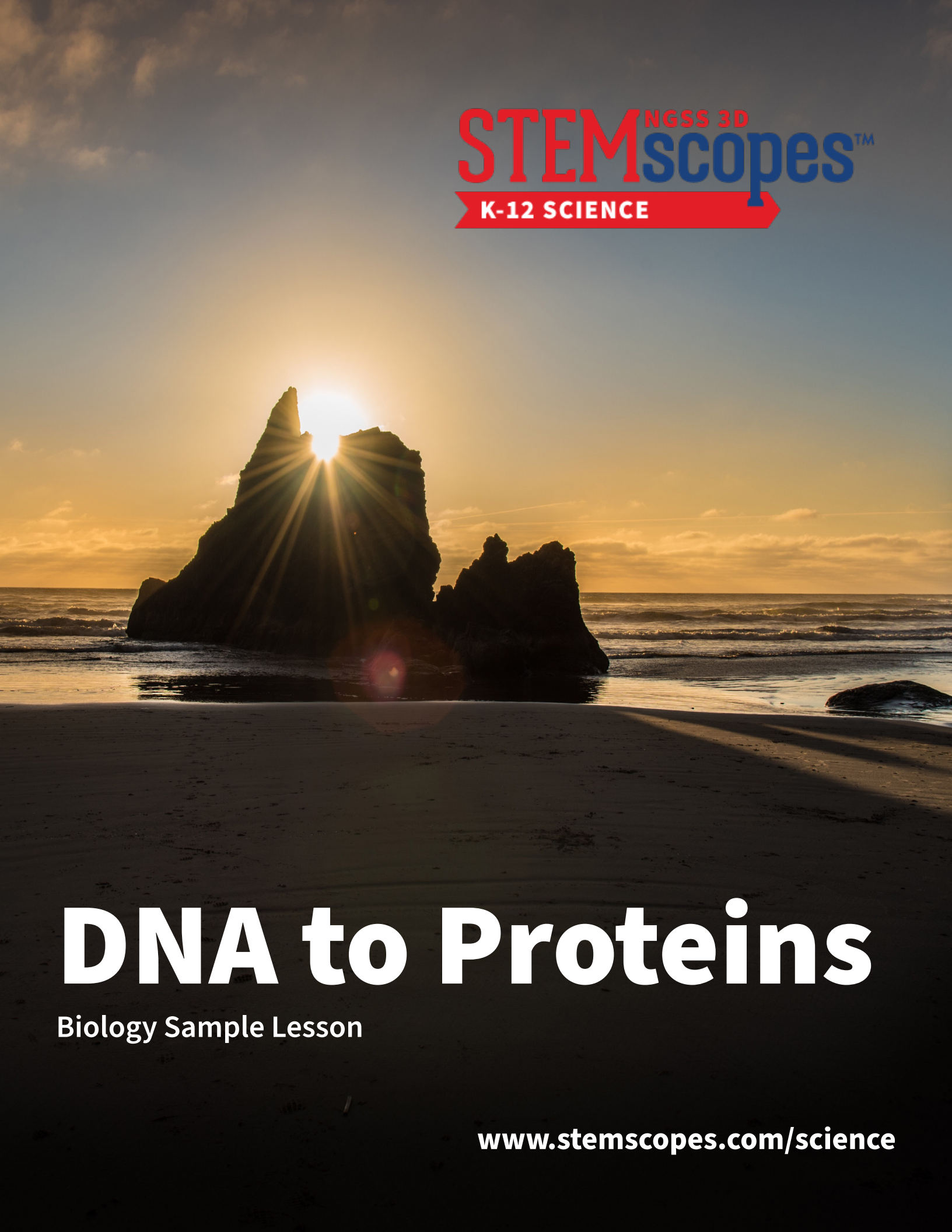


STEMscopes NGSS 3D
K-12 SCIENCE

DNA to Proteins

Biology Sample Lesson

www.stemscopes.com/science

Scope (Unit) DNA to Proteins

Explore (Lesson) Scientific Investigation - Enzyme Simulation

The following pages introduce lesson resources that guide you through the STEMscopes NGSS Biology lesson. This sample lesson does not include all the elements and features of our digital and print science curriculum.

Resource List:

The following resources, as well as additional Scope resources not listed, can be found in the digital curriculum *Biology Scope, DNA to Proteins.*

Home

- Standards Alignment
- Sample Lesson Plan
- Teacher Scope Presentation
- Teacher Background
- CCC and SEP Scoring Rubric
- Answer Keys
- Materials List

Engage

- Investigative Phenomena – Introductory activity that facilitates a connection between the content and real-world phenomena and encourages students to ask why or how something happens.
- Graphic Organizer – Students fill this in as they work through the elements of this Scope.
- Accessing Prior Knowledge – A brief probing activity to gauge students' prior knowledge before engaging in the inquiry process.
- Hook – An engaging activity that includes instructor preparation, supplemental resources, and ready-made handouts for students.

Explore

- Explore 1: Activity
- Explore 2: Activity
- Explore 3: Scientific Investigation – This lesson sample.

Explain

- Picture Vocabulary – Key terms explained through pictures and by definition.
- Linking Literacy – Strategies to help students comprehend difficult informational text.
- STEMscopedia – Reference materials that include parent connections, career connections, technology, and science news.
- Communicate Science – A class activity in which students use different forms of communication to discuss scientific topics connected to the content of this Scope.
- Concept Review Game – An interactive game that helps students review important concepts.
- Content Connections Video – A short video that supports student understanding of the content.

Elaborate

- Math Connections
- Reading Science
- Career Connections
- Scientist Spotlight
- PhET: Simulation Practice

Evaluate

- Claim-Evidence-Reasoning
- Open-Ended Response Assessment
- Multiple Choice Assessment

Intervention

- Guided Practice
- Independent Practice
- Concept Attainment Quiz

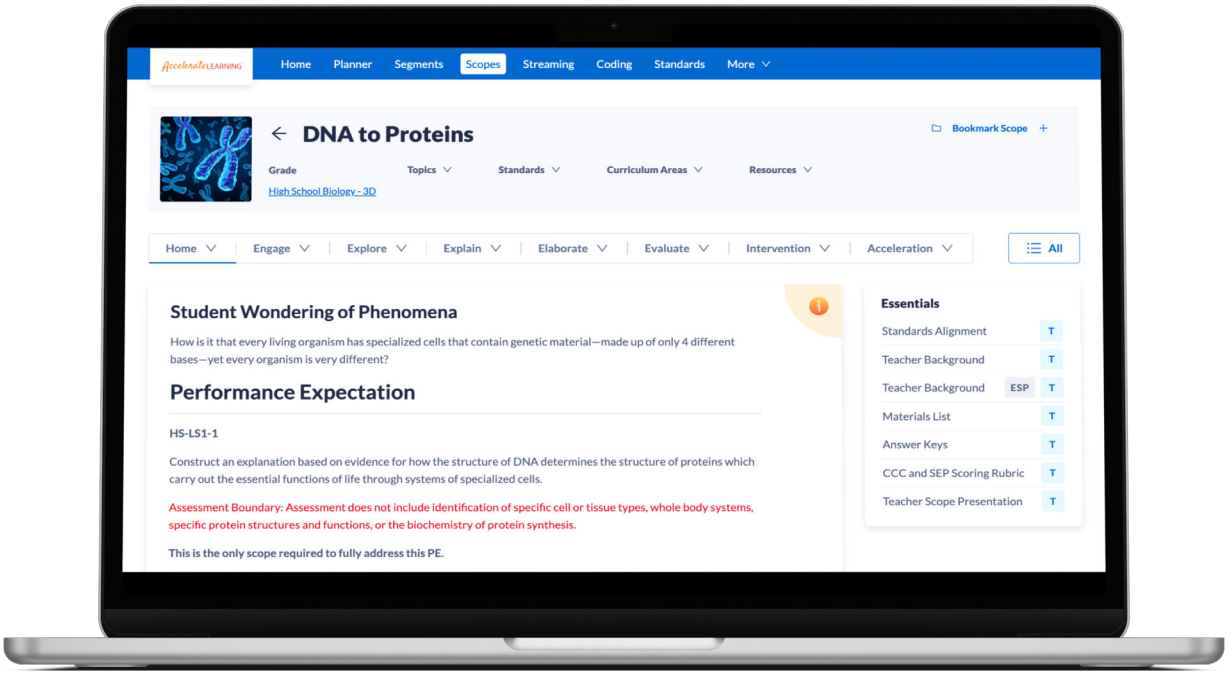
Acceleration

- Extensions
- Science Art
- Books on Topic

Table of Contents

Scope (Unit) Overview

Scope (Unit) DNA to Proteins



Student Wondering of Phenomena

How is it that every living organism has specialized cells that contain genetic material—made up of only 4 different bases—yet every organism is very different? ?

Performance Expectations

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.

Assessment Boundary: Assessment does not include identification of specific cell or tissue types, whole body systems, specific protein structures and functions, or the biochemistry of protein synthesis.

Scope (Unit) Overview

Scope (Unit) Ecosystem Biodiversity

Three-Dimensional Focus

Science and Engineering Practice	Disciplinary Core Idea	Crosscutting Concept
Constructing Explanations and Designing Solutions 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.	LS1.A Structure and Function LS1.A.1 Systems of specialized cells within organisms help them perform the essential functions of life. LS1.A.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 the work of cells.	Structure and Function 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 its function and/or solve a problem.

DNA to Proteins

Explore 3: Scientific Investigation - Enzyme Simulation

Description

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 Materials
1 Enzyme Simulation (per student)

Reusable
1 Bowl (per group)

Consumable
50 Flat toothpicks (per student)
1 Roll of masking tape (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.

STEMcoach in Action

The skills inherent in designing and implementing a scientific investigation are applicable to many situations outside of the science classroom. Skills such as observing, asking questions, collecting and analyzing data, and drawing and communicating reasonable conclusions are important to all individuals. When we say "cultivating scientific investigation" we are describing the practices that help students develop the skills associated with scientific investigation. For more information on Cultivating Scientific Investigations, please click on the provided link.
Site

Procedure and Facilitation Points

- 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.
- **(CCC)** 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.

Part I: Design of Enzymes

- 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.

1. You will be divided into groups of four.
2. Each student in your group will be assigned a letter, A through D. Using tape, modify the hand you will be using to break the toothpicks according to your assigned letter.
   a. Tape together the thumb and pointer finger.
   b. Tape together the ring and pinkie finger.
   c. No modification.
   d. Tape together all fingers except for the thumb.

- 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.

Part II: Enzyme Activity

- Go over the rules with the class before playing the game (see below).
- It is important that students follow the rules during the game so that the data collected is valid.

The Rules

- You must break each toothpick one at a time.
- You must break each toothpick with one hand ONLY.
- You must break each toothpick completely in half.
- You cannot rebreak a broken toothpick.
- All broken toothpicks must remain in the bowl along with the unbroken toothpicks.
- You cannot begin before I say, "GO!"
- You must stop precisely when I say, "STOP!"
- Keep your eyes closed during this portion of the investigation.

Go over the steps below and have students play the game.

- Count out 50 unbroken toothpicks into a bowl on your desk.
- When I say, "GO!" begin breaking toothpicks.
- At the end of 1 minute, I will say, "STOP!"
- Count and record the total number of toothpicks broken.

Make sure students are counting how many toothpicks were broken, not the number of broken pieces.

- Report your group's data.

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.

- Record class data.

Enzyme Modification	Number of Toothpicks Broken	Class Total Number of Toothpicks Broken
A	Data will vary.	Data will vary.
B	Data will vary.	Data will vary.
C	Data will vary.	Data will vary.
D	Data will vary.	Data will vary.

- Add the total number of toothpicks broken for each enzyme modification and the class total in the data table on Enzyme Simulation.
- Lead class discussion, using the questions below:
  - 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.
  - Which modification resulted in the greatest number of toothpicks broken? Modification C. Least? Modification A, B, or D
  - Were there any results that were unexpected? Answers may vary.

  - Enzymes are special types of proteins. How are proteins produced in cells? Proteins are produced through the processes of transcription and translation.
- **(SEP)** After students complete the investigation, they will use the data and observations they gathered in the investigation to write a scientific explanation.

Almost all the chemical reactions that take place within cells are catalyzed by enzymes. Enzymes are biological catalytic proteins that lower the activation energy needed to start a chemical reaction and, as a result, greatly increase the rate of the reaction. The structure of an enzyme is based on the interaction and bonding of amino acids that make up the protein. There are thousands of different enzymes in a cell, and they are structurally diverse. The structure of the enzyme determines the chemical reaction that it will catalyze.

How does DNA impact the function of enzymes?

Claim
Sample answer: DNA sends a message to the ribosome to produce proteins. The sequence of DNA determines the amino acids that make up a protein and, therefore, determines the shape of the enzyme.

Evidence
Sample answer: Since the shape of the enzyme (hand) was different for each modification, the number of toothpicks broken (function) was also different.

Reasoning
Sample answer: Enzymes are special types of proteins that catalyze biochemical reactions. Enzyme function changes when the shape changes. Since enzymes are proteins, this also means that protein function changes when its shape changes. The sequence of genes contains instructions that code for proteins, so if the gene sequence changes, the amino acid sequence also changes, which could result in a change in the shape and function of proteins.

- At this time, you could introduce the following terms, using the Picture Vocabulary found in the Explain section:
  - Enzyme
  - Protein
  - Catalyst
  - Substrate
- When appropriate, close the activity by referring students to the Investigative Phenomena/Graphic Organizer and fill in the appropriate information.

Connection to the Investigative Phenomena

Once students have completed the activity, have them refer to the Investigative Phenomena question, anchor their learning, and revise their thinking.

ELL Strategies

Claim-Evidence-Reasoning:

Have students work in pairs to develop their CER. After completing the CER, students should read another student's reasoning and ask questions to make sure they understand what was written. Then have students write a rebuttal or reflection based on the other

student's CER responses. Allow students to complete the sentence stems before the discussion portion. Sentence stem examples: "My claim is __. My evidence is __. My reasoning is __. I heard you say __, and I hadn't thought about that before. However, I think __."

Intervention Strategies

Does Not Interact with Peers: Strategic Grouping

Group students with others who feel less threatening. Try various groupings until you find one that is best.

Math Moment

NGSS specifies no Common Core Math alignment; however, we suggest extending this learning task by making the connection to math standard MP.2 Reason abstractly and quantitatively.

Students learned that enzymes are special types of proteins that catalyze biochemical reactions and speed up biological reactions. The model of an enzyme-catalyzed reaction is represented by S + E -> P + E, where S is the substrates and P is the products. Ask students, "If the concentration of the substrate is increased, what happens to the reaction rate?"

Student Answers: If the concentration of the substrate is increased, the reaction rate will go up in a linear fashion.

Check out this module's Math Connection for further practice!

DNA

Explore Lesson

Explore

Name: _____ Date: _____

Enzyme Simulation

Introduction
Enzymes are special types of proteins that catalyze biochemical reactions. Enzymes work to speed up biological reactions but are not used up in the process. The substance on which an enzyme acts is called a substrate. In this investigation, you will simulate the reaction of an enzyme with its substrate. You will pretend that toothpicks are the substrate to be broken down and your hand is the enzyme. However, not all enzymes have the same shape. Each group member's hand will be modified slightly to represent different shaped enzymes.

Question
How does changing the shape of enzymes impact their function?

Hypothesis

.

Materials
Flat toothpicks
Bowl
Tape

What, if any, safety steps need to be taken?

Procedure

Part I: Design of Enzymes

1. You will be divided into groups of four.
2. Each student in your group will be assigned a letter, *A* through *D*. Using tape, modify the hand you will be using to break the toothpicks according to your assigned letter:
    A. Tape together the thumb and pointer finger.
    B. Tape together the ring and pinky finger.
    C. No modification.
    D. Tape together all fingers except for the thumb.

Explore

Part II: Enzyme Activity

The Rules

- You must break each toothpick one at a time.
- You must break each toothpick with one hand ONLY.
- You must break each toothpick completely in half.
- You cannot rebreak a broken toothpick.
- All broken toothpicks must remain in the bowl along with the unbroken toothpicks.
- You cannot begin before the teacher says, “GO!”
- You must stop precisely when the teacher says, “STOP!”
- Keep your eyes closed during this portion of the investigation.

Play the Game

1. Count out 50 unbroken toothpicks into a bowl on your desk.
2. When the teacher says, “GO!” begin breaking toothpicks.
3. At the end of 1 minute, the teacher will say, “STOP!”
4. Count and record the total number of toothpicks broken.
5. Report your group’s data.
6. Record class data.

Data

Enzyme Modification	Number of Toothpicks Broken	Class Total Number of Toothpicks Broken
A		
B		
C		
D		

Explore

Part III: What's the Connection?

Almost all the chemical reactions that take place within cells are catalyzed by enzymes. Enzymes are biological catalytic proteins that lower the activation energy needed to start a chemical reaction and, as a result, greatly increase the rate of the reaction. The structure of an enzyme is based on the interaction and bonding of amino acids that make up the protein. There are thousands of different enzymes in a cell, and they are structurally diverse. The structure of the enzyme determines the chemical reaction that it will catalyze.

How does DNA impact the function of enzymes?

Claim

Evidence

.

Reasoning

Explore

Rubric for Writing a Scientific Explanation

Points Awarded	2	1	0
Claim	Answers the question, and is accurate based on data.	Answers the question, but is inaccurate based on data.	No claim, or does not answer the question.
Evidence	Cites data and patterns within the data and uses labels accurately.	Cites data from the data source, but not within the context of the prompt.	No evidence, or cites changes, but does not use data from the data source.
Reasoning	Cites the scientifically accurate reason, using correct vocabulary, and connects this to the claim. Shows accurate understanding of the concept.	Cites a reason, but it is inaccurate or does not support the claim. Reasoning does not use scientific terminology or uses it inaccurately.	No reasoning, or restates the claim but offers no reasoning.

Explore

Name: _____ Date: _____

Enzyme Simulation

Introduction
Enzymes are special types of proteins that catalyze biochemical reactions. Enzymes work to speed up biological reactions but are not used up in the process. The substance on which an enzyme acts is called a substrate. In this investigation, you will simulate the reaction of an enzyme with its substrate. You will pretend that toothpicks are the substrate to be broken down and your hand is the enzyme. However, not all enzymes have the same shape. Each group member's hand will be modified slightly to represent different shaped enzymes.

Question
How does changing the shape of enzymes impact their function?

Hypothesis
I think changing the shape of enzymes could increase or decrease their function.

Materials
Flat toothpicks
Bowl
Tape

What, if any, safety steps need to be taken?
Students will add safety precautions here.

Procedure

Part I: Design of Enzymes

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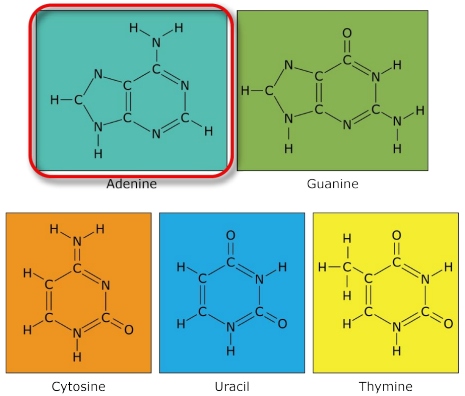
Picture Vocabulary

DNA to Proteins

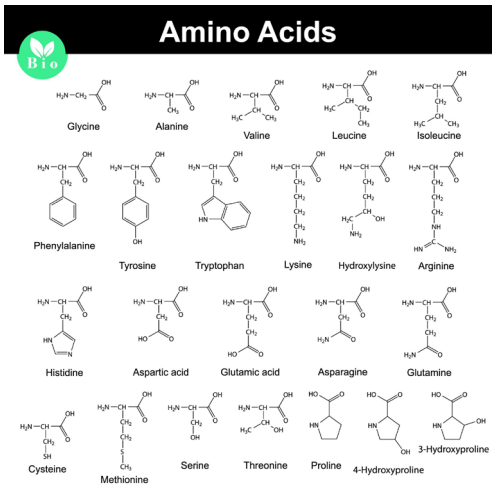
Picture Vocabulary

Adenine



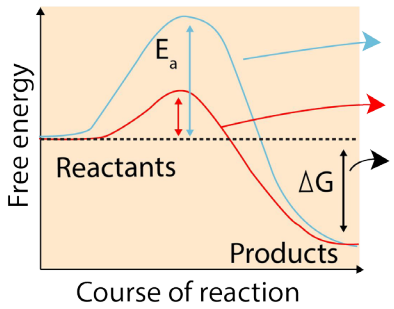
A purine base that pairs with thymine in DNA and uracil in RNA

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



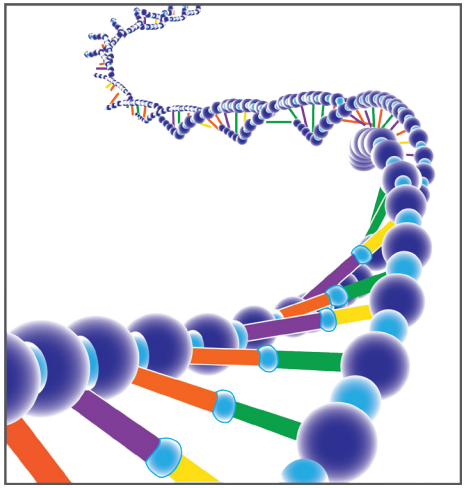
An uncatalyzed reaction requires a higher activation energy than does a catalyzed reaction.

There is no difference in free energy between catalyzed and uncatalyzed reactions.

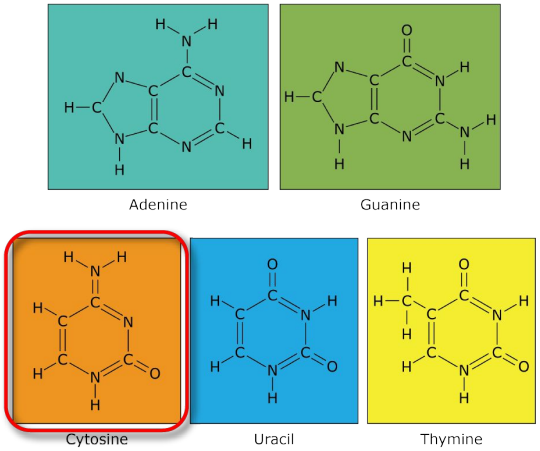
A substance that speeds up or promotes a chemical reaction without being chemically changed by the reaction

Complementary Base Pairing

When a DNA molecule's nitrogenous bases align with each other

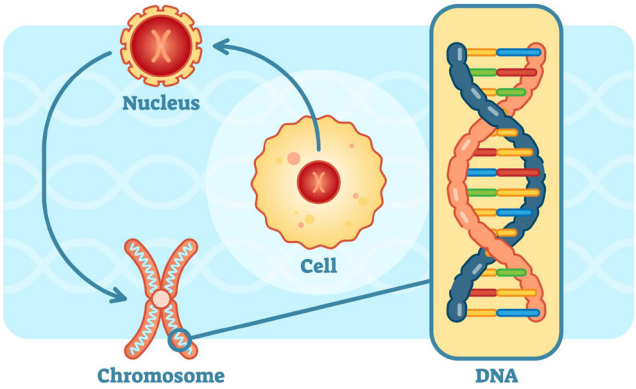


Cytosine



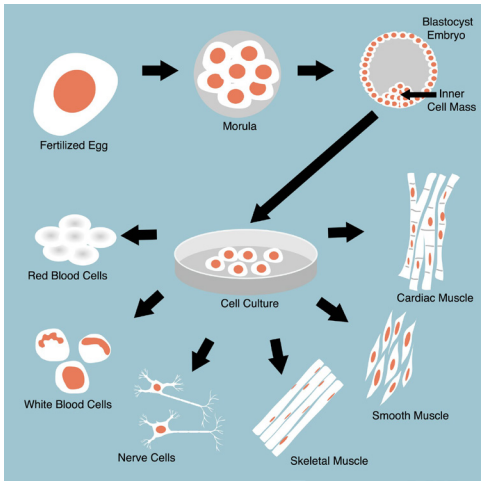
A pyrimidine base that pairs with guanine

Deoxyribonucleic Acid (DNA)



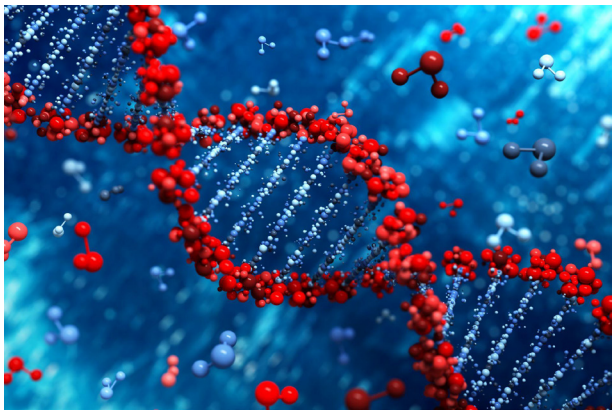
The carrier of genetic information present in nearly all organisms; forms a double helix

Differentiation



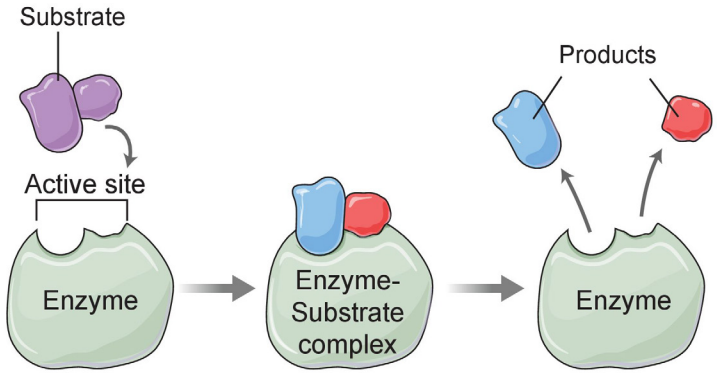
The process through which a cell develops and specializes to perform a certain function

Double Helix



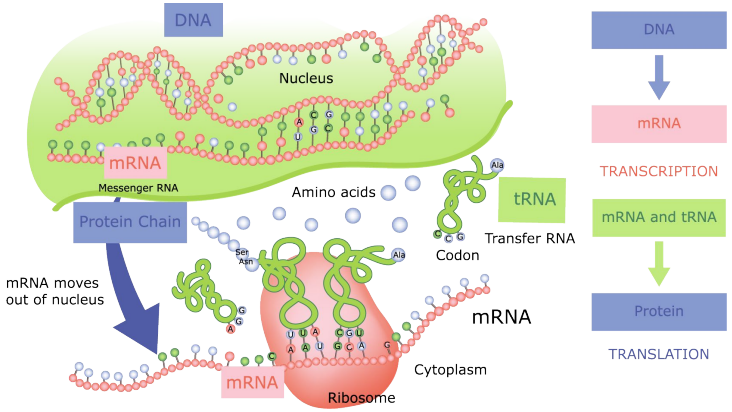
The primary physical shape of double-stranded DNA molecules

Enzymes



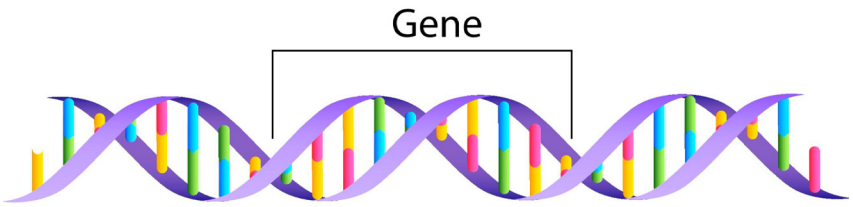
Proteins that can change the rates of specific reactions

Gene Expression



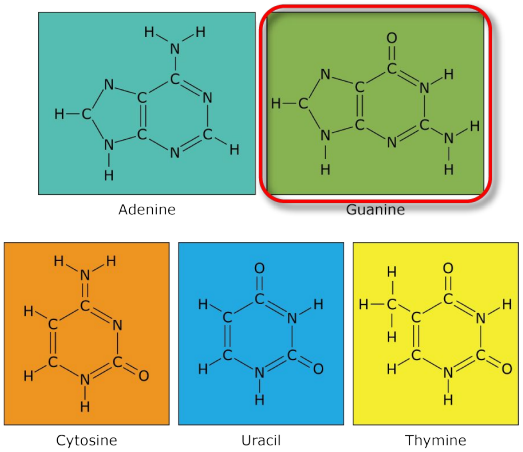
The process by which genetic information generates a specific protein or trait

Genes



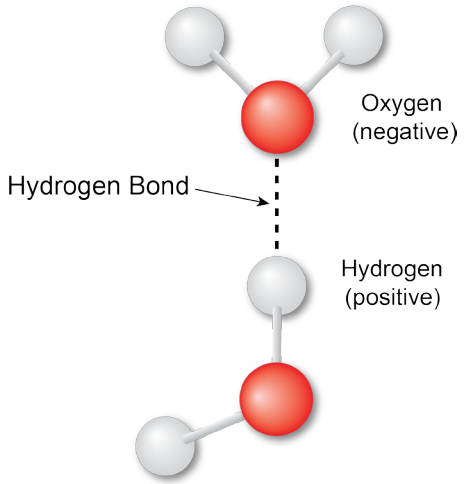
Segments of DNA that code for protein or functional RNA

Guanine



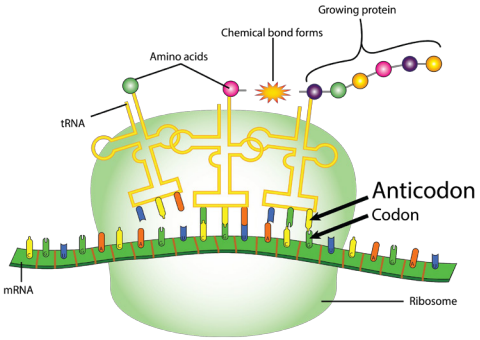
A purine base that pairs with cytosine

Hydrogen Bond



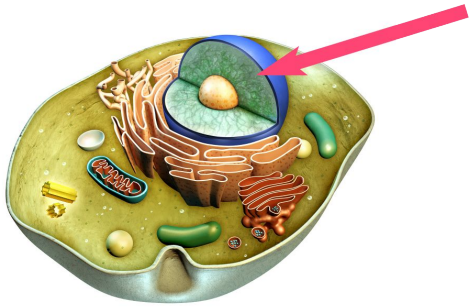
An attraction between a hydrogen atom that is covalently bonded to a highly electronegative atom (e.g., oxygen or nitrogen) and another highly electronegative atom to which the hydrogen is not covalently bonded

Messenger RNA (mRNA)



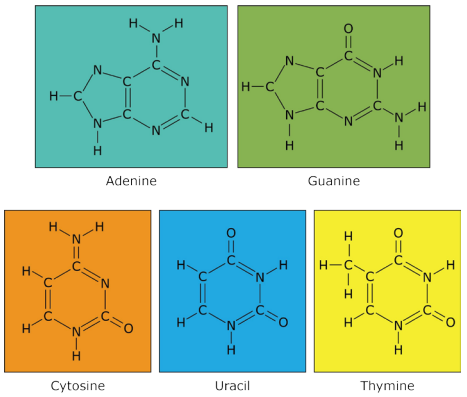
A single-stranded nucleic acid, made of RNA, that is a copy of a specific DNA sequence; created by the cell for transferring the genetic information in DNA to a ribosome to make a protein

Nucleus



The organelle where a eukaryotic organism's genetic material is located; the control center of the cell

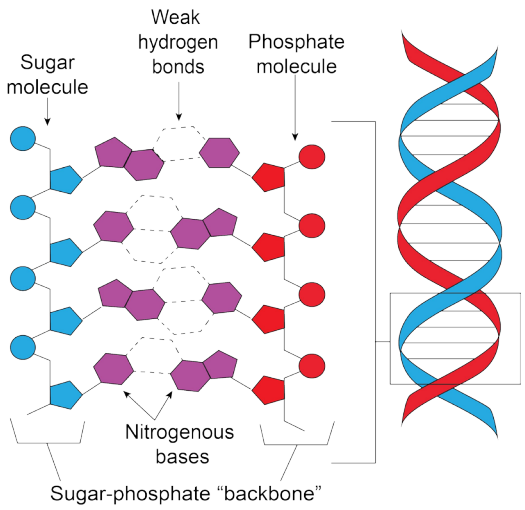
Nitrogen Base



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

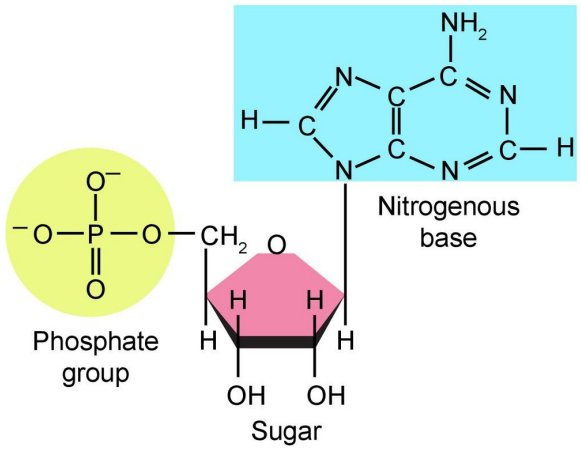
Nucleic Acid

A nucleotide polymer capable of storing and transferring genetic information

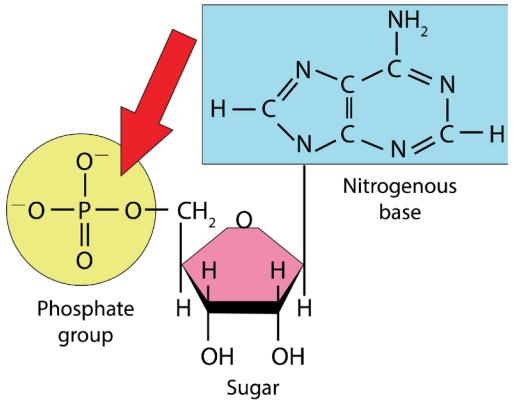


Nucleotide

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

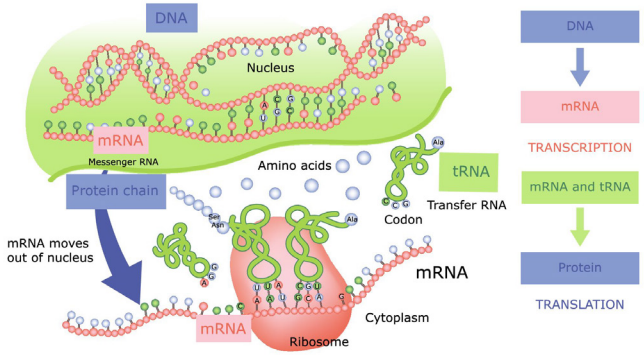


Phosphate



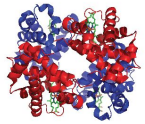
An inorganic compound consisting of a central phosphorus atom bound to four oxygen atoms

Protein Synthesis



The production of a protein molecule through DNA transcription and translation

Proteins

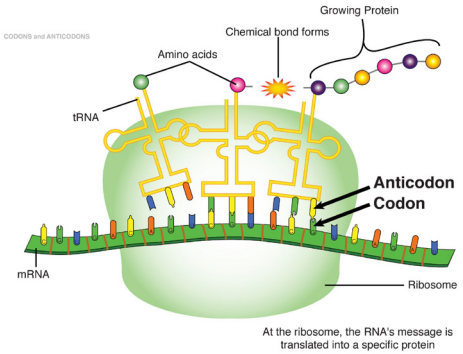
Type of Protein	Fibrous	Globular	Conjugated
Shape	 Collagen: a fibrous protein		
Examples of This Type of Protein	Collagen Keratin	Enzymes Antibodies Hormones	Hemoglobin

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

Ribonucleic Acid (RNA)

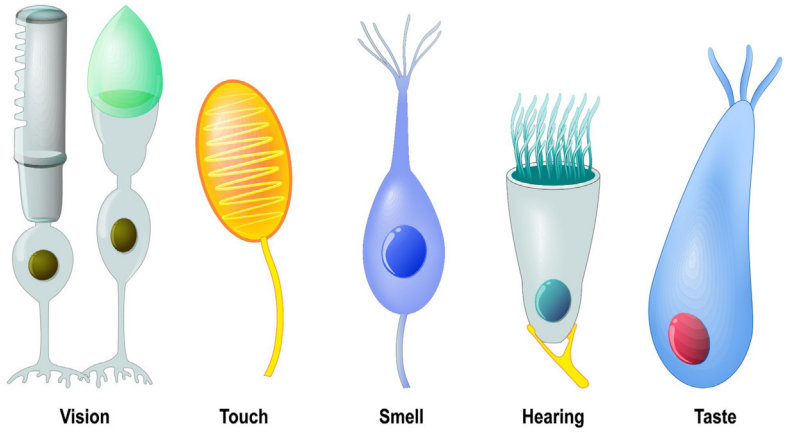
A single-stranded nucleic acid that contains uracil instead of thymine; can make tRNA, mRNA, or rRNA

Ribosome



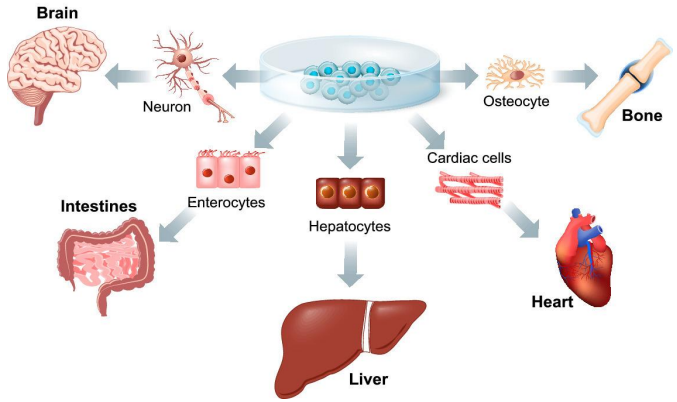
A structure made of protein and rRNA that converts messenger RNA sequences into amino acid sequences with the help of transfer RNAs

Specialized Cells



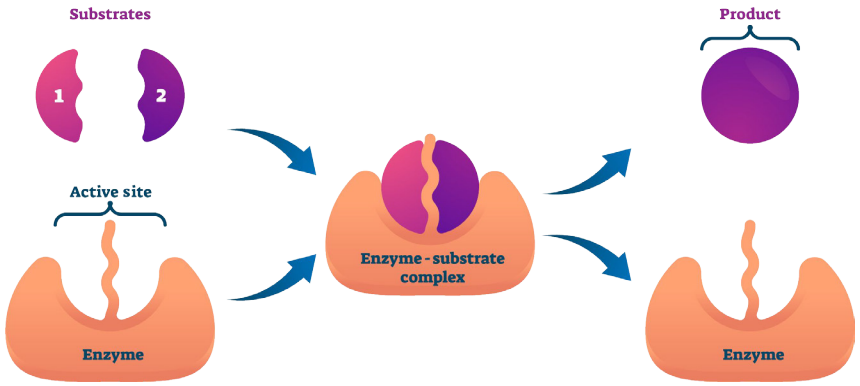
Cells that are specialized to perform a specific function

Stem Cell



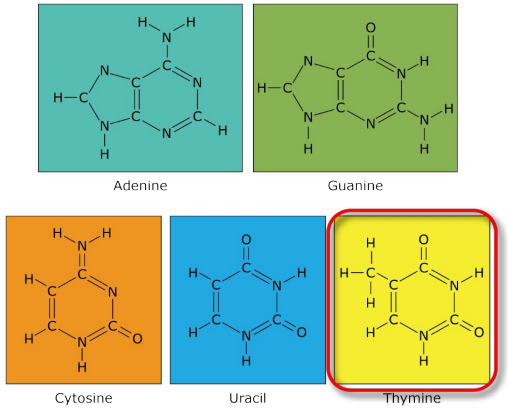
An undifferentiated cell that gives rise to specialized cells

Substrate



A substance being acted upon by an enzyme

Thymine



A pyrimidine base that pairs with adenine and is found only in DNA

Trait

Earlobe Attachment

Eye Color

Hair Color

	RT	Rt	rT	rt
RT	RRTT	RRTt	RrTT	RrTt
Rt	RRTt	RRtt	RrTt	Rrtt
rT	RrTT	RrTt	rrTT	rrTt
rt	RrTt	Rrtt	rrTt	rrtt

Tongue Rolling

Handedness

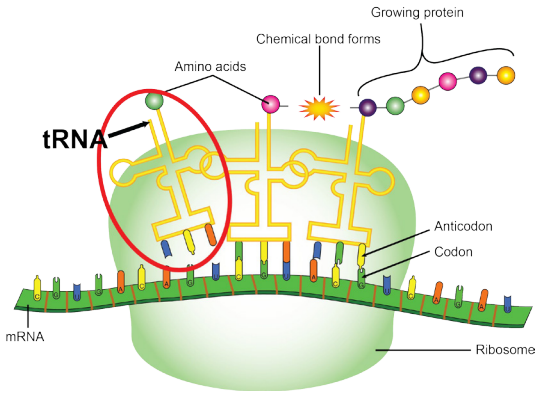
Dimples

Freckles

Hitchhiker's Thumb

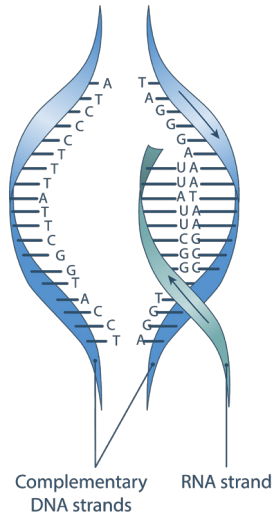
A distinct characteristic of an organism, which may or may not be inheritable

Transfer RNA (tRNA)



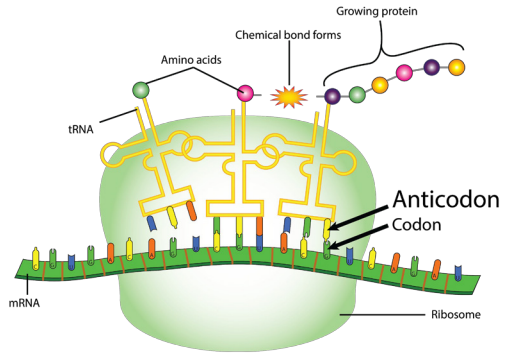
An RNA molecule that is responsible for transporting amino acids to the ribosome to be used in the synthesis of proteins

Transcription



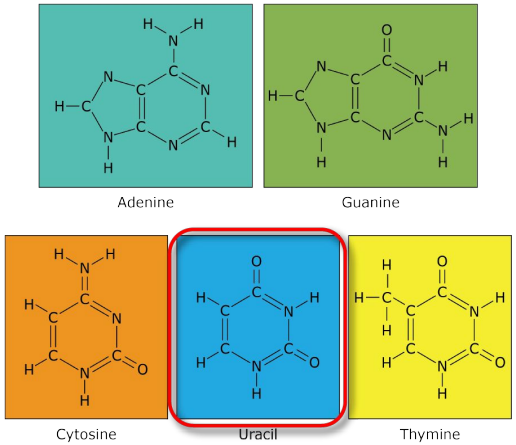
The process in which a strand of DNA is copied into an RNA strand for the purpose of protein synthesis

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

DN

Math Connections

Name: _____ Date: _____

Transcription is the process of synthesizing RNA from DNA code. **Translation**, on the other hand, is the process of synthesizing proteins by linking specific amino acids in an order determined by the codons found in the messenger RNA (mRNA). Codons are sets of three specific nucleotides. Each codon designates a specific amino acid, except for the three stop codons, which cause the newly synthesized polypeptide to be released from the ribosome. Ribosomes contain ribosomal RNA (rRNA) and, together with transfer RNA (tRNA) and mRNA, facilitate translation by allowing the mRNA to be read and the amino acids to be linked together to form a protein.

DNA Codon Usage

For most amino acids, there is more than one codon that can be translated into that particular amino acid. For these amino acids, some codons are used more often than others in the DNA sequence.

1. If there are four different bases (A, T, C, and G) that can make up a triplet codon, how many different codons are possible? How can you represent this mathematically, without counting all the combinations below?

Amino Acid	DNA Codons
Isoleucine	ATT, ATC, ATA
Leucine	CTT, CTC, CTA, CTG, TTA, TTG
Valine	GTT, GTC, GTA, GTG
Phenylalanine	TTT, TTC
Methionine	ATG
Cysteine	TGT, TGC
Alanine	GCT, GCC, GCA, GCG
Glycine	GGT, GGC, GGA, GGG
Proline	CCT, CCC, CCA, CCG
Threonine	ACT, ACC, ACA, ACG
Serine	TCT, TCC, TCA, TCG, AGT, AGC
Tyrosine	TAT, TAC
Tryptophan	TGG
Glutamine	CAA, CAG
Asparagine	AAT, AAC
Histidine	CAT, CAC
Glutamic acid	GAA, GAG
Aspartic acid	GAT, GAC
Lysine	AAA, AAG
Arginine	CGT, CGC, CGA, CGG, AGA, AGG
Stop codons	TAA, TAG, TGA

Math Connections

2. A protein consisting of 110 amino acids has been translated from an mRNA strand. Below is a table of the DNA codons transcribed to the mRNA that was used to build the protein. Using the DNA codon table from page 1 and your knowledge of DNA, RNA, and amino acids, complete the table below and answer the following questions.

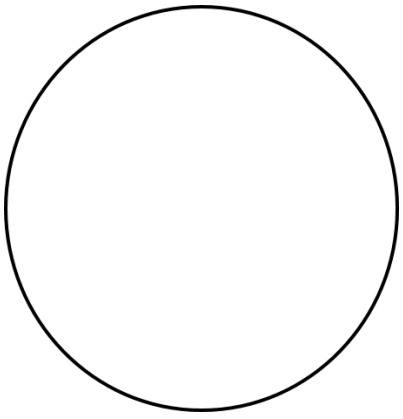
DNA Codon	Number of Times Used in DNA Sequence	% Used in DNA Sequence	Amino Acid
GGT	8		
TTT	4		
TGG	3		
GGG	13		
CAA	6		
CAG	19		
GGC	18		
TAT	9		
GGA	13		
TTC	6		
TAC	11		

3. Each codon contains three nucleotides. How many nucleotides are in the protein represented in the chart?

4. Which amino acid made up the largest portion of the protein? What percentage did it represent?

5. For the amino acid named in question 4, list all the codons representing that amino acid in the protein. Calculate the percent usage for each one. Create a circle graph to represent the data in the table.

Codon	Number of Times Used in DNA Sequence	Codon Usage (%)
Total:		100%



Legend

DNA to P

Claim-Evidence-Reasoning

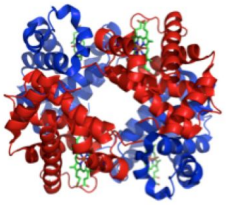
CER Assessment

Name: _____ Date: ___

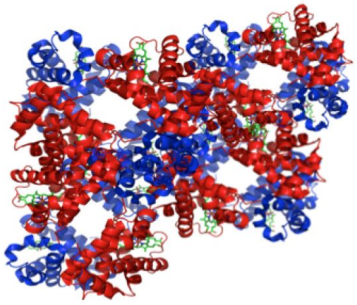
Scenario

Hemoglobin is a protein that helps transport oxygen in specialized red blood cells. Oxygen is a required component for cellular metabolism (energy production), which powers important cellular processes. A person with sickle cell anemia does not produce normal hemoglobin, as seen below.

External Data



Normal Hemoglobin Protein



Clumped Hemoglobin Proteins
As found in Sickle Cell Disease

Prompt

How is DNA responsible for sickle cell anemia?

Claim-Evidence-Reasoning

Name: _____ Date: _____

DNA to Proteins

Rubric for Writing a Scientific Explanation

Points Awarded	2	1	0
Claim	Makes an accurate claim or answers the question.	Makes an inaccurate claim.	No claim, or does not answer the question.
Evidence	Cites comparative data, uses labels, and addresses variables. .	Cites some, but not all, appropriate data, or does not use labels or statistical analysis.	No evidence, or cites changes but does not use data from the data table.
Reasoning	Cites the scientifically accurate reason, using correct vocabulary, and connects this to the claim. Is able to show accurate understanding of the concept.	Cites a reason, but it is inaccurate or does not support the claim. Reasoning does not use scientific terminology or uses it inaccurately.	No reasoning, or restates the claim but offers no reasoning.

Claim-Evidence-Reasoning

Name: _____ Date: _____

Claim:

Evidence:

Reasoning:

Claim-Evidence-Reasoning

Name: _____ Date: _____

Claim:

The genes within the DNA molecule determine the structure of the hemoglobin protein, which carries out its function of transporting oxygen, which is used in cellular metabolism.

Evidence:

Evidence includes *four or more* of the following:

- DNA structure has four nucleotides (ATCG).
- Nucleotides are in a specific order.
- Segments of the DNA are called *genes*.
- Genes are used to synthesize proteins.
- If there is a problem on the gene, the protein may not function correctly.
- When hemoglobin is produced wrong, it will cause sickle cell anemia.

Reasoning:

All proteins are made from DNA in a process called protein synthesis. The protein relies on the order of nucleotides found in DNA. If a person has a mistake in the order of nucleotides, it can produce the wrong kind of protein, potentially leading to a disease such as sickle cell anemia.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