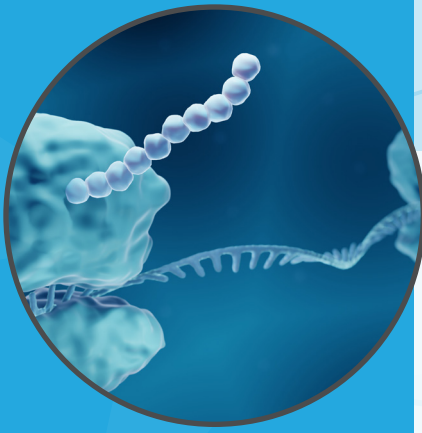


DNA to Proteins

Scope Planning and Overview



Student Wondering of Phenomenon

What impact could a mutation have on the essential function of life coded for in DNA?

Student Expectations

The student will–

- construct an explanation based on evidence that the essential functions of life are primarily carried out through the work of proteins that are coded for by genes in DNA, as described by the Central Dogma (i.e., transcription, translation).

Scope Overview



In this instructional unit, students explore the fundamental biological processes that underpin genetics and protein synthesis, delving into how life's essential functions are encoded and executed. Through constructing DNA models, simulating protein synthesis, and modeling enzyme-substrate interactions, students apply theoretical knowledge to tangible activities. These hands-on experiments enhance their understanding of genetic coding, protein function, and enzymatic activity, aligning with the Central Dogma of molecular biology. The unit emphasizes critical thinking and problem-solving, empowering students to construct explanations from evidence and develop solutions to biological problems.

Scope Vocabulary



The terms below and their definitions can be found in Picture Vocabulary and are embedded in context throughout the scope.

Adenine

A purine base that pairs with thymine in DNA and uracil in RNA

Amino acid

A molecule containing an amine group, a carboxylic acid group, and a side chain that is specific to each type of amino acid

Catalyst

A substance that speeds up or promotes a chemical reaction without being chemically changed by the reaction

Chromosome

A structure made of DNA that contains the genetic information in the form of genes needed to carry out cell functions

Codon

A sequence of three nucleotides in mRNA that encodes a specific amino acid or a signal to stop translation

Cytosine

A pyrimidine base that pairs with guanine

Deoxyribonucleic acid (DNA)

The carrier of genetic information present in nearly all organisms; forms a double helix

Enzymes

Proteins that can change the rates of specific reactions

Gene expression

The process by which genetic information generates a specific protein or trait

Genes

Segments of DNA that code for protein or functional RNA

Guanine

A purine base that pairs with cytosine

Hormone

A chemical substance secreted by endocrine glands into the bloodstream that controls or regulates specific physiological processes

Hydrogen bond

An attraction between a hydrogen atom that is covalently bonded to a highly electronegative atom (e.g., oxygen or nitrogen) and another highly electronegative atom to which the hydrogen is not covalently bonded

Messenger RNA (mRNA)

A single-stranded nucleic acid, made of RNA, that is a copy of a specific DNA sequence; created by the cell for transferring the genetic information in DNA to a ribosome to make a protein

Nitrogen base

A nitrogen-containing compound that forms part of a nucleotide; functions as the fundamental unit of the genetic code

Nucleotide

A molecule made of a sugar, a phosphate, and a nitrogenous base; the monomer of nucleic acid

Phosphate

An inorganic compound consisting of a central phosphorous atom bound to four oxygen atoms

Protein synthesis

The production of a protein molecule through DNA transcription and translation

Proteins

Biomolecules made of one or more amino acid polymers joined together by peptide bonds and then folded into a complex structure that performs a specific function

Replication

The process by which DNA makes a copy of itself

Ribonucleic acid (RNA)

A single-stranded nucleic acid that contains uracil instead of thymine; can make tRNA, mRNA, or rRNA

Ribosome

A structure made of protein and rRNA that converts messenger RNA sequences into amino acid sequences with the help of transfer RNAs



Home



Engage



Explore



Explain



Elaborate



Evaluate



Intervention



Acceleration

Specialized cells*Cells that are specialized to perform a specific function***Thymine***A pyrimidine base that pairs with adenine and is only found in DNA***Trait***A distinct characteristic of an organism, which may or may not be inheritable***Transcription***The process in which a strand of DNA is copied into an RNA strand for the purpose of protein synthesis***Transfer RNA (tRNA)***An RNA molecule that is responsible for transporting amino acids to the ribosome to be used in the synthesis of proteins***Translation***The process by which the sequence of nucleotides in a messenger RNA is converted by a ribosome and transfer RNAs into a polypeptide with a specific sequence of amino acids***Uracil***A pyrimidine base that pairs with adenine and is found only in RNA***Engage Activity Summaries**

APK

Accessing Prior Knowledge: : Sliding Scale

In this activity, students evaluate their understanding of gene expression by positioning themselves along a sliding scale in response to various statements, visually representing their agreement or disagreement. This interactive method helps uncover misconceptions about gene expression, such as the nature of mutations and the universality of protein synthesis. Students discuss their viewpoints in pairs, fostering peer learning and allowing them to reconsider their positions based on peer explanations. This activity is diagnostic and not graded.

SP

Scope Phenomenon

In this activity, students watch a video of hot chocolate being made with varied instructions to understand how changes in processes affect outcomes. They use the "Changing Instructions" handout to guide their learning and express their thoughts through doodles instead of written words. The activity encourages students to think about the impact of procedural variations and to engage visually and creatively in answering questions related to the phenomenon being studied.

**Explore Activity Summaries**

Explore 1

Activity - Components of DNA

In this hands-on science activity, students construct DNA models to deepen their understanding of its structure and function. They use puzzle pieces to build and label DNA, applying base-pairing rules to create strands, enhancing their grasp of genetic coding. This task integrates constructing explanations for observed phenomena and designing solutions to theoretical problems, enabling students to explore how life's essential functions are encoded in DNA. The activity is structured to foster critical thinking and problem-solving skills through collaborative learning.

Explore 2

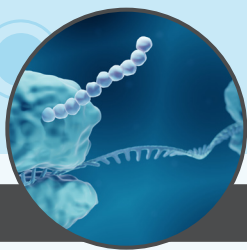
Activity - Make Me a Sandwich

In this interactive activity, students simulate protein synthesis by acting out transcription and translation processes using a classroom scenario about making a sandwich. They use designated roles and materials to represent the components and steps of protein synthesis, enhancing their understanding of how DNA sequences are translated into functional proteins. This model helps students visualize and construct explanations for biological phenomena and solve problems, further exploring the systems and models in biology.

Explore 3

Scientific Investigation - Enzyme Simulation

In this activity, students simulate enzyme-substrate reactions using their hands as enzymes and toothpicks as substrates, exploring how enzyme shape affects function. They modify their hand shapes to represent different enzyme structures and observe the effects on breaking toothpicks, simulating substrate processing. Students then compile data, analyze results, and engage in argumentation from evidence to evaluate explanations and solve problems related to enzyme activity. This hands-on investigation culminates in writing a scientific explanation based on their observations and data.



DNA to Proteins

Accessing Prior Knowledge: Sliding Scale

Activity Preparation



Students will listen to prompts about gene expression and communicate how much they agree or disagree with the statements by forming a sliding scale across the classroom. This element is designed to uncover student misconceptions. It should not be taken for a grade.

Materials

Activity Files

- Gene Expression Sliding Scale (per student)
- Gene Expression Sliding Scale Presentation, projected (per teacher)

Reuseable

- None

Consumable

- None

Preparation

- If not assigning the Accessing Prior Knowledge digitally, print one Gene Expression Sliding Scale sheet for each student.
- Project the Gene Expression Sliding Scale Presentation.

Procedure and Facilitation



Activity

Sliding Scale

1. Pass out the Gene Expression Sliding Scale to each student.
2. Tell students to rank how much they agree or disagree with each statement.
3. Allow students time to consider their opinion and shade in the corresponding circle, "5" meaning agree and "1" meaning disagree.
4. Designate one end of the room as Agree and the opposite end as Disagree. Students will stand on the line to represent their opinion. Students may group into different parts of the line.
5. Project the first prompt on the Gene Expression Sliding Scale Presentation and allow students to move to the appropriate location along the sliding scale across the room. Encourage student discussion by doing the following:
 - a. Break the line at the midpoint and have half the students move down selecting partners on the opposite end of the line. For example, a "1" could pair with a "5".
 - b. Give each student in the pair one minute to explain why they chose their ranking.
 - c. Give each student 30 seconds to summarize their partner's view.
 - d. Ask students to return to the line, moving to a new location if they so desire.
6. Repeat steps 5-6 with each remaining prompt.

ACTIVITY TIP

If it's challenging for students to line up on a sliding scale, you could modify the activity by using four corners: strongly agree, agree, disagree, and strongly disagree. The modified movement still allows for varying opinions to be expressed.

CLASSROOM ENVIRONMENT TIP

Provide sentence stems on the board to help students start their discussion with their partner. For example:

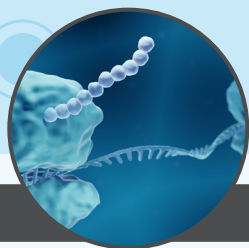
"I agree/disagree with the statement because..."

"I strongly agree/disagree with the statement because..."

Identifying Misconceptions

- Prompt 1 - Students may believe that all mutations are bad. Mutations can be positive, neutral, or negative.
- Prompt 2 - Students may think that the process of protein synthesis is different for different species, although the basic process is the same in all organisms.
- Prompt 3 - Students may believe that different organisms have different sets of amino acids, when in fact all living organisms have the same set of 20 amino acids.

Notes



DNA to Proteins

Scope Phenomenon

Activity Preparation



Students will view someone making hot chocolate to learn about how altering the instructions for something affects the outcome or product. Students should build on their knowledge and understanding of the phenomenon as they move through the different activities in this scope.

Materials

Printed Material

- 1 Student Handout: Changing Instructions (per student)

Reusable

- None

Consumable

- None

Preparation

- If not assigning the activity digitally, print one Student Handout per student.
- Prepare to project the Student Handout.
- Brainstorm additional questions you may want to discuss beyond the Student Handout during the activity.

Procedure and Facilitation



ACTIVITY TIP

Ask students to write out instructions for making hot chocolate before and after watching the video. Then, prompt them to compare their initial instructions with the ones they wrote after watching the video. Encourage them to consider whether their instructions stayed the same or if they changed, and to explain why any changes were made. Pose the question, "Does the body have ways of correcting errors?"

ACTIVITY TIP

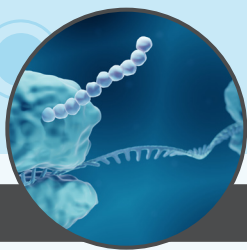
Review the components of DNA, preferably through an anchor chart that can be referred back to. Ensure that it includes the four different nitrogenous bases, hydrogen bonds, the sugar-phosphate backbone, and what constitutes a nucleotide. This visual aid will help reinforce understanding and serve as a reference for students.

Activity

1. Distribute the Student Handouts.
2. Show students the video.
3. Ensure that all students have a blank piece of scrap paper and a writing utensil.
4. Ask the whole class the questions from the Student Handout.
5. Instruct students to doodle their answers. Encourage students to not write in sentences but instead use images, pictographs, or funny phrases to answer.
6. When students finish their doodles, have them turn over their papers.
7. After everyone has had a chance to doodle, call on a student.
8. Introduce students to the Student Wondering of Phenomenon question below:
 - a. What impact could a mutation have on the essential function of life coded for in DNA?
9. Let students know that, as they move through the scope, they will be doing a number of activities to help them answer the Student Wondering of Phenomenon question and to learn the information that is needed to describe the events in the Scope Phenomenon.
10. When the scope is completed, have students review the Scope Phenomenon. As you lead them in answering the question, encourage them to use the information that they learned throughout the scope.



Notes



DNA to Proteins

Explore 1: Activity - Components of DNA

Activity Preparation



Timestamp: 30–45 minutes

Students will build models of DNA.

Materials

Printed

- 1 Student Handout (per student)
- 1 DNA Puzzle (per student)

Consumable

- None

Reusable

- 1 Pair of scissors (per student)

Preparation

- Copy the Student Handout and the DNA Puzzle for each student.
- If needed, have a sample puzzle assembled to assist students who may struggle.

Connections



SEP Connection

Constructing Explanations and Designing Solutions

During this activity, students will construct explanations and design solutions to explain phenomena or solve problems.

While students work through this activity, they should do the following:

- Construct explanations to explain phenomena
- Construct explanations to solve problems
- Design solutions to solve problems

Once students have completed this activity, ask these questions:

- What phenomena were witnessed in the activity?
- How were explanations constructed to explain the phenomena?
- What problems were presented in the activity?
- In what ways did you explain or solve these problems?

CCC Connection

Structure and Function

During this activity, students will explore the structure and function of systems and parts.

Ask students the following questions:

- Where do you see the structure and function of systems and parts in this activity?
- Where have you seen the structure and function of systems and parts before this activity?
- Where do you see the structure and function of systems and parts outside the classroom?
- Where do you think you will see the structure and function of systems and parts in other science lessons?

Once students have completed this learning activity, revisit the Student Wondering of Phenomenon and use the following questions to guide a class discussion.

What impact could a mutation have on the essential function of life coded for in DNA?

- How does this activity connect to or answer the question above?
- How does this activity change your thinking about the phenomenon?
- Do you have any additional questions or observations about the connection between the phenomenon and the activity?



Home



Engage



Explore



Explain



Elaborate



Evaluate



Intervention



Acceleration



Procedure and Facilitation

Part I

1. Distribute a Student Handout and DNA Puzzle to each student.
2. Review the introduction with students. Instruct students to complete steps 1–3 on the Student Handout.
3. Monitor as students attempt to fit the pieces together, and assist as needed to help them build models of DNA.
4. When students have completed their models, instruct them to answer questions 4–5 under Part I.

Part II

1. Instruct the students to begin Part II by reading the passage about DNA.
2. Monitor students to make sure that they properly label and color their puzzles after reading the passage.
3. With their labeled and colored DNA puzzle pieces, have each student pair up with another student to create a DNA strand using base-pairing rules for the code ACTGCATG.
4. Debrief with the following question: Why do you think it is important that certain pieces fit only with other certain pieces?

Answers will vary. A possible student response could include the following: This allows for the “code” of the DNA.

Phenomenon Connection

Once students have completed this learning activity, revisit the Student Wondering of Phenomenon and use the following questions to guide a class discussion.

- What impact could a mutation have on the essential function of life coded for in DNA?
- How does this activity connect to or answer the question above?
- How does this activity change your thinking about the phenomenon?
- Do you have any additional questions or observations about the connection between the phenomenon and the activity?

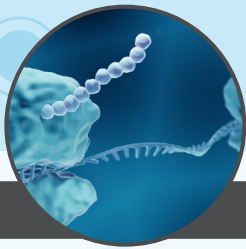
ACTIVITY TIP

Before asking students to complete steps 1–3, review the monomers of DNA. Pose clarifying questions and consider showing a brief video clip to enhance the visualization of a DNA model.

DIFFERENTIATION TIP

Encourage students to share and describe their models to other students in their group or with a shoulder partner. Repeating key vocabulary words such as deoxyribose nucleic acid, 5-carbon sugar, nitrogenous base, phosphate group, and hydrogen bond can enhance content retention.

Notes



DNA to Proteins

Explore 2: Activity - Make Me a Sandwich

Activity Preparation



Timestamp: 1–2 hours

Students will model protein synthesis by using a classroom scenario and performing transcription and translation on DNA sequences.

Materials

Printed

- 1 Student Handout (per student)
- 1 DNA Sequences (per group)
- 1 Sandwich Menu (per class)
- 1 Ingredient Cards (per group)
- 1 Codon Chart (per group)

Consumable

- None

Reusable

- 1 Envelope, size 10 (4½ in. x 9½ in.) (per class)

Preparation

- Print one copy of the Student Handout for each student.
- Print one set of Ingredient Cards and one Sandwich Menu for the class. Laminate both if desired. Cut out the Ingredient Cards, and place them in designated areas of the classroom arranged by ingredient category.
- Print a set of DNA Sequences for each group. Cut apart the four DNA sequences.
- Print a Codon Chart for each group.
- Divide students into groups of four prior to Part II of the activity.

Connections



SEP Connection

Constructing Explanations and Designing Solutions

During this activity, students will construct explanations and design solutions to explain phenomena or solve problems.

While students work through this activity, they should do the following:

- Construct explanations to explain phenomena
- Construct explanations to solve problems
- Design solutions to solve problems

Once students have completed this activity, ask these questions:

- What phenomena were witnessed in the activity?
- How were explanations constructed to explain the phenomena?
- What problems were presented in the activity?
- In what ways did you explain or solve these problems?

CCC Connection

Systems and System Models

During this activity, students will explore systems and system models.

Ask students the following questions:

- Where do you see systems and system models in this activity?
- Where have you seen systems and system models before this activity?
- Where do you see systems and system models outside the classroom?
- Where do you think you will see systems and system models in other science lessons?

Notes



Home



Engage



Explore



Explain



Elaborate



Evaluate



Intervention



Acceleration



Procedure and Facilitation

Part I

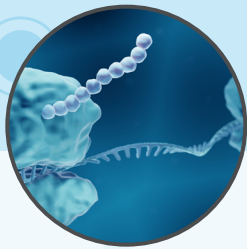
1. Explain to students that they will model the process of protein synthesis, which is a key cell process.
2. Ask for the following volunteers:
 - An injured student (who has broken their leg on a trampoline)
 - A sibling
 - A sandwich builder
 - A sandwich-shop owner
3. Ingredient carriers (all of the remaining students in the class). Assign to each ingredient carrier one or two ingredients from the Sandwich Menu.
4. Begin reading the scenario aloud: A student, Mark, broke his leg while jumping on a trampoline. Mark is stuck at home for a few days while he begins to heal. While sitting at home, Mark talks to his sibling, Isabel, about how much he would love a sandwich from the sandwich shop around the corner. Isabel offers to pick up a sandwich and asks Mark what he wants.
5. For the sake of the explanation, we have used sample names in the scenario. It is recommended that you use your students' names.
6. Have the injured student review the Sandwich Menu. Instruct them to pick at least one ingredient from each of the five categories in any order that they want, but they must start and end their ingredient list with a bread choice. The student must pick at least 10 but no more than 20 ingredients. They can choose the same ingredient twice, but each duplicate counts as one of the 20-item maximum.
7. Have another student write the sandwich ingredients on the board in the same order that the injured student chooses them. Encourage the sibling to write the order down so that they get the sandwich order correct.
8. Continue reading the scenario: Isabel gets the details of what Mark wants and then heads to the sandwich shop. When she gets there, she begins to read off the order to the sandwich builder.
9. Explain that, in this unique sandwich shop, the ingredients are moved around by carriers and given to the sandwich builder to make the sandwich. Have each ingredient carrier find and pick up one piece of paper that represents their assigned ingredient. Have the carriers randomly circulate around the room until their ingredients are needed by the sandwich builder.
10. Direct the sandwich builder to stand in one spot and begin building the sandwich by calling for each ingredient in order. The sandwich builder will collect the ingredients as the ingredient carriers bring them. To assemble the sandwich, the sandwich builder should simply stack the cards on top of each other, beginning with the first bread choice and ending with the second bread choice.
 - As ingredients are removed from the carriers, the carriers are allowed to go get the same ingredient and cycle through the shop again.
11. When the sandwich is fully assembled, instruct the sandwich builder to pass the sandwich to the shop owner, who will then place it in an envelope for delivery.
12. Have a student deliver the envelope to you. List the ingredients on the board in the order in which they were assembled, starting at the bottom of the stack.

ACTIVITY TIP

To enhance understanding, consider showing a short video clip of protein synthesis both before and after completing Part I of the activity. This can be helpful for students who have trouble visualizing transcription and making connections with the activity.

ACTIVITY TIP

If time permits, revisit Part I after completing Part II. Instruct students to write a summary of the events and identify the representation of each character.



DNA to Proteins

Explore 2: Activity - Make Me a Sandwich

ACTIVITY TIP

Ensure each student comprehends how to read a codon chart by assigning them an mRNA sequence to translate. Move around the room to assist students with their translations, incorporating multiple sequences to maintain class engagement. Students typically find enjoyment in mastering the codon chart. Conclude by inviting the class to read a line of transcription and translation as a choral response.

ACTIVITY TIP

To assist students, consider writing the base pairing in DNA and RNA on the board as a reference. Additionally, think about incorporating base pairs into an anchor chart that compares and contrasts DNA and RNA.

Part II

1. Before beginning the lesson, assign students to groups of four.
2. Give each group a Codon Chart and a set of DNA sequences. Explain that each student in the group needs to choose a different DNA sequence.
3. Students will go through a simplified process of transcription and translation. Model the process with the entire class using the sample DNA sequence in step 3 of the Student Handout (3'TACGTTAGGAACCCCGACGCTGGATCATATT 5') so that students understand how to do the process correctly. This will also provide a chance for you to clear up any misconceptions.
 - a. Ask students to read the definition of *transcription* in step 3 of the Student Handout.
 - b. Transcribe the sample DNA strand into mRNA, starting at the 3' end of the DNA strand. Stress the importance of all DNA being read in this way. You could compare this to reading a book in the correct way and not backward.
 - c. Match each base on the DNA strand with the corresponding base for RNA. Remind students that DNA pairs adenine with thymine, but RNA pairs adenine with a different nitrogenous base called uracil. This is one of the most common misconceptions about DNA and RNA and completing this process.
 - d. Ask students what A (adenine) pairs with. They should answer that it pairs with T (thymine). Then, ask students what C (cytosine) pairs with. They should note that it pairs with G (guanine).
 - e. Have students record the new mRNA strand sequence under the sample DNA sequence in step 3 of the Student Handout.
 - f. Have students check what they wrote with group members to be sure that they have correctly transcribed the DNA to mRNA. This is also a chance for them to discuss as a group whether there are any parts of the process that they do not understand. After their discussion, take questions to clear up any misconceptions.
 - g. Explain that the next step is to translate the mRNA strand into amino acids. Translating mRNA means reading the mRNA in three-base sections called codons. Direct students' attention to the groups of three nitrogenous bases listed as mRNA codons in step 3 of the Student Handout.
 - h. To translate the mRNA to amino acids (AA), have students find the start codon, AUG.
 - i. Show students how to read the provided Codon Chart by taking them through each letter of the start codon. On the Codon Chart, find the first letter, A, on the left side of the chart. Next, find the U at the top of the chart. Finally, find the G on the right side of the chart.

Notes



- j. Note that where these letters meet on the chart is the abbreviation Met, indicating the amino acid methionine. Explain that methionine is one of several amino acids that are represented by a codon. Make sure that students understand that the same codon always refers to the same amino acid. This is a good place to discuss that Met is always the first amino acid in a sequence of amino acids that forms a protein.
 - k. Have students record Met beside AA in the sample sequence on the Student Handout.
 - l. Instruct students to follow this same procedure to translate each codon in the sample sequence. For the first four codons after Met, have them translate one codon at a time, giving them the answer after each one. Then, have them translate the remaining five codons before checking their answers first with their groups and then with the entire class.
4. Have students return to their chosen DNA sequences and repeat the process of transcription and translation.
 5. Instruct students to answer the questions on the Student Handout.

Phenomenon Connection

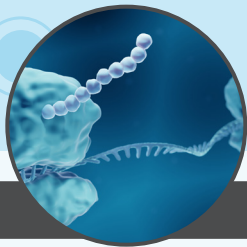
Once students have completed this learning activity, revisit the Student Wondering of Phenomenon and use the following questions to guide a class discussion.

- What impact could a mutation have on the essential function of life coded for in DNA?
- How does this activity connect to or answer the question above?
- How does this activity change your thinking about the phenomenon?
- Do you have any additional questions or observations about the connection between the phenomenon and the activity?

CLASSROOM ENVIRONMENT TIP

Reiterate to students that mastering protein synthesis takes time. With consistent repetition and practice, they will develop a solid understanding of the concept. Maintain ongoing support for any students who may be facing challenges.

Notes



DNA to Proteins

Explore 3: Scientific Investigation - Enzyme Simulation

Activity Preparation



Time Stamp 1 hr - 2 hrs

Students will simulate the reaction of an enzyme with its substrate by using their hands to represent the enzyme and toothpicks to represent the substrate. Students' hands will be modified slightly to represent differently shaped enzymes. After compiling class data, students will describe how changing the shape of enzymes and proteins impacts their function. After students complete the investigation, they will use the data and observations they gathered in the investigation to write a scientific explanation that includes a claim, evidence, and reasoning (CER).

Materials:

Printed Material

- 1 Enzyme Simulation (per student)

Consumable

- 50 Flat toothpicks (per student)
- 1 Roll of masking tape (per group)

Reusable

- 1 Bowl (per group)

Preparation

- Print copies of Enzyme Simulation for each student.
- Gather enough toothpicks for each student to have 50 toothpicks at the start of the activity. Unbroken toothpicks can be reused for the next class. Make sure to use flat toothpicks, since they are easier to break and safer to use.
- Students will work in groups of four in this investigation. If there are any groups with fewer than four students, you may omit modification D for these groups.

Connections



SEP Connection

Engaging in Argument from Evidence

During this activity, students will engage in argumentation from evidence to identify strengths and weaknesses in a line of reasoning, to identify best explanations, to resolve problems, and to identify best solutions.

While students work through this activity, they should do the following:

- Engage in argumentation from evidence to identify strengths and weaknesses in a line of reasoning
- Engage in argumentation to identify the best explanations
- Engage in argumentation to resolve problems
- Engage in argumentation to identify the best solutions

Once students have completed this activity, ask these questions:

- Is the reasoning supported by evidence?
- How can we evaluate the different explanations to find the best explanation?
- How does the resolution or solution here compare to real-world resolutions?

Give students two different arguments related to a phenomenon in the activity, one with evidence and one without, and then ask students to identify which argument is more scientific and why.

CCC Connection

Structure and Function

During this activity, students will explore the structure and function of systems and parts.

Ask students the following questions:

- Where do you see the structure and function of systems and parts in this activity?
- Where have you seen the structure and function of systems and parts before this activity?
- Where do you see the structure and function of systems and parts outside the classroom?
- Where do you think you will see the structure and function of systems and parts in other science lessons?



Home



Engage



Explore



Explain



Elaborate



Evaluate



Intervention



Acceleration



Procedure and Facilitation

- Before passing out the Scientific Investigation: Enzyme Simulation, discuss the following with your students:
 - What are enzymes? They are biological catalysts; they speed up biological reactions.
 - What are some enzymes you know? Amylase, pepsin, lipase, etc. If students say "saliva," mention that enzymes are found in saliva.
 - What are enzymes made up of? Proteins
 - What do these enzymes act on? Sugars, starch, fats, proteins, etc.
 - What could increase or decrease the function of these enzymes? Temperature, concentration, pH, something that causes these enzymes to change their shapes
- Pass out copies of Enzyme Simulation and give students time to read through the Introduction.
- Present the question that the students will be testing: How does changing the shape of enzymes impact their function?
- Students will state their hypothesis in Enzyme Simulation.
- Divide the students into groups of four and assign each student within the group a letter from A through D. If there are any groups with fewer than four students, you may omit modification D for these groups.
- Distribute one roll of masking tape to each group. Have students read questions 1 and 2 in Enzyme Simulation.
- Lead class discussion, using questions below:
 - What are your hands representing? Enzymes or proteins
 - What are the toothpicks representing? Substrate, or what will be broken down by the enzyme
 - What are the modifications you made to your hands representing? Different shapes of enzymes or proteins
 - Which modification do you think would result in the greatest number of toothpicks broken? Modification C. Least number of toothpicks broken? Modification A, B, or D. Why? It is easiest to pick up and break toothpicks when fingers are not taped together. It is difficult to pick up and break toothpicks when fingers are taped together.
- Go over the rules with the class before playing the game.
- It is important that students follow the rules during the game so that the data collected is valid.
- Make sure students are counting how many toothpicks were broken, not the number of broken pieces.

ACTIVITY TIP

In biochemical nomenclature, the suffix -ase is employed to denote enzymes. Frequently, -ase is appended to the end of a substrate. For example, maltase is responsible for breaking down maltose.

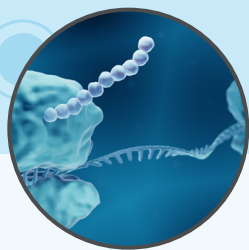
CLASSROOM MANAGEMENT TIP

If time or supplies are limited, or if students are facing challenges with the directions, you might opt to conduct the investigation as a whole class. Divide the class into groups A-D and assign roles, designating one student as the enzyme and another to count broken toothpicks. Display a timer on the board and instruct all groups to commence breaking their toothpicks simultaneously. This approach ensures that student groups stay on track and minimizes waiting time for completion.

SAFETY TIP

Before students begin, demonstrate the proper way to break toothpicks to reduce the risk of injuries. This practical demonstration aims to ensure everyone understands the technique.

Notes



DNA to Proteins

Explore 3: Scientific Investigation - Enzyme Simulation

ACTIVITY TIP

Highlight strategies for generating more reliable data. Students might observe instances where others intentionally raced faster as the trials progressed, introducing inconsistency into the data. Stress the significance of using class averages to ensure the reliability and validity of the data collected.

11. Designate one student from each group to report his or her group's data. The data can be compiled on the board or in a spreadsheet displayed onto the board.
12. Add the total number of toothpicks broken for each enzyme modification and the class total in the data table on Enzyme Simulation.
13. Lead class discussion, using the questions below:
 - a. Why do we want to use the class data and not group data? Class data is more accurate and reliable; there might have been several students who did not follow the rules correctly.
 - b. Which modification resulted in the greatest number of toothpicks broken? Modification C. Least? Modification A, B, or D
 - c. Were there any results that were unexpected? Answers may vary.
 - d. Enzymes are special types of proteins. How are proteins produced in cells? Proteins are produced through the processes of transcription and translation.
14. After students complete the investigation, they will use the data and observations they gathered in the investigation to write a scientific explanation.

Phenomenon Connection

Phenomenon Connection

Once students have completed this learning activity, revisit the Student Wondering of Phenomenon and use the following questions to guide a class discussion.

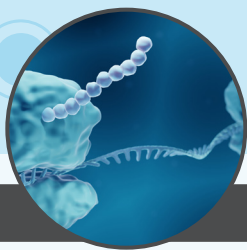
What impact could a mutation have on the essential function of life coded for in DNA?

- How does this activity connect to or answer the question above?
- How does this activity change your thinking about the phenomenon?
- Do you have any additional questions or observations about the connection between the phenomenon and the activity?

Notes



Notes



DNA to Proteins

Scope Resources and Assessment Planner

Scope Resources



Explain

- ☐ **Picture Vocabulary**
A slide presentation of important vocabulary terms along with a picture and definition.
- ☐ **STEMscopedia**
Reference materials that includes parent connections, career connections, technology, and science news.
- ☐ **Linking Literacy**
Strategies to help students comprehend difficult informational text.



Elaborate

- ☐ **Math Connections**
A practice that uses grade-level appropriate math activities to address the concept.
- ☐ **Reading Science - Structure, Function, and Heredity**
A reading passage about the concept, which includes five to eight comprehension questions.
- ☐ **Engineering Connections**
A creative, kinesthetic extension into engineering and design that uses concepts addressed in the scope.



Evaluate

- ☐ **Claim-Evidence-Reasoning**
An assessment in which students write a scientific explanation to show their understanding of the concept in a way that uses evidence.
- ☐ **Open-Ended Response Assessment**
A short-answer and essay assessment to evaluate student mastery of the concept.
- ☐ **Multiple Choice Assessment**
A standards-based assessment designed to gauge students' understanding of the science concept using their selections of the best possible answers from a list of choices



Intervention

- ☐ **Guided Practice**
A guide that shows the teacher how to administer a small-group lesson to students who need intervention on the topic.



Acceleration

- ☐ **Extensions**
A set of ideas and activities that can help further elaborate on the concept.

Notes



Home



Engage



Explore



Explain



Elaborate



Evaluate



Intervention



Acceleration



Assessment Planner

Use this template to decide how to assess your students for concept mastery. Depending on the format of the assessment, you can identify prompts and intended responses that would measure student mastery of the expectation. See the beginning of this scope to identify standards and grade-level expectations.

Student Learning Objectives

What Prompts Will Be Used?

What Does Student Mastery Look Like?

construct an explanation based on evidence that the essential functions of life are primarily carried out through the work of proteins that are coded for by genes in DNA, as described by the Central Dogma (i.e., transcription, translation).