintains the continuity of a species from one generation to the next.

**Materials (team of 2)**

[Transcription video .mp4](#)

Poster board

Scissors

Assorted construction paper

Tape or glue

Different-colored felt-tipped markers or crayons

**Resources - Explain Resources Expression of Genetic information**

[DNA Sequence for hemoglobin alleles](#)

[Hemoglobin and Red Blood Cell Abnormalities in Sickle Cell Disease](#)

[Translating the Message in mRNA](#)

[The sequence of aminoacids detrmns the hemoglobin molecules shape](#)

[Transcription video .mp4](#)

[The Expression of Genetic Information](#)

[Translating the Message in mRNA](#)

**Analysis:**

Use the information on your poster and in the essays to respond to the following. Record your responses in your science notebook. Your teacher will use your science notebook to evaluate your understanding of gene expression.

1. Create a concept map in your science notebook. Include the following words on your map. Be sure to include linking phrases between the terms.
  1. Amino acid
  2. Nucleotide
  3. DNA

4. Protein
5. Chromosome
6. rRNA
7. mRNA
8. tRNA
9. Gene
10. Nucleus
11. Cytoplasm
12. Physical characteristic
13. Organism

-The poster that you made on sickle cell disease may suggest a general scheme for your outline.

**Modifications:** Consider stopping the video at key points to discuss and allow them to write notes about what they see. Have them read articles/ essay in class again.

**Formative/Summative Assessments :** Observation, Facilitating class discussion and Analysis question and outcomes and indicators of success. Utilizing webb's Depth of knowledge chart, Test at the end of chapter.

**Explain Resources Expression of Genetic information**

DNA sequence for Hemoglobin Alleles [DNA Sequence for hemoglobin alleles](#)

[Hemoglobin and Red Blood Cell Abnormalities in Sickle Cell Disease](#)

[Translating the Message in mRNA](#)

[The sequence of aminoacids detrmins the hemoglobin molecules shape](#)

[The Expression of Genetic Information](#)

**Elaborate: “Genetic Technology” Day 9 to day 11**

**Major Topics:** Molecular variation; applications of genetic engineering; ethical and social issues associated with genetic engineering.

**Key idea:** Because scientists understand the molecular basis of gene expression, they have been able to develop many genetic technologies.

In this elaborate activity “Genetic Technology” students will learn details of some recent genetic technologies and also consider ethical issues. Students will apply their understanding of the basic principles of gene action. To elaborate on their understanding of molecular genetics, students will study the technologies that scientists have developed to manipulate DNA. **Students will summarize the scientific technology information from the assigned essays and resources to identify benefits and concerns that are tied to related technologies and will have opportunity to present to class.**

**Analysis**

1. Use the information from your assigned essays and any other reliable Internet resources to complete the following tasks. Record your responses in your science notebook. Be prepared to explain your topic and answers to your

teammate.

**Resources needed-** [Landmark Discovery: Extraordinary New Technique Changes Biology Forever](#)

[Manipulating Genetic Material](#)

[Landmark Discovery: New Technique Discovered While Driving](#)

[Mapping and Sequencing the Human Genome](#)

[Genetic Screening: A Dilemma for All of Us](#)

### **Evaluate Day 12-Day 14: “Effect of Mutations”**

**Key Idea:** Gene mutations can have different effects

**Major Topics** DNA replication; protein synthesis; mutations

In this Evaluate activity “Effects of Mutation” students will look at the gene expression in examples of mutations that do not cause disease. Students will use their knowledge of genetic processes to analyze a mutation that relates to coloration in animals. In this Evaluate activity, students will have the opportunity to use their knowledge of genetic information and learn about a mutation in an organism that relates to coloration in animals and they culminate the activity by teaching their fellow students about their knowledge.

#### **Materials**

different-colored pens or pencils (optional)

chart paper, poster board, or construction paper (optional)

**Mrs. Preeti Jain**  
**JVJ STEM Academy**  
**Grade 10-12**  
**Biology Honors**  
**2/12/2022**

**Resources:** [Gene expression rubric](#) and other articles associated with their topic (Coloration in Jaguars, Resistance to Insecticide in Mosquitoes, or Geese Living at High Altitude).

**Formative/Summative Assessments:** Observation, Facilitating class discussion and Analysis question and outcomes and indicators of success. Utilizing Webb's Depth of knowledge chart, Test at the end of chapter.