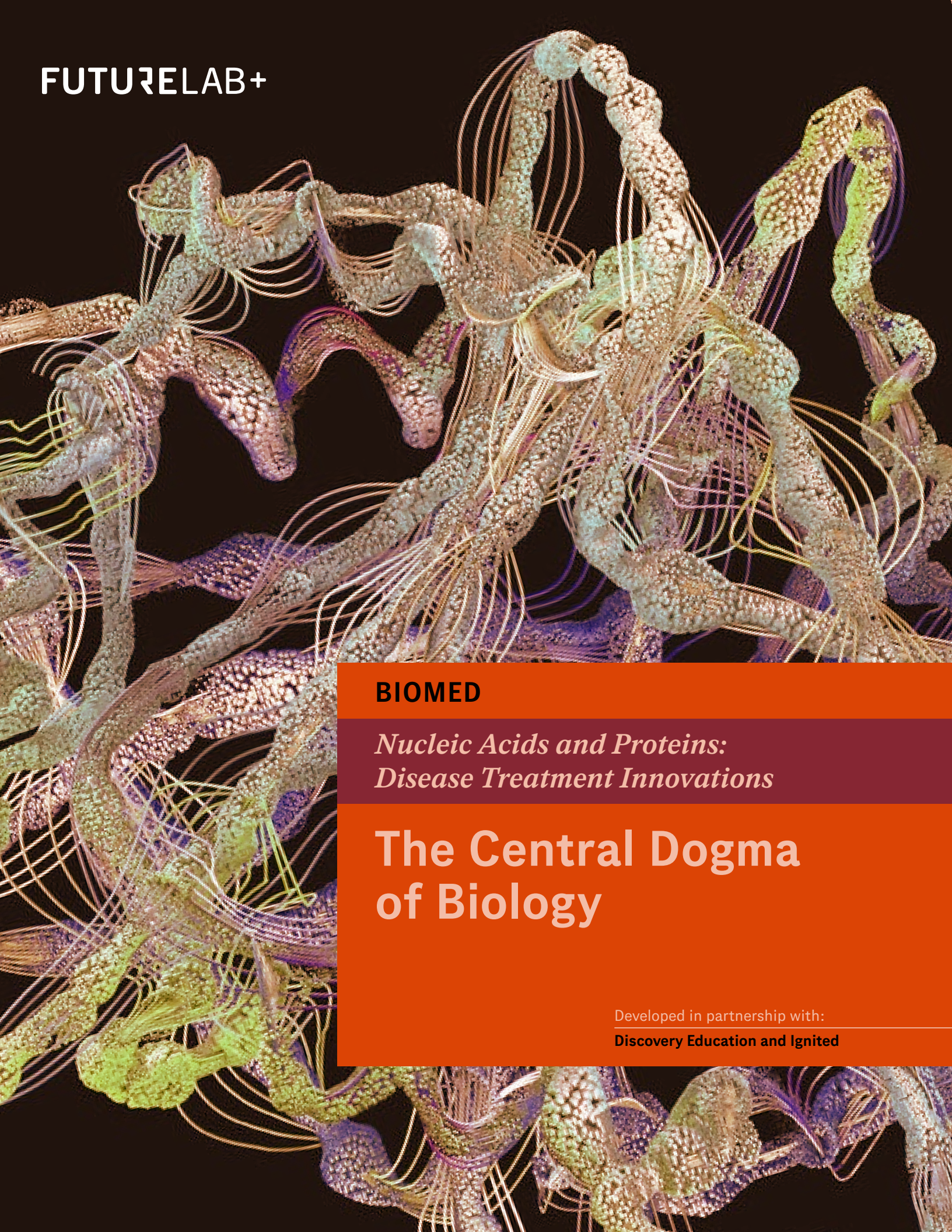
FUTURELAB+



BIOMED

Nucleic Acids and Proteins: Disease Treatment Innovations

The Central Dogma of Biology

Developed in partnership with:

Discovery Education and Ignited

In this Lesson Plan:

Print the **Teacher Section** →

Print the **Student Section** →

This document is separated into two sections, For Teachers [T] *and* Student Resources [S]*, which can be printed independently.*

Select the appropriate printer icon above to print either section in its entirety.

Follow the tips below in the Range field of your Print panel to print single pages or page ranges:

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Cover Image
This is an illustration of a protein.

BIOMED / NUCLEIC ACIDS AND PROTEINS: DISEASE TREATMENT INNOVATIONS

The Central Dogma of Biology

DRIVING QUESTION

How can you tell the difference between DNA and RNA?

OVERVIEW

Throughout this unit, students will focus on the concept of diagnosing and treating diseases. They will explore the role medical devices play in the treatment of patients. For the final unit project, students will create a drug delivery innovation for patients who have been diagnosed with or are at risk for a disease that does not yet have a cure. Students will use the information and skills acquired throughout the lessons in this unit in order to successfully complete the culminating project. They will apply the knowledge gained from initial lessons on how DNA, RNA, and proteins are modified and isolated. Students will later apply their understanding of the mechanisms of nucleic acids and proteins in the phases of drug testing and drug delivery.

In this lesson, students will learn about the "central dogma" of biology and how genetic information is perpetuated through RNA and the creation of proteins. DNA and DNA replication is at the center of all biological processes, and through study of these phenomena, students will develop a more thorough understanding of disease and advances in medical research and treatments. The unit project will be introduced wherein students will consider a treatment for a disease without a cure. They will consider the mechanism of the disease and which treatments and drugs that already exist. With their groups, they will create a device that will improve upon these to prevent or treat the disease.

ACTIVITY DURATION

Five class sessions
(45 minutes each)

ESSENTIAL QUESTIONS

How is DNA responsible for an organism's structure and/or appearance?

What are some similarities and differences between transcription and translation?

How are DNA, RNA, and proteins used as pharmaceuticals?

How do DNA, RNA, and proteins differ in structure and function?

OBJECTIVES

Students will be able to:

Conduct an experiment to extract DNA.

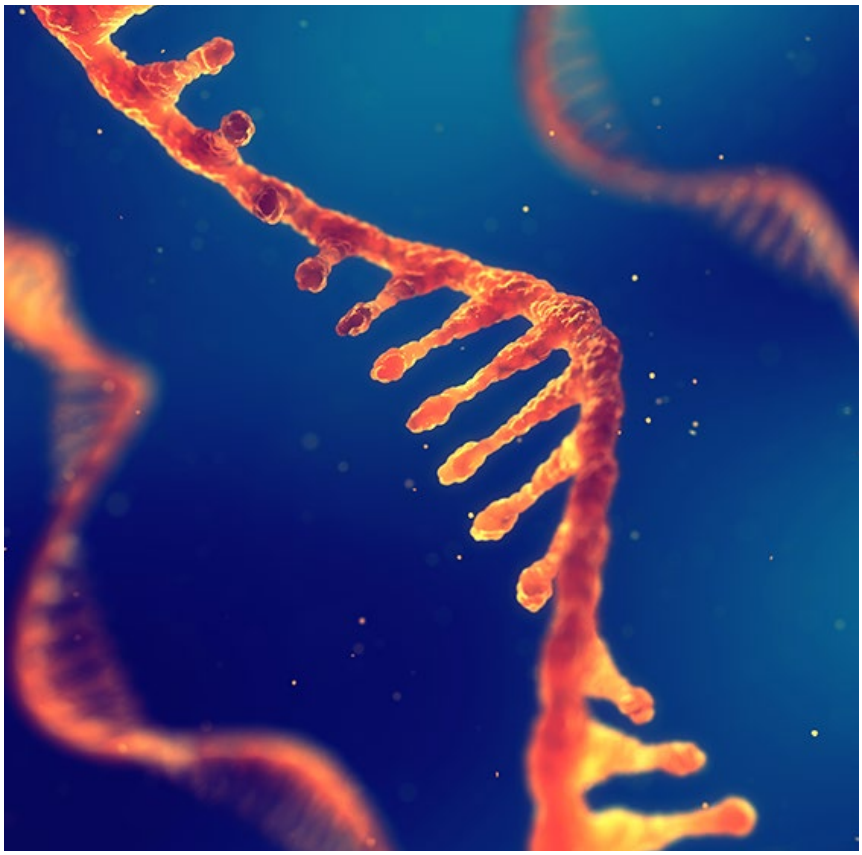
Explain the differences between DNA, RNA, and proteins.

Investigate recombinant drugs that utilize DNA, RNA, or proteins.

Illustrate the processes of transcription and translation.

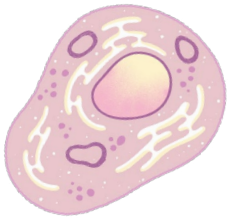
BACKGROUND INFORMATION[1]

The development of COVID-19 vaccines brought synthetic mRNA technology into mainstream conversation. Many people looked at these vaccines with skepticism, imagining that they were manufactured using brand new and untested methods. The truth is that mRNA research is more than thirty years old and incredibly well studied. Scientists have long believed that synthetic mRNA therapies could protect against some of the worst diseases plaguing humanity, like HIV and the flu. Vaccines are just one way that existing treatments are delivered to patients. In this lesson, students will think about other mechanisms that could be used for implementing DNA and RNA therapies.



Materials

- **Cardboard**
- **Colored Pencils**
- **DNA Model Build (printout)**
- **Glue**
- **Large Paper (Desk or Table-sized)**
- **Markers**
- **DNA and RNA Venn Diagram**
- **Protein Synthesis Flow Chart Rubric**
- **DNA Protein Illustration Rubric**
- **Code for an Animal Instructions**
- **Trait Guide Capture Sheet**
- **Gene Tracker Capture Sheet**
- **Codon Table Capture Sheet**
- **Animal DNA Code Capture Sheet**
- **Macromolecules as Medicine Capture Sheet**
- **Macromolecule Medicine Guide**
- **Macromolecule Medicine Rubric**
- **Nucleotide Cut-outs Capture Sheet**
- **DNA, RNA, and Protein Foldable**
- **Comparative Foldable Rubric**
- **Design Journal**



[1] COVID-19 mRNA vaccines: How could anything developed this quickly be safe?

Pedagogical Framing

Instructional materials are designed to meet national education and industry standards to focus on in-demand skills needed across the full product development life cycle—from molecule to medicine—which will also expose students and educators to the breadth of education and career pathways across biotechnology.

Through this collection, educators are equipped with strategies to engage students from diverse racial, ethnic, and cultural groups, providing them with quality, equitable, and liberating educational experiences that validate and affirm student identity.

Units are designed to be problem-based and focus on workforce skill development to empower students with the knowledge and tools to be the change in reducing health disparities in communities.

SOCIAL-EMOTIONAL LEARNING

Students will complete work every day in groups, honing important self awareness and management skills along with critical responsible decision making skills. They will need to demonstrate self management, like persevering in the face of setbacks and frustrations, in completing research and projects while working with others. Some students will have had personal experience with disease, and carry that experience with them into sensitive discussions. This requires all discussion participants to demonstrate empathy and practice appropriate social awareness skills.

CULTURALLY AND LINGUISTICALLY RESPONSIVE INSTRUCTION

This lesson employs culturally and linguistically responsive strategies in order to encourage learners from all backgrounds to engage in a format that is comfortable for them. Material is presented in a variety of formats—written, video, and hands-on assignments. Equitable practices allow students to safely discuss sensitive topics like the role medical devices play in the treatment of patients' health, any disparities in that treatment, and questions involving specific communities. While the lesson centers the students' personal experience in their learning, they will complete many of their assignments in cooperative learning groups.

ADVANCING INCLUSIVE RESEARCH

This lesson introduces students to the challenge of creating a theoretical innovative drug delivery system, planning for a clinical trial, and showing how the drug will target certain molecules to stop a disease. They need to consider the diversity of patient populations as they consider how the drug will be delivered. They must ensure that information is communicated in an equitable way that allows patients to make informed decisions.

COMPUTATIONAL THINKING PRACTICES

Students will use the computational thinking strategy of finding patterns as they explore the basics of DNA. They will decompose the process of demonstrating how DNA is translated via RNA transcription. With this knowledge, students collect and analyze data in order to determine what codons are required to make amino acids. They wrap up by abstracting what features of DNA would enable it to be used in a drug.

CONNECTIONS TO THE PRODUCT LIFE CYCLE

This lesson focuses on the **discovery** aspect of the product life cycle. At this point researchers would be acquiring more information on the topic of DNA, RNA, and protein recombinant technologies as they seek out a drug delivery method for new pharmaceuticals.

Have you ever wondered…

How does DNA control what I look like?

DNA is often called the "blueprint" of our body, but how does one go from blueprints to a house? The answers lie in two processes—transcription and translation. While DNA contains your genes, it takes RNA to transcribe the DNA and to turn it into something useful for our body's ribosomes. The RNA copy of DNA (mRNA) can be read by the ribosomes through translation which produces proteins that influence the physical characteristics we attribute to our DNA "blueprint."

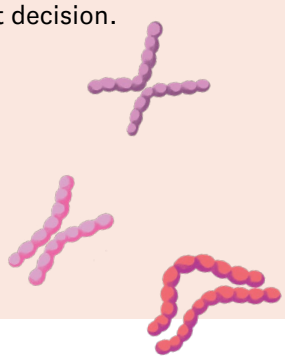
Isn't RNA in viruses? Why is it in my body?

RNA is present in some viruses, but also in our bodies naturally. Although it is often upstaged by DNA, RNA is vital in DNA replication, transcribing genetic material, and the protein synthesis necessary to carry out our daily lives.

MAKE CONNECTIONS!

How does this connect to the larger unit storyline?

Learning about the central dogma provides the scientific basis for recombinant drug delivery. The transformation of genetic information into proteins is at the core of these new technologies, and so in turn must be the basis for new learning on the topic of drug delivery systems. It would be impossible to choose a new drug's delivery method without first understanding the why and how behind that decision.



How does this connect to careers?

Product development engineers examine the company's goals and from that help to conceptualize, research, and test new products. They also play a vital role in ensuring final products meet the company's standards and any legal parameters.

Molecular biologists work with DNA and RNA on projects such as cloning and DNA sequencing. They work for years conducting research that yields some of our greatest medical breakthroughs.

How does this connect to our world?

The central dogma of biology may seem like something that would only be of importance in a classroom; however, understanding the nature of our bodies and emerging medical treatments is important to us as healthcare consumers. Many believe the future of medicine lies in the manipulation of DNA, RNA, and proteins—to better appreciate and evaluate these new treatments, we must first fully grasp the biological processes they seek to alter or suppress.

Day 1

Procedure

LEARNING OUTCOMES

Students will be able to:

Analyze a video on DNA and its function.

Optional Unit Launch Activity (30 minutes)

1 Launch students into their project and this unit by allowing them to take on the role of a team of scientists researching a scientific breakthrough in the field of pharmaceutical research and development.

2 Students will work in groups of four to five to learn more about the different roles and tasks that their team must complete. They will need to work collaboratively and communicate effectively in order to "breakout" within the time constraints.

3 Share the *Breakout EDU link* with students. Students will use clues to unlock each digital lock and discover more about the unit ahead.

Whole Group (5 minutes)

Ask the class to *Stand and Share*: "Why do people often look like other members of their family?" Students will respond with answers about similar DNA, genes, or traits.

Teacher Note > *Because this unit contains academic vocabulary, you may want to create Quizlet decks for students to look at prior to the unit, revisit during the unit and, use for review at the end of the unit.*

INDUSTRY AND CAREER CONNECTION

Students will need to have strong time management skills as they write or draw what they think of when they hear "DNA" in only five minutes. Professional molecular biologists use this same skill when they conduct research on the functioning of cells in a timely manner.

Small Group (15 minutes)

1 Ask students to form small groups of three or four. Give each group a large piece of paper and two or three markers, so that each member will use a different-colored marker. Use the *Roundtable* strategy to brainstorm and to activate prior knowledge. Have students pass around the paper and write or draw what they think when they hear the term "DNA." Students may draw things like double-helix structures, Punnett squares, or write facts they've learned in previous classes.

COMPUTATIONAL THINKING IN ACTION

As students watch the video, color code their notes, and identify the ways their ideas relate to one another. In doing so, they are using the computational thinking strategy of finding patterns to process their learnings about DNA.

2 Watch this video: *The Basics of DNA—Science Learning* (5:23 min). Pause the video two or three times to allow students to jot notes. Then, students will work together using the same *Roundtable* strategy as in the previous activity. They should each use a different-colored marker to record on a large piece of paper any ideas about DNA from *The Basics of DNA—Science Learning* that they think are important. This might include doodles that relate to the material or any questions that arise for them.

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Day 1

Continued

Procedure

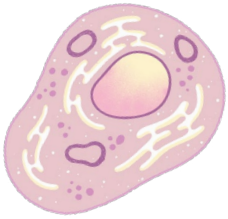
3	Following the end of the video, groups should add any final key ideas or drawings (models) to their *Roundtable* paper. Next, ask students to think about, discuss, and show how the ideas about DNA on their paper relate to one another. They should: • draw arrows to connect their ideas to a group member's ideas, • circle to highlight key points, • doodle next to a group member's vocabulary word to better define it, • answer a different student's question, or • correct incorrect assumptions from their earlier brainstorming.
4	Next, ask students if they can describe the relationship between a mutation and DNA. Allow students to share their ideas with the class using the strategy *Raise a Righteous Hand*. Remind students that the code in the DNA is used to make a specific chain of amino acids, as seen in the video. Pose the following questions to students: How do mutations affect proteins? What effect can this have on an organism, such as a person? Tell students that in this lesson they will seek to find the answer to this question by exploring how the message of DNA becomes proteins—the Central Dogma of Biology.

INDUSTRY AND CAREER CONNECTION

Students will need to have the technical skills of understanding basic lab techniques and the ability to follow protocol. These skills are used by professional product development engineers.

Small Group (25 minutes)

Students can remain in their groups and should begin by reviewing the short 3D animations of *Transcription* and *Translation*.



Day 2

Procedure

LEARNING OUTCOMES

Students will be able to:

Compare and **contrast** DNA and RNA.

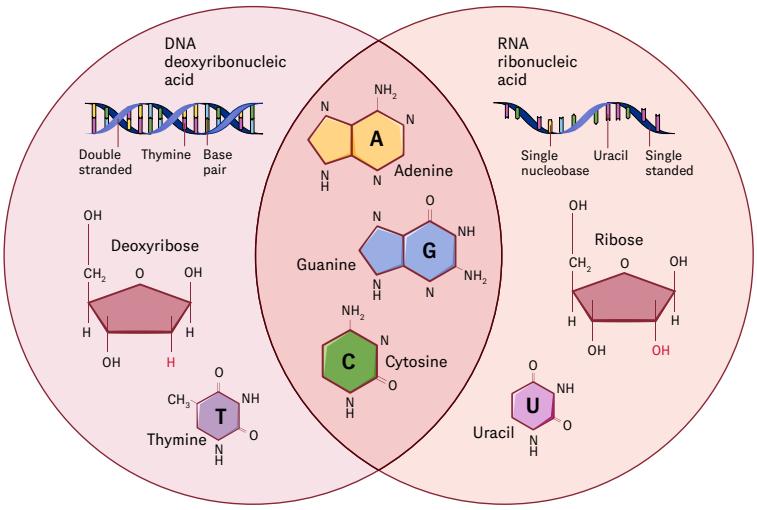
Create a flowchart detailing the processes of transcription and translation.

Illustrate the processes of transcription and translation.

Individual Work (10 minutes)

1 Distribute to students a blank DNA and RNA Venn diagram. Students should label one side "DNA" and the other "RNA."

DNA vs RNA



2 Students will read the article *DNA and RNA* and complete the *Venn Diagram*. Students should only read the first sections of both "DNA" and "RNA." When completed, students can compare their work with a classmate's and add new information to their own *Venn Diagram*.

Small Group (15 minutes)

Place students in groups of two or three. Give each group a blank sheet of paper and ask them to create a flowchart to explain the processes of transcription, RNA processing, and translation using the video *From DNA to protein*.

Small Group (20–25 minutes)

After completing the flowchart, students should use their *Venn Diagram* and flowchart to create a digital illustration, demonstrating how DNA is translated via RNA transcription to protein inside cells (mRNA processing does not need to be included). Students could use *SketchIO*, *Autodraw*, or Google Drawings to create their illustration. When illustrations are complete, they can be downloaded and printed for display around the classroom or for students to use as notes during the lesson.

INDUSTRY AND CAREER CONNECTION

Students will need to have strong organization skills and attention to detail as they create their transcription and translation flowcharts. Professional product development engineers use these same organization and detail skills when they test new products.

COMPUTATIONAL THINKING IN ACTION

As students develop their Venn diagrams and flowcharts, they are using the computational thinking strategies of abstraction, decomposition, and developing algorithms to understand the transcription process.

Day 3

Procedure

LEARNING OUTCOMES

Students will be able to:

Transcribe a strand of DNA into mRNA.

Convert a strip of DNA into a unique animal.

Teacher Note > *Cut the Animal DNA Code Capture Sheet into strips before class.*

Whole Group (5 minutes)

1 To begin the lesson, ask students to review their infographics from the previous day. Explain that these infographics show the "Central Dogma of Biology," the set of principles that explains how all proteins are created from the message in the DNA.

2 Tell students that they will now look in more detail at how the nucleotide bases in the DNA are transcribed and translated by RNA to create proteins that give living things their unique traits.

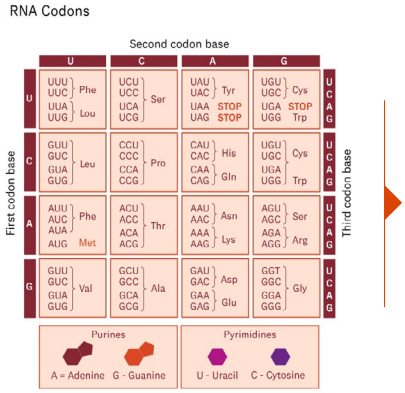
3 Project this video on *The Central Dogma of Biology*, using the instructional strategy *AEIOU* to capture student impressions.

Small Group (30 minutes)

1 Have students move into groups of two to three to complete the Code for an Animal activity. Then distribute to each group the following capture sheets: *Code for an Animal Instructions*, *Gene Tracker*, *Codon Table*, *Trait Guide*, and an *Animal DNA Code*.

2 Ask students to translate their animal DNA code strip into its mRNA counterpart. Have groups then work to break this into codons, recording all information on the *Gene Tracker Capture Sheet*.

3 Have groups compare their codons to the *Codon Table*, determining which amino acid is being coded for. It may be helpful to display the Codon Table on the overhead screen or front board and to demonstrate how to translate a codon into an amino acid. Each amino acid will code for a specific part of each group's animal. When they've completed transcribing and translating their DNA strip onto the translator, give students a blank sheet of paper and ask them to attempt to draw their new animal.



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Day 3

Continued

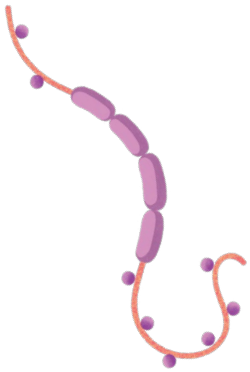
Optional

Small Group (10 minutes)

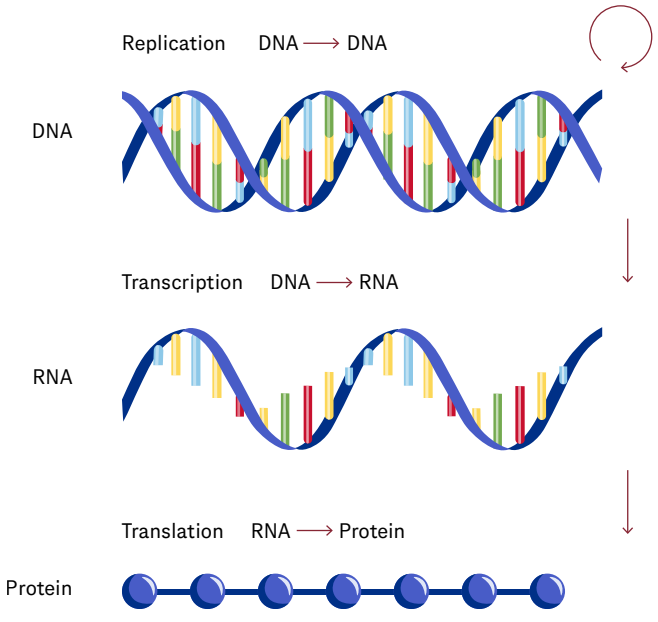
1 As a challenge, ask groups to choose one trait their animal has and find the gene that corresponds with it on the *Trait Guide*. Ask the students to determine what would have to happen in their animal's DNA to change it to one of the other listed traits for that gene. They should work backwards using the *Codon Table* to determine what mutation would have to occur in the DNA of their animal to cause this. For example, a base may have to change from cytosine (C) to adenine (A) in the codon to code for a different amino acid. Once finished, ask students to report on the following:

- What codons are required to make those amino acids?
- What is the corresponding mRNA and DNA code?
- What are these changes in the DNA called?

2 Afterwards, groups should compare animals and determine what changes at the codon or nucleotide level led to differences between their two animals.



Teacher Note > *If there is enough time and students want to explore more about codons, this activity would be appropriate. It is acceptable if not all students do this activity and focus just on the required assignment.*



Day 4

Procedure

LEARNING OUTCOMES

Students will be able to:

Investigate how DNA, RNA, and proteins can be used in pharmaceuticals.

COMPUTATIONAL THINKING IN ACTION

Computational Thinking in Action: Here, students are using the computational thinking strategies of collecting and analyzing data to examine three different ways genes can be used in therapies.

INDUSTRY AND CAREER CONNECTION

Students will need to have an openness to learning and motivation to learn as they research a drug and create a presentation on its usage. Professional product development engineers use these same skills when they conceptualize and discuss new product ideas.

Whole Group (15 minutes)

1 Allow students to select from one of the following three sources. Give students 10 minutes to review their chosen resource, and summarize it on their *Macromolecules as Medicine Capture Sheet* under the correct section.

Gene Therapy Video
Therapeutic Proteins Podcast (stop at the 6:15 mark)
RNA Therapy Reading

2 After completing their section of the capture sheet, allow students to meet with classmates to complete the rest of the capture sheet. Students may want to discuss with more than one person of each group (time allowing) as students may have chosen different things to focus on in their summary. Students that finish early may access one of the other resources for themselves and compare their thoughts with their classmates.

Small Group (15 minutes)

1 Students should form groups of two to three with other students who read the same initial article.

2 Distribute to students the *Macromolecule Medicine Guide* and *Macromolecule Medicine Rubric*. Groups should use an app or free design software, such as *Creatopy*, to create a flyer or brochure that will highlight their research about the drug. Review the rubric so students are aware of what information must be included.

Individual Work (10 minutes)

After all projects are complete, ask students to conduct a *Gallery Walk* and provide feedback to their peers on at least three other projects, either virtually, using post-it notes, or with a simple feedback form attached to each poster.

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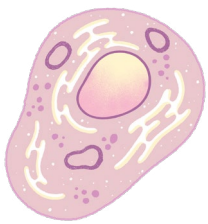
Day 4

Continued

Procedure

Whole Group (5 minutes)	
1	Review answers to the *Macromolecule Medicine Guide* with the class. Ask volunteers to share answers and record them on the board.
2	To end the lesson, explain to students that in today's lesson they have learned how nucleic acids—DNA and RNA—and proteins can be used as medicine to treat disease. Ask students if they think that these same biomolecules might eventually be used to stop or cure diseases that do not have a known cure, such as HIV and chronic heart disease. Allow students to share their thoughts briefly with a partner.
3	Tell students that at the end of this unit, they will take what they have learned to create a theoretical innovative drug delivery system that might be used to cure or prevent a disease and improve the lives of countless people faced with health issues currently or in the future. They will create a model or animation of the "mechanism of action" of their drug, which will show how the drug will target certain molecules to stop the disease, and a plan for a clinical trial for their drug. All of this information will be presented at a mock Mystery Disease Conference as they role play as a member of a drug research and development team.
4	Distribute the **Design Journal** for students to use throughout the unit. They will refer back to this journal during each lesson.



Day 5

Procedure

LEARNING OUTCOMES

Students will be able to:

Build a model of DNA.

Create a foldable representing the differences between DNA, RNA, and proteins.

Small Group (20 minutes)

Have students work in groups of two to three to complete the *DNA Model Build* and respond to the included questions. They should use the *Nucleotide Cut-outs Capture Sheet* to complete their model.

Teacher Note > *Before starting this activity, feel free to provide vocabulary scaffolding, such as the culturally responsive strategy called Vocabulary Quadrants, for any students who may have difficulty understanding certain terms of the DNA Model Build. This may help get them started in their groups.*

Small Group (25 minutes)

1	In their same groups, ask students to create a foldable to detail the differences between DNA, RNA, and proteins using the *DNA, RNA, and Protein Foldable Template*. Have students fold along the solid line and cut down the dotted lines.
2	The end result should look like a skinny paper with three flap doors. Students should label the front of the flaps “DNA” “RNA” and “Proteins.”

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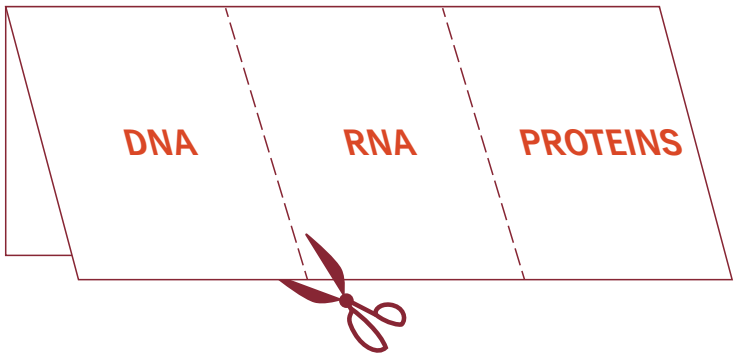
Day 5

Continued

Procedure

3 When each flap is lifted, the top portion should include a description of the structure and function of the material, with an emphasis on what makes the material unique. Each lower portion should include a drawing of the structure. Have students turn in their foldable once they are finished, to be graded on how well they explained the differences. Students should work together and use the things they have created in this lesson (the *Venn Diagram*, illustration, etc.) to help them complete their foldable.



Teacher Note > *When completed the interior of each section should include a picture and information like the following:*

DNA: Double stranded, double helix shape, deoxyribose, thymine, found in nucleus, stores genetic information

RNA: Single stranded, ribose, uracil, found throughout cell, turns stored information into proteins

Proteins: Complex 3D shapes, not a nucleic acid, made of amino acids/polypeptides

4 Provide time for students to respond to the lesson questions in their **Design Journal**. They will elaborate on the differences between DNA and RNA, explain how DNA is used to make proteins, and consider medical treatments that rely on central dogma.

National Standards

Next Generation Science Standards

LS1.A Structure and Function
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.

Science and Engineering Practices
Obtaining, evaluating, and communicating information
Critically read scientific literature adapted for classroom use to determine the central ideas or conclusions and/or to obtain scientific and/or technical information to summarize complex evidence, concepts, processes, or information presented in a text by paraphrasing them in simpler but still accurate terms.

Crosscutting Concepts
Patterns
Different patterns may be observed at each of the scales at which a system is studied and can provide evidence for causality in explanations of phenomena.

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.

Career and Technical Education (CTE)

A3.1
Define and describe the structure and function of DNA ribonucleic acid (RNA) and proteins, explain the consequences of DNA mutations on proteins.

A4.3
Use information and communication technologies to synthesize, summarize, compare, and contrast information from multiple sources.

A9.2
Identify several products obtained through recombinant DNA technology.

Educator Resources

BreakoutEDU Set-up and Answers

Students access the *digital breakout* and work together to solve the clues. The locks may be completed in ANY order. No one lock is required to unlock other locks.

Number Lock

Go to the FDA website *Review Team Responsibilities* (Found under Center for Drug Evaluation and Research).

Each of the job titles has a description in the right column with a number.

Using the order of the job titles, the description numbers appear (top to bottom) as 4–1–5–2–3.

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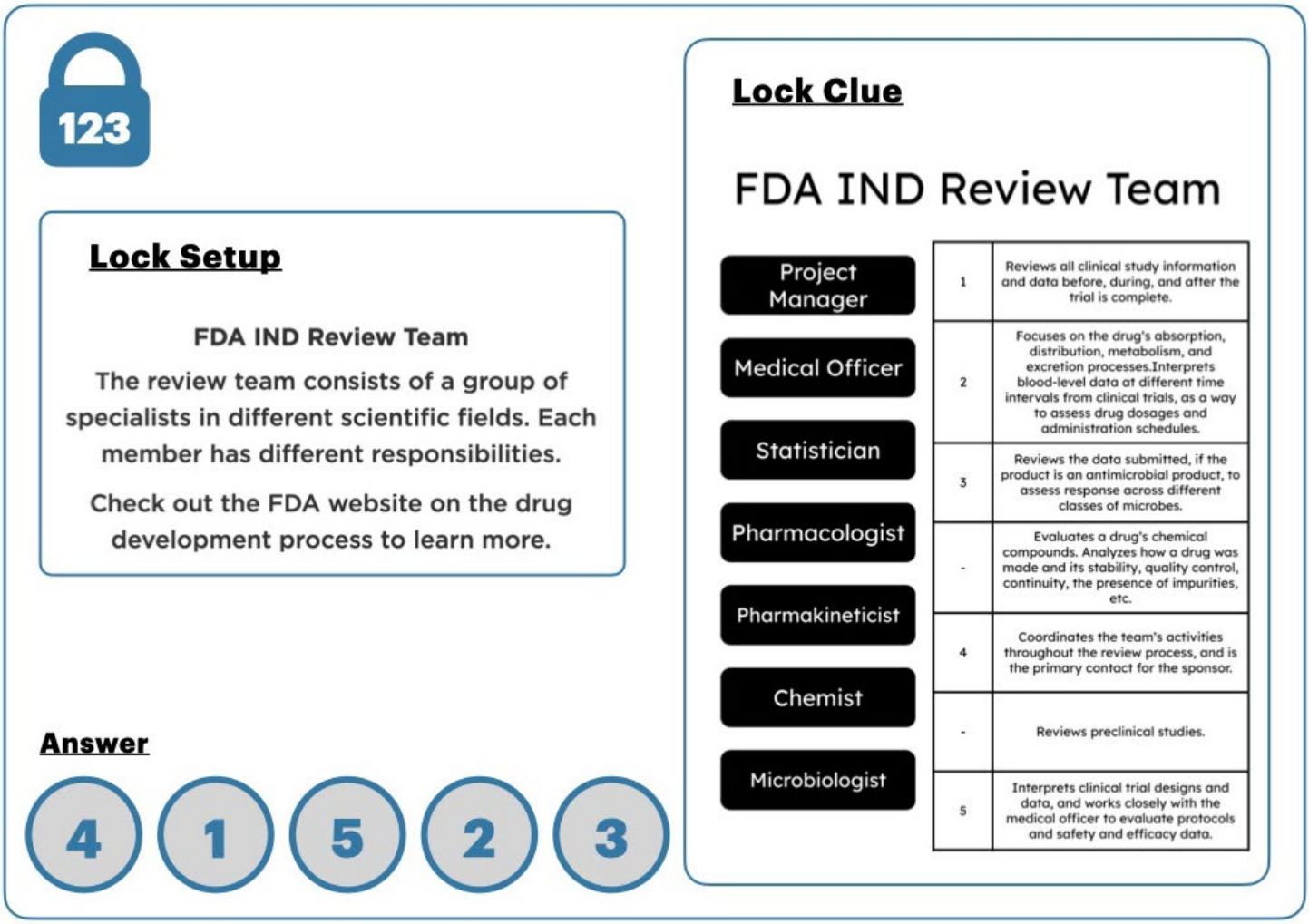

Educator Resources

BreakoutEDU Set-up and Answers

Continued

Letter Lock

In the Investigational New Drug process file, the first letter of each of the steps is in bold print. Going top to bottom on the bullet points, enter A–M–C–D–I.

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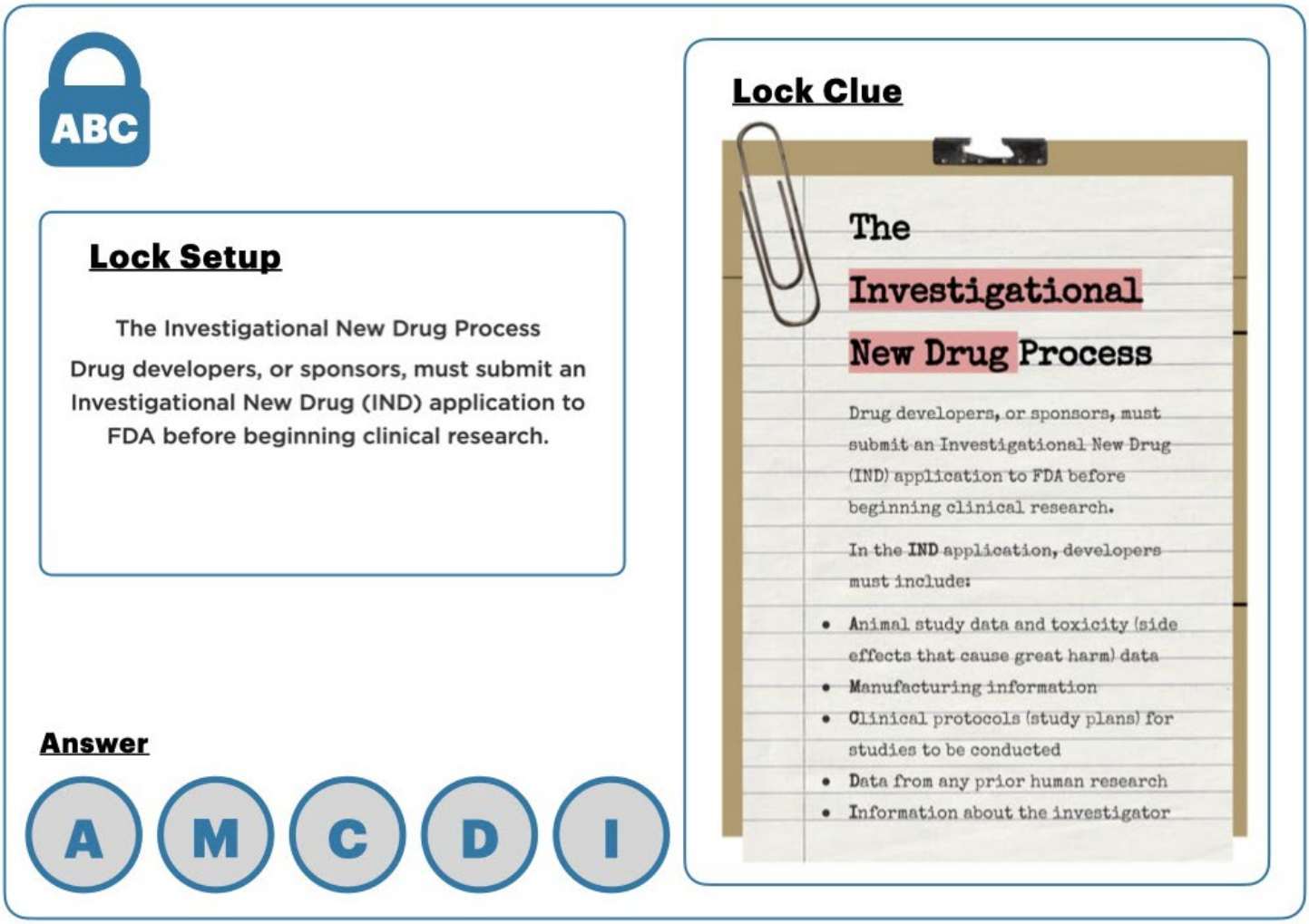

Educator Resources

BreakoutEDU Set-up and Answers

Continued

Directional Lock

Using the flowchart to place the dropped "index" cards, the first card would be down, the second card would be a NO response so it would go to the right, the third card would be the option on the left, the fourth card is below that so the movement would be down, the fifth card would also be down (and based on the hint, you would not repeat that entry), and the sixth card moves to the right.

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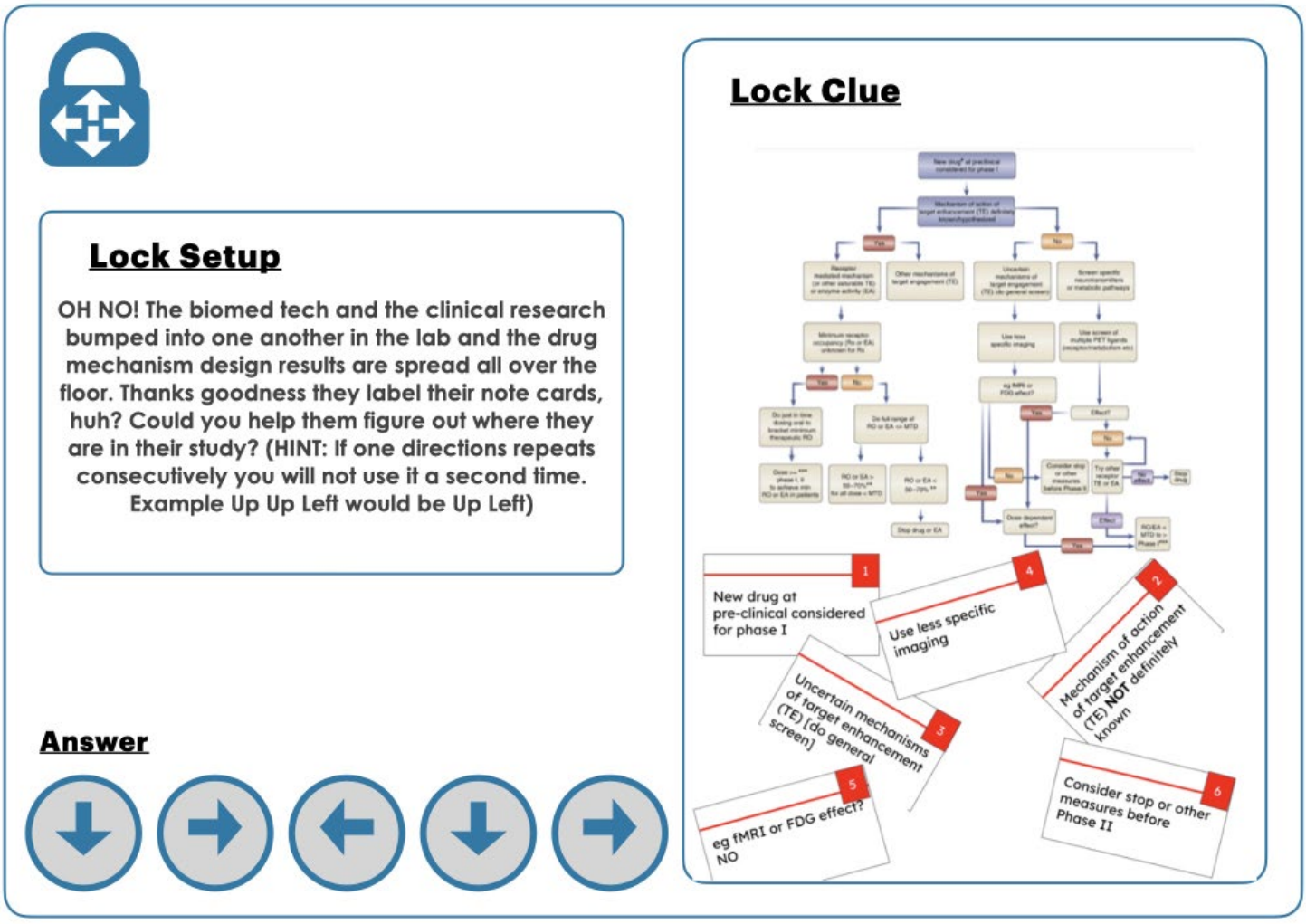


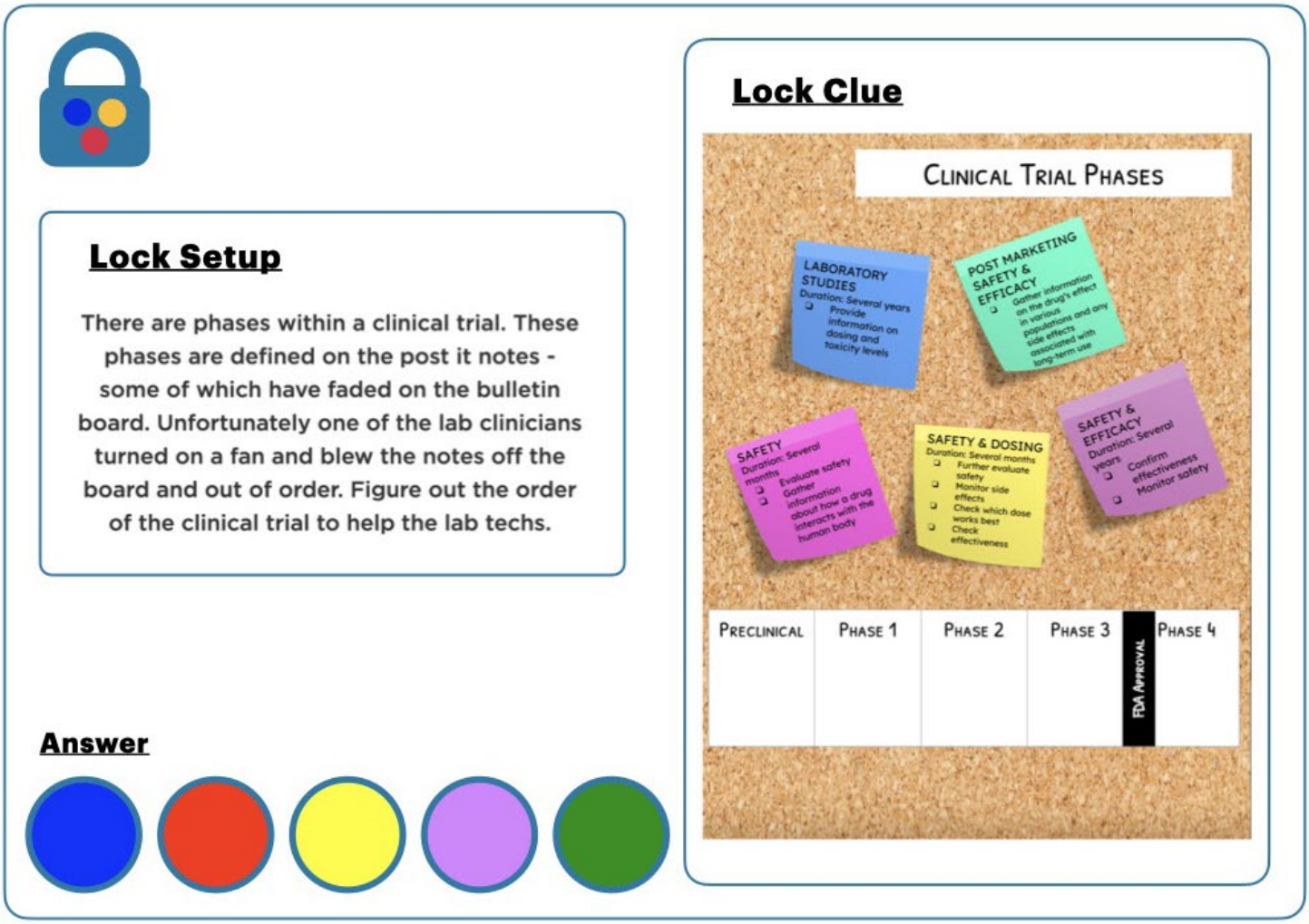
Educator Resources

BreakoutEDU Set-up and Answers

Continued

Color Lock

In this lock, reading the colored sticky notes will lead the learner to the order of the Clinical Trial Phases which result in the order of Blue–Red(Pink)–Yellow–Purple–Green.



DNA and RNA Venn Diagram

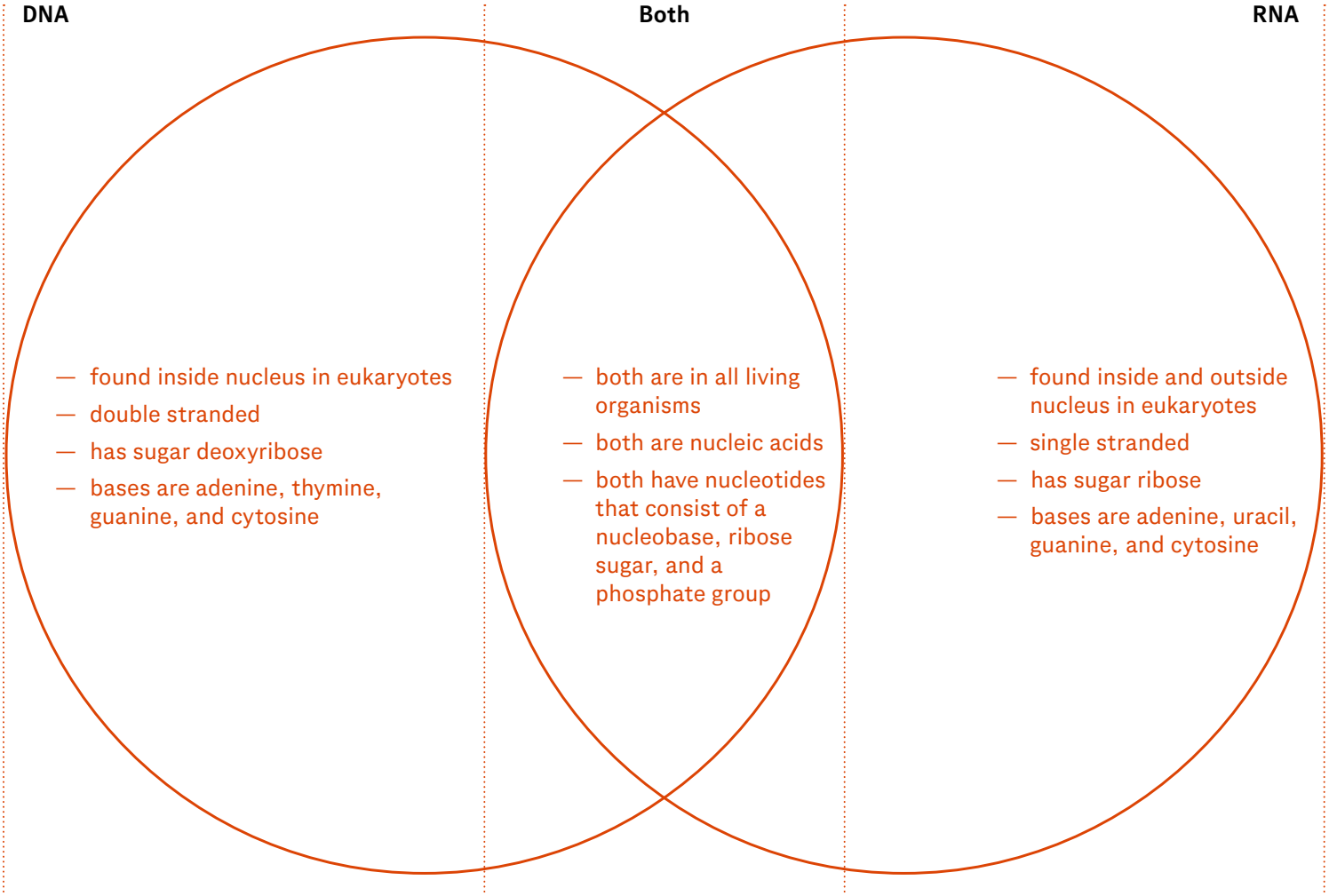
ANSWER KEY — **Do not share with students**

Directions

Label the left side "DNA", the middle "Both", and the right side "RNA." Compare and contrast DNA and RNA. Write down at least three differences for both in the outer circles and three similarities in the inner circle.

Answer Bank

Bases are adenine, uracil, guanine, and cytosine	Bases are adenine, thymine, guanine, and cytosine
Found inside and outside nucleus in eukaryotes	Found inside nucleus in eukaryotes
Has sugar ribose	Has sugar deoxyribose
In all living organisms	Is a nucleic acid
Double-stranded	Single-stranded
Nucleotides that consist of a nucleobase, ribose sugar, and a phosphate group	



Macromolecules as Medicine Capture Sheet

ANSWER KEY **Do not share with students**

Directions
Select one of the following three sources.
Then, summarize your learning below.

- ☐ *Gene Therapy Video*
- ☐ *Therapeutic Proteins Podcast*
  (stop at the 6:15 mark)
- ☐ *RNA Therapy Reading*
  (stop after section "For what diseases are…")

Gene Therapy Video
How Does Gene Therapy Work?

Works by targeting genes that may cause disease

Isolates a gene and either turns the gene off or enhances a gene within a cell to help stop certain diseases

Used with CRISPR to find the correct genes

Therapeutic Proteins Podcast
Therapeutic Proteins:

Medicine made out of proteins instead of chemicals like older medicine

Proteins are our bodies natural defense against disease.

Can help the body defend against things it is not naturally defending

Has less if any side effects than chemical medicines

RNA Therapy Reading
RNA Therapies Explained:

RNA is used as a blueprint for DNA for a cell so it can be used to change DNA.

RNA silencing is a way to use RNA to destroy certain RNA with a specific code, causing protein expression from a gene to be silenced.

Because RNA is central to all biological processes, there are numerous potential avenues for addressing human disorders using RNA.

RNA can also be used to turn down the expression of some proteins and not turn them all the way off.

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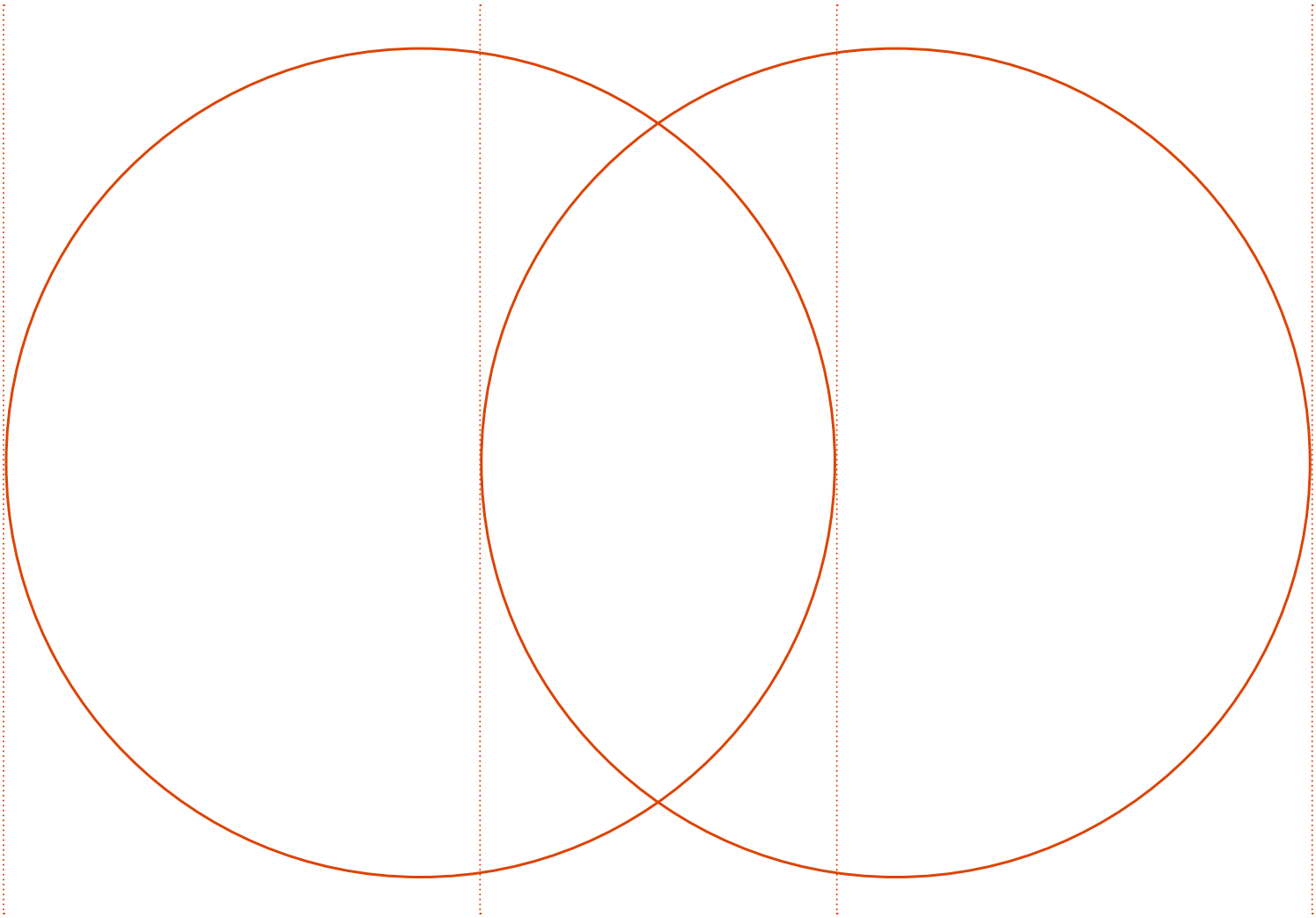
DNA and RNA Venn Diagram

Directions

Label the left side "DNA", the middle "Both", and the right side "RNA." Compare and contrast DNA and RNA. Write down at least three differences for both in the outer circles and three similarities in the inner circle.

Answer Bank

Bases are adenine, uracil, guanine, and cytosine	Bases are adenine, thymine, guanine, and cytosine
Found inside and outside nucleus in eukaryotes	Found inside nucleus in eukaryotes
Has sugar ribose	Has sugar deoxyribose
In all living organisms	Is a nucleic acid
Double-stranded	Single-stranded
Nucleotides that consist of a nucleobase, ribose sugar, and a phosphate group	



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Protein Synthesis Flow Chart Rubric

	Score	3	2	1
	Flowchart	Flowchart is easy to navigate and professional looking; steps are contained in boxes and arrows dictate the direction.	Some effort was made to develop flowchart, appears more as list or is missing steps; has errors, sloppy and difficult to navigate.	Student did not create a flowchart.
	Transcription	All steps are included, explained, and in the correct order.	Transcription steps are missing detail, out of order, or not complete.	Most or all of the transcription steps are missing.
	Processing	All steps are included, explained, and in the correct order.	Processing steps are missing detail, out of order, or not complete.	Most or all of the processing steps are missing.
	Translation	All steps are included, explained, and in the correct order.	Translation steps are missing detail, out of order, or not complete.	Most or all of the translation steps are missing.
	Final Score			

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DNA Protein Illustration Rubric

	Score	3	2	1
	General Appearance	Illustration is eye-catching and colorful; it takes up the entire page.	Some effort is made in illustration, some color used, takes up most of the page.	Illustration is not attempted or very little created.
	Transcription	Transcription is included and illustration demonstrates the student's understanding of the process.	Transcription is included and somewhat correct.	Transcription is not depicted.
	Translation	Translation is included and illustration demonstrates the student's understanding of the process.	Translation is included and somewhat correct.	Translation is not depicted.
	Macromolecules	DNA, RNA, and proteins are all included in the illustration and easy to distinguish.	Macromolecules are all or mostly present but poorly rendered and hard to identify.	Major macromolecules are missing from illustration.
	Final Score			

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Code for an Animal Instruction

Directions

Today, you will be using a genetic code to create a new animal. You will first transcribe your unique DNA code into its mRNA counterpart, translate it into tRNA and codons, and use the associated amino acids to determine traits.

Start by converting your DNA code into mRNA. This is done by determining your code's complement nucleotides (remember that RNA uses uracil instead of thymine).

For example, if your DNA code looked like this:

TACCCGTTAGCG

Then this would be its complementary mRNA strand:

UACGGCAAUCGC

1. Write your DNA code on the first line, and write its mRNA complement on the second line.

_____

_____

Next, use the mRNA strand to determine the tRNA strand. Again, match complementary nucleotides (tRNA still uses uracil instead of thymine).

This is the complementary tRNA strand for the example above:

AUGCCGUUAGCG

2. Write your mRNA strand from question one on the first line, and write its tRNA complement on the second line.

_____

_____

Next, divide your code into groups of three to determine your codons. You'll use the results to determine the amino acid. To use our previous example, it would look like this:

AUG CCG UUA GCG

3. Write your codons on the line below.

_____

You can now insert your findings into the Gene Tracker Capture Sheet and use the Codon Table to determine an amino acid.

Gene 1

DNA	ATG
mRNA	UAC
Codon	AUG
Amino Acid	Met
Trait	Start

In this case the first codon codes for Methionine (Met or M), which is the universal START codon for protein synthesis.

Once you determine your amino acids, match them to their corresponding traits in the guide below. After compiling all of your animal's traits, attempt to draw your new organism.

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Trait Guide Capture Sheet

Directions

Once you determine your amino acids, match them to their corresponding traits in the guide below. Record the traits on your Gene Tracker capture sheet.

Gene 1	Start/Stop
MET	Start animal creation
STOP	No animal created

Gene 2	Body Shape
ILE	Upright, humanoid/ape
HIS	Serpentine
ARG	Flat/narrow, lizard-like
SER	Long, cylindrical, dog/cat-like

Gene 3	Head Shape
GLN	Round
PRO	Long/narrow
LEU	Triangular, feline
ASN	Round

Gene 4	Ears
TYR	Floppy
HIS	Triangular, wolf-like
GLN	Rounded, bear-like
LYS	Tall/tuffed, squirrel-like

Gene 5	Nose Shape
LEU	Long snout, horse/ crocodile-like
LYS	Pig nose
ASP	Beak
ALA	Small black nose, dog-like

Gene 6	Eyes
THR	2 small eyes on top of the head
TRP	2 big eyes, sides of head
ARG	2 front facing predatory eyes
PRO	1 eye, center of head
PHE	Eye clusters or compound eyes, spider-like

Gene 7	Limbs
GLN	4 equal sized limbs
ALA	2 big back leg, and 2 smaller front legs
LEU	8 legs
ARG	4 flippers, turtle-like

Gene 8	Tail
THR	No tail
GLN	Short bunny-like tail
GLY	Long fluffy tail
CYS	Prehensile tail, monkey-like

Gene 9	Skin
PRO	Scales
TRP	Feathers
PHE	Fur
ASP	Smooth, slick skin, salamander-like

Gene 10	Pattern
VAL	No pattern
GLY	Stripes
TRY	Spots

Gene 11	Color
LEU	Green/blue
SER	Yellow/brown
PRO	Purple/pink
ASN	Black/white
CYS	Orange/red

Gene 12	Adaptation
LEU	Claws
SER	Sharp teeth
THR	Webbed feet
ILE	Gills

Gene 13	Adaptation
ILE	Venom
PHE	Camouflage
LEU	Blubber
GLU	Wings

Gene 14	Start/Stop
STOP	Animal complete

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Gene Tracker Capture Sheet

Directions

Today, you will be using a genetic code to create a new animal. Record your information here as you translate the animal DNA code strip into its mRNA counterpart and break it into codons.

Gene 1

DNA

mRNA

Codon

Amino Acid

Trait

Gene 2

DNA

mRNA

Codon

Amino Acid

Trait

Gene 3

DNA

mRNA

Codon

Amino Acid

Trait

Gene 4

DNA

mRNA

Codon

Amino Acid

Trait

Gene 5

DNA

mRNA

Codon

Amino Acid

Trait

Gene 6

DNA

mRNA

Codon

Amino Acid

Trait

Continues next page >

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Gene Tracker Capture Sheet

Continued

Gene 7

DNA

mRNA

Codon

Amino Acid

Trait

Gene 8

DNA

mRNA

Codon

Amino Acid

Trait

Gene 9

DNA

mRNA

Codon

Amino Acid

Trait

Gene 10

DNA

mRNA

Codon

Amino Acid

Trait

Gene 11

DNA

mRNA

Codon

Amino Acid

Trait

Gene 12

DNA

mRNA

Codon

Amino Acid

Trait

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Codon Table Capture Sheet

Directions

Use the Codon Table to determine the amino acids and record your findings on the Gene Tracker.

1	2				3
	U	**C**	**A**	**G**	
U	UUU, UUC: Phe UUA, UUG: Leu	UCU, UCC, UCA, UCG: Ser	UAU, UAC: Tyr UAA: stop UAG: stop	UGU, UGC: Cys UGA: stop UGG: Trp	**U C A G**
C	CUU, CUC, CUA, CUG: Leu	CCU, CCC, CCA, CCG: Pro	CAU, CAC: His CAA, CAG: Gin	CGU, CGC, CGA, CGG: Pro	**U C A G**
A	AUU, AUC, AUA: Ile AUG: Met	ACU, ACC, ACA, ACG: Thr	AAU, AAC: Asn AAA, AAG: Lys	AGU, AGC: Ser AGA, AGG: Arg	**U C A G**
G	GUU, GUC, GUA, GUG: Val	GCU, GCC, GCA, GCG: Ala	GAU, GAC: Asp GAA, GAG: Glu	GGU, GGC, GGA, GGG: Gly	**U C A G**

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Animal DNA Code Capture Sheet

Directions
Cut the DNA sequences into strips.

ATGTCTCAATATGATACTGCATGTTGGGTTCCTAATATTTAA

ATGCGTCAGTATGACACCCAATGCGACGGGCCCATCATCTAG

ATGAGACCTTATGCTCCCTTATGTTTTTACCCACTTATATAG

ATGTCACCCTATAAAACACAGTGCTTTGGCCCGATTCTTTAG

ATGATTTTACATAAGTTTTTGTGCGATGGTAATATACTCTAG

ATGAGCTTGCATGCCACGCTGTGTCCCGTGAATTCACTATAG

ATGATCAATCATTTATGGCGTGGTCCATATAACACTTTTTAG

ATGTCCAACCAATTGTTCTTGGGCTTCGTAAACACCTTTTGA

ATGATTCAACAAGCATGGCGCGGACCTTACTCTACATTCTGA

ATGCATCTTCAACTTTGGGCTGGGCCGGTGTCCACGGGATGA

ATGCGTCTCAAACTCAGAGCCGGGTTCGTTTCATCGGAGTGA

ATGTCTAATAAAGCGTTCGCAGGCTTGGGTTCGAGTGAGTGA

ATGTCCAATAAACTAAGGCTGGGTGATTACCCTAGCGAGTGA

ATGATCCAGTACCTGAGAGCGCAACCAGGGTGTAGTGAGTAG

ATGCACCAGTACCTGCCTCGACAGTTCGTCTGCAGCGGATAG

ATGATACAATACCTACCCTTACAGCCCGTACCTTTATTTTAA

ATGCGTCCGCACGCGCCATTGCAGTTTGGACCATTGTTCTAA

ATGCGCCTACACCTCCCGCGGCAAGATTACAATCTTTTTTAG

ATGCGACTGCACCTTTTCCTTTATCCAGGCAACCTCCTCTAG

ATGCGGTTACAGGCATTTGCATACCCGGTCTCTTCACTTTAG

ATGAGACTTCAGTTGACTCTCTACTTGGTCTCATCGCTATAG

ATGAGGAATCAGTTAACGTTATATGATGGTCCTTTAATATGA

ATGTCATTAAAGGCCTTCCTATATCCGTATCTACTTATCTAG

ATGTCGCTTAAGAAGAGACGTTACTTTTATTGTACCATCTGA

ATGAGTAATAAGAAACCCCTGTACTTCGTTTGCATAATTTAG

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Macromolecules as Medicine Capture Sheet

Directions
Select one of the following three sources. Then, summarize your learning below.

- ☐ *Gene Therapy Video*
- ☐ *Therapeutic Proteins Podcast (stop at the 6:15 mark)*
- ☐ *RNA Therapy Reading*

Gene Therapy Video
How Does Gene Therapy Work?

Therapeutic Proteins Podcast
Therapeutic Proteins:

RNA Therapy Reading
RNA Therapies Explained:

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Macromolecule Medicine Guide

Directions
In your small group, select one real medicine created from your given macromolecule.

DNA	RNA	Protein
☐ Humulin	☐ Pegaptanib	☐ Epogen
☐ Recombivax	☐ Golodirsen	☐ Humalog
☐ Intron A	☐ Patisiran	☐ Activase
☐ Glucagon (for injection)	☐ Nusinersen	☐ Saizen

Your group will research your medication using *rxlist* and create a short presentation on your chosen medication. Be sure to include the following in your presentation:

1. Whether it is derived from DNA, RNA, or proteins
2. What the medication is used to treat or prevent
3. Information on one of the conditions your medication treats
4. Side effects and precautions

Notes

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Macromolecule Medicine Rubric

	Score	3	2	1
	Presentation	Presentation is professional looking, includes use of color or pictures, and information is easy to find.	Presentation includes all required elements.	Presentation is incomplete or not created.
	Medication	Medication source and usage is clearly present and complete.	Some information is present on the type of medication and its usages, but it is brief and lacks details.	Minimal information is present on the purpose of the medication.
	Disease	Disease information is clearly present and complete.	Some information is present on the disease process it treats, but is brief and lacks details.	Minimal information is provided on the disease process for which the medication is indicated.
	Side Effects	Information on side effects or precautions is clearly present and complete.	Some information is present on side effects and precautions, but is brief and lacks details.	Minimal information is provided on side effects or precautions.
	Final Score			

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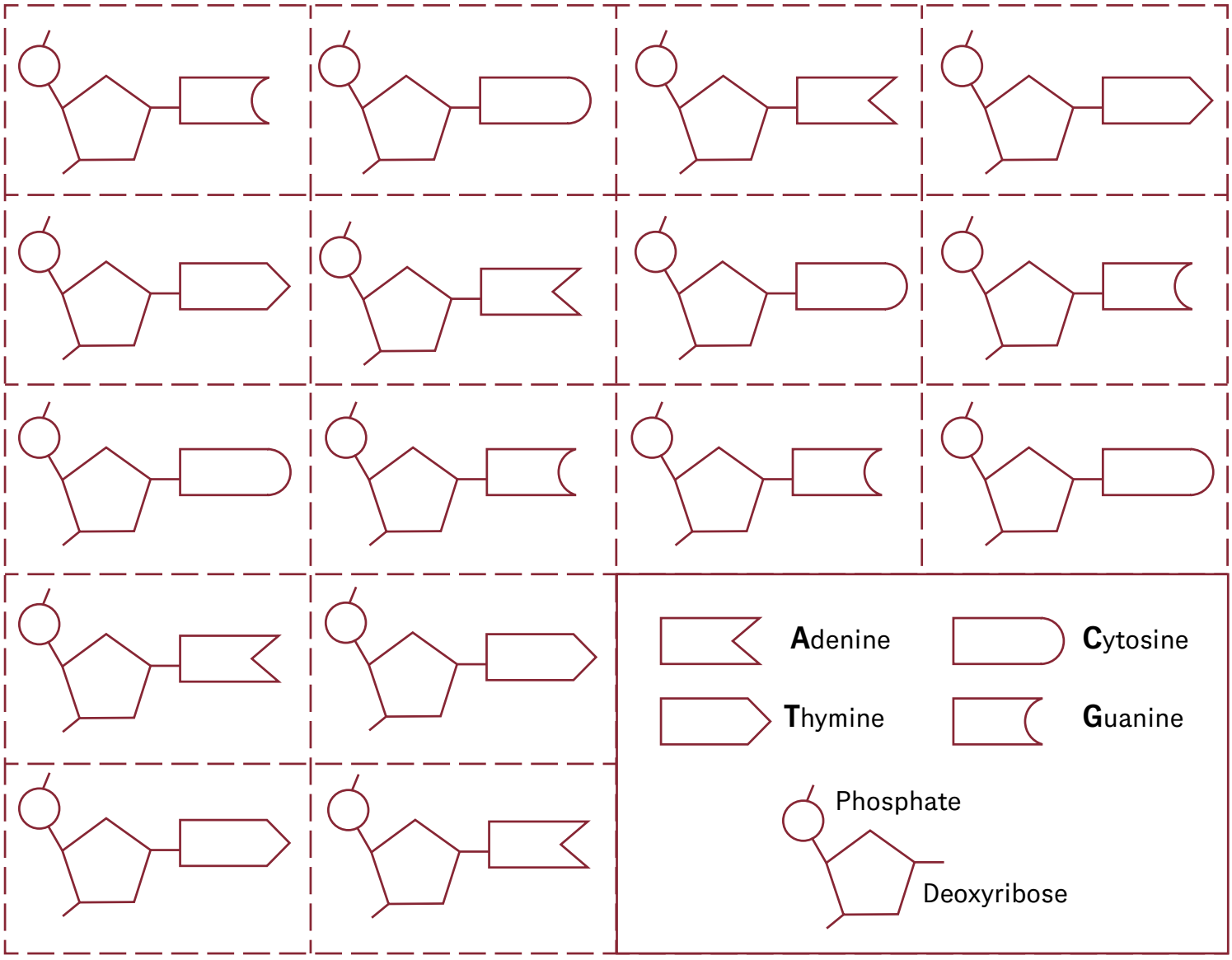
Nucleotide Cut-outs Capture Sheet

Directions

Use the cut-outs to complete the DNA Model Build.



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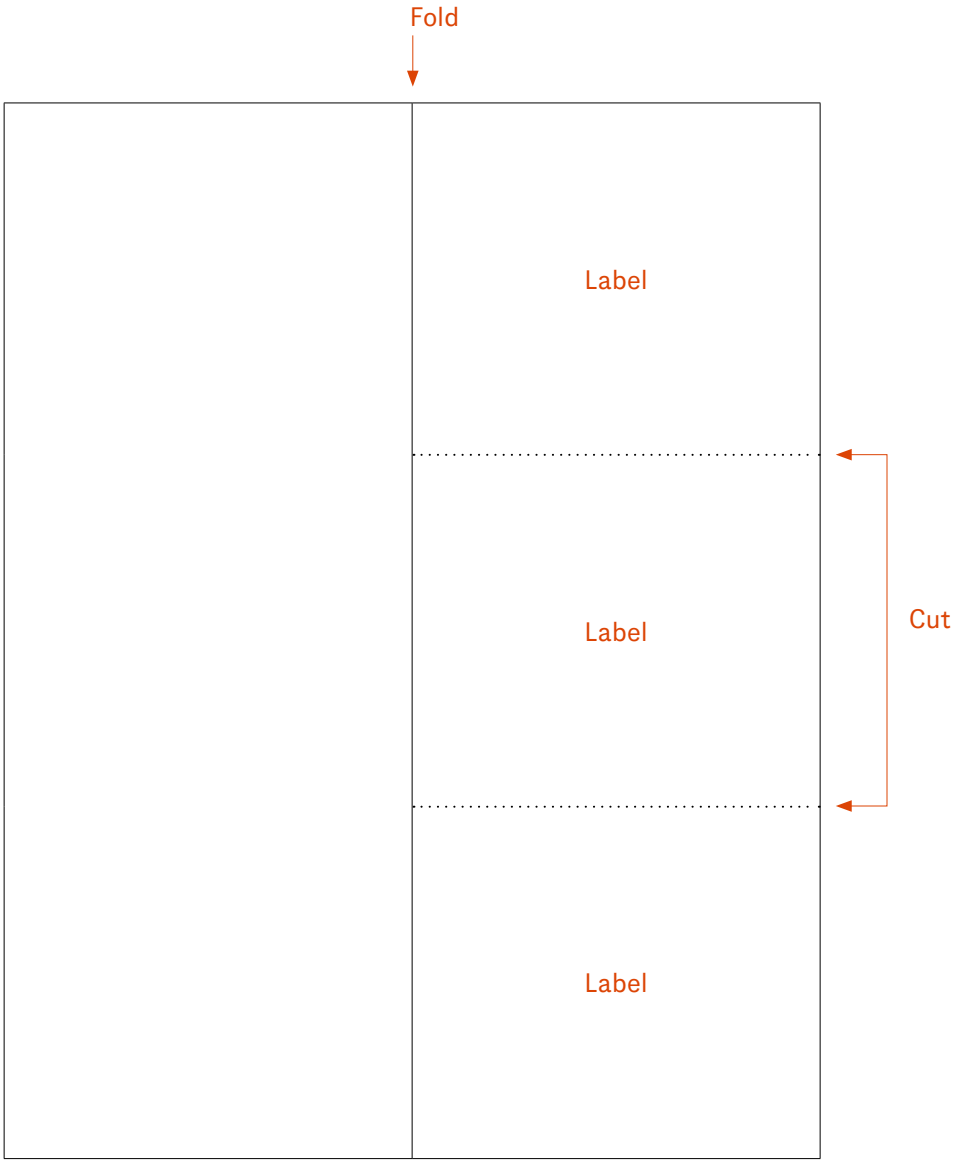
DNA, RNA, and Protein Foldable

Directions

Fold along the solid line and cut down the dotted lines of the template found on the next page. Label each of the front flaps: DNA, RNA, and Proteins. Under each flap, detail the differences between the three. When the flap is lifted, the top portion should include written information on the structure and function with focus on what makes the material unique, while the lower portion should include a drawing of its structure.



DNA, RNA, and Protein Foldable Template

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Comparative Foldable Rubric

	Score	3	2	1
	DNA	Foldable includes a thorough list of DNA's unique qualities.	Information on DNA is included but brief.	DNA section is not complete.
	RNA	Foldable includes a thorough list of RNA's unique qualities.	Information on RNA is included but brief.	RNA section is not complete.
	Proteins	Foldable includes a thorough list of protein's unique qualities.	Information on protein is included but brief.	Proteins section is not complete.
	Final Score			

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Rubric for Biotech Unit Challenge

Nucleic Acids and Proteins:
Disease Treatment Innovations

Observable features of the student journal	Meets Expectations 8–10 points	Progressing 5–7 points	No attempt 0 points
Research			
a. Journal shows that the student has used learning from previous lessons as a foundation for the information in their drug innovation as well as additional research on specific clinical trials.			
Defining the Problem			
a. Student identifies the problem that needs to be addressed in the treatment and prevention of diseases.			
b. Student understands how the components of the presentation can be used to convey information and influence the community.			
Brainstorming			
a. Student shows the purpose and intent for each component of the presentation and how those components will connect to one another to convey the overall idea.			
Final Score			
Grade			

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Rubric for Biotech Unit Challenge: Mystery Disease Conference Project

Nucleic Acids and Proteins: Disease Treatment Innovations

Observable features of the student journal	Meets Expectations 8–10 points	Progressing 5–7 points	No attempt 0 points
Create design solution using scientific knowledge			
a. Students use knowledge about DNA, RNA, and proteins, as well as technology using these biomolecules, to help them create the drug innovation.			
b. Students include information from research and data in presentation to convey a clear message to the target audience.			
c. Students include information from research and patient profile in the presentation to influence the target audience and support a call for action.			
d. Students create a plan for a clinical trial that seeks to ensure equity in medical research.			
Describes criteria and constraints			
a. Students describe criteria (how does this design meet the challenge) and constraints (for example, information about the mechanism of action of their drug innovation) in the presentation.			

Continues next page >

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Rubric for Biotech Unit Challenge: Mystery Disease Conference Project

Nucleic Acids and Proteins: Disease Treatment Innovations

Continued

Observable features of the student journal	Meets Expectations 8–10 points	Progressing 5–7 points	No attempt 0 points
Evaluating potential solutions			
a. Student uses data and research to determine how their drug innovation is different or improves upon existing similar products.			
b. Student determines their target population or demographic based on research and data and took into account racial or ethnic disparities in medicine and healthcare locally or globally.			
Refining or optimizing the solutions			
a. Student identifies revisions that may be made to their campaign based on testing, peer feedback, and evidence from data collection.			
Final Score			
Grade			