FUTURELAB+

BIOMED

Behind the Scenes of Scientific Breakthroughs

Can an Organism Have No Parents?

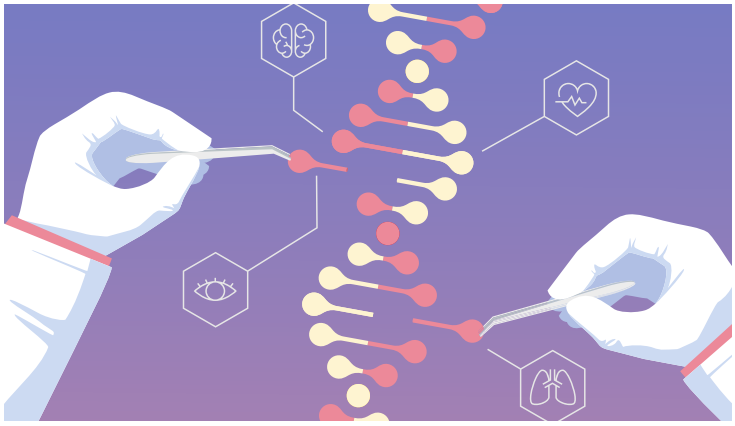
Developed in partnership with:

Discovery Education and Ignited

In this Lesson Plan:

Print the **Teacher Section** →

Print the **Student Section** →



This is an illustration of a gene editing tool.

—

Cover Image
This is a conceptual illustration of genetic engineering.

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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BIOMED / BEHIND THE SCENES OF SCIENTIFIC BREAKTHROUGHS

Can an Organism Have No Parents?

DRIVING QUESTION

Could we start synthesizing better versions of genes and should we?

OVERVIEW

There are many applications for synthetic DNA, such as modifying them within organisms to produce rubber to use in tires or to consume toxic chemicals in water to keep our environment clean. We could even ask ourselves the question, should we start synthesizing large versions of genes for therapeutic use?

In this lesson, students will understand the difference between DNA replication happening in the cell and DNA synthesized artificially. They will explore the new technologies capable of producing millions of DNA copies per minute and weigh the limitations and ethical questions ultimately arising from altering, modifying, and using genetic material. The week will conclude by students building a model they have had artificially synthesized. They will discuss potential ethical concerns encountered and present it to the class.

ACTIVITY DURATION

Five class sessions
(45 minutes each)

ESSENTIAL QUESTIONS

Will technology enable us to produce a wholesome synthetic individual?

Could we engineer individuals with superior intellect?

What could be the consequences if synthesis biology was used for malicious purposes, such as artificially synthesized viruses?

Could synthetic DNA possibly wipe out any genetic diseases?

OBJECTIVES

Students will be able to:

Identify methods for artificial DNA synthesis.

Apply their knowledge on DNA replication to artificial DNA synthesis.

Examine ethical questions arising from synthetic biology.

Develop a model of their choice on creating a new organism with a synthetic genome.

Materials

- **DNA Synthesis—Mission Not Impossible! Capture Sheet**
- **Three Truths and a Lie Capture Sheet**
- **What are the Boundaries of Synthetic Biology? Capture Sheet**
- **Computational Synthetic Biology Video Sequencing**
- **Synthetic Organism Poster Rubric**
- **Sticky Notes (different colors)**
- **Design Journal**

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 address serious ethical concerns associated with synthetic biology and develop their sense of integrity to make responsible decisions that have a positive impact on others and the environment. They will need to engage with others and show open-mindedness while working in small groups throughout the activities.

CULTURALLY AND LINGUISTICALLY RESPONSIVE INSTRUCTION

Students will assess who will have access to synthetic biology. As each student hears questions or information read aloud, it provides repetition of the facts and spoken examples of difficult academic vocabulary for linguistically diverse students. There are instances of culturally responsive instructional strategies to allow for the building of common experience to encourage cultural empathy. The lesson calls for non-volunteerism, while encouraging thoughtful individual engagement in a group activity to spot the correct response when it occurs, and to help explain with correct responses, to affirm diverse forms of communication.

COMPUTATIONAL THINKING PRACTICES

In this lesson, students apply the computational thinking strategies of decomposing problems, finding patterns, and analyzing data in order to create a synthetic organism and alter it for a specified purpose. They begin by making connections between DNA synthesis and artificial synthesis of DNA molecules. Later they examine the steps in computational synthetic biology and consider ethical decisions related to access.

CONNECTIONS TO THE PRODUCT LIFE CYCLE

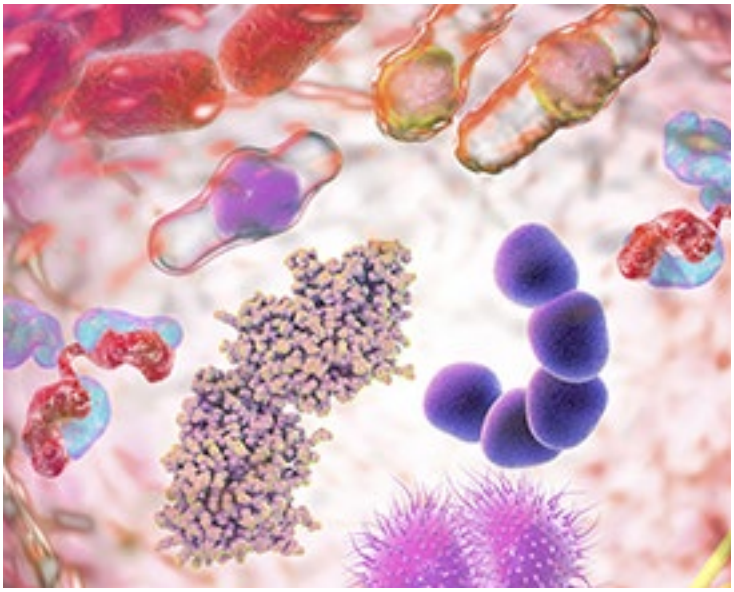
This lesson addresses the **developing** phase of the product life cycle. It focuses on how to synthesize DNA and the methods involved.

Have you ever wondered…

What is the difference between cloning and DNA synthesis?
Cloning is the process of creating a new cell or entire organism from a preexisting cell, while DNA synthesis is the creation of entirely new DNA molecules without the use of a template or a cell.

What was the first organism created using synthetic DNA?
Mycoplasma mycoides, a parasite living in ruminants such as goats, was the first organism to be synthetically created.

How can DNA synthesis help cure Huntington disease?
Huntington disease is a progressive brain disease causing uncontrolled movements and loss of thinking ability. The defective gene codes for an abnormally long protein that accumulates in neurons. Through the injection of synthetic DNA, researchers have found that the effect of that protein can be reversed.



MAKE CONNECTIONS!

How does this connect to the larger unit storyline?

Cells and organisms were always thought to be derived from a parent cell or serve as a template for a new one to be created. However, recent findings show that scientists are now able to synthesize DNA entirely, independently and without a support template. This could lead the way to major applications, including the possibility to cure inherited diseases.

How does this connect to careers?

Synthetic genomics researchers study how gene alteration affects the protein and its function in the cell. By analyzing genes, they create new medicines and help treat inherited diseases.

Computational biologists invent new technologies and tools to alter and measure gene expression using statistics and machines. They model complex methods and design algorithms to improve operating systems and equipment.

How does this connect to our world?

With emerging viruses and diseases, artificial synthesis of DNA is becoming one of the fastest developing areas in biology and medicine with the manufacturing of new treatments and diagnosis.

Day 1

Procedure

LEARNING OUTCOMES

Students will be able to:

Understand the role of DNA polymerase in DNA synthesis.

Examine the link between DNA replication and cell division.

Teacher Note > *Let students know that they will present a poster on a synthetic organism that they will choose to alter for a certain purpose. They can use information collected over the next few days to help develop this poster.*

Whole Group (10 minutes)

1 Start the class by using a Thumbs Up, Thumbs Down engagement activity to review prior knowledge about DNA replication. Read the pre-video questions aloud and ask students to use a thumbs up (True) or thumbs down (False) signal of their knowledge. After each question, elaborate on the answer from someone who gave a thumbs up. You can also display the questions on a slide show and have explanations on the next slide.

a. Q: DNA replication is necessary to make new cells.

A: True

b. Q: The process for duplicating DNA molecules is transcription.

A: False. The process of duplicating DNA molecules is DNA replication.

c. Q: DNA replication occurs in the cell nucleus.

A: True

d. Q: Enzymes, such as DNA helicase and DNA polymerase, are needed for DNA replication.

A: True.

e. Q: DNA replication occurs so each cell can have more than one copy of the DNA.

A: False. DNA replication occurs so each new cell can have one copy of DNA.

f. Q: Cells need to copy DNA to make new cells and replace old cells.

A: True

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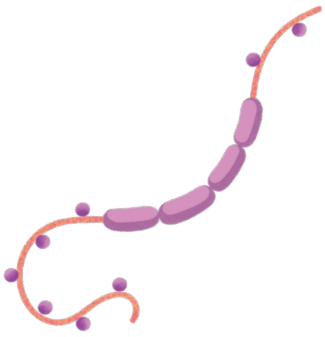
CULTURALLY AND LINGUISTICALLY RESPONSIVE INSTRUCTION

Thumbs Up, Thumbs Down: As each student hears the question or information read aloud, it provides repetition of the facts and an example of difficult academic vocabulary for linguistically diverse students. It calls for non-volunteerisim, while encouraging thoughtful individual engagement in a group activity to spot the correct response, when it occurs, and to help explain with correct responses.



Day 1

Continued

Procedure

2 Ask students to watch *DNA Replication 2010* (1:10). After the video, use the Thumbs Up, Thumbs Down strategy to review and explain the important parts of the video below.

a. Q: The molecular machine, the DNA replisome, pulls apart the double helix and makes an exact copy of DNA.

A: True

b. Q: DNA polymerase unwinds the DNA into two strands.

A: False. DNA Helicase is the enzyme that unwinds the DNA. DNA Polymerase is the enzyme that adds nucleotides to build the new DNA molecules.

c. Q: The leading strand is copied continuously.

A: True

d. Q: The lagging strand is copied in the opposite direction, which requires a more complicated copying mechanism.

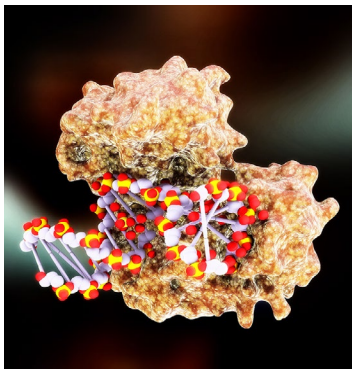
A: True

e. Q: The end result is one new DNA molecule.

A: False. The end result is two new DNA molecules.

3 Lead students into a discussion about the types of enzymes involved in DNA replication. There is DNA polymerase, helicase, and primase when elaborating on the enzyme question.

Teacher Note > *Students may have difficulty with the enzymes. Provide definitions for DNA polymerase, helicase, and primase.*



This image shows a 3D illustration of DNA polymerase.

Individual Work (15 minutes)

1 Ask the class what enzyme is responsible for DNA molecule synthesis in the cell. Tell the students it is the DNA polymerase.

2 Instruct them to watch *DNA Polymerase 2010* (1:06). Let students know that they will play a connect-the-dots game. This is a variation of the *Connect the Dots* strategy.

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Day 1

Continued

Procedure

3	Draw a dot on one end of the board and write the sentence "DNA polymerase synthesizes DNA molecules" next to that dot. Draw another dot on the other side of the board and write the sentence: "Exact copy of the DNA code synthesized."
4	Ask students to copy the dots and the sentences on their own sheets of paper. Instruct them to draw arrows from the first dot as they add information and concepts from the video that connect the first dot to the final dot.
5	When students are finished, let them share their diagrams with a partner for a few minutes. Watch the video a second time (if necessary) and tell students to add in anything that was missed the first time. Ask the class: *What would be the consequence of frequent errors from DNA polymerase? Would it be possible to synthesise DNA synthetically without a template?*

INDUSTRY AND CAREER CONNECTION

Students will have to demonstrate time management as they pass the papers with their questions. They will carry out this skill in a similar way that synthetic genomics researchers need to display time management while analyzing genes.

Small Group (20 minutes)

1	Ask students to form five groups and read the article about DNA synthesis: *DNA Synthesis*.
2	Assign sections of the article to each team: • Requirements for DNA Synthesis • DNA Synthesis, 5' to 3' and DNA Synthesis is semidiscontinuous • Leading Strand Synthesis and Lagging Strand Synthesis • Structure of DNA and all of the sections after that up until Chemical Inhibitors of DNA Replication • Chemical Inhibitors of DNA Replication

Teacher Note > *Some students may get confused between DNA synthesis that occurs normally during DNA replication and synthetic DNA that is made outside of a cell. These sound very similar, but are different processes.*

3	Instruct each team to discuss important concepts of their reading segment and write four questions down and answer them on the same piece of paper.
4	Each group will then pass their questions to another group and answer these questions by writing their answers in another color on the same paper. This should be repeated until each group answers all questions. Ask groups to read all answers written down as they go through questions.

Day 2

Procedure

LEARNING OUTCOMES

Students will be able to:

Investigate how DNA can be artificially synthesized.

Explore possible uses of DNA synthesis.

CULTURALLY AND LINGUISTICALLY RESPONSIVE INSTRUCTION

Printed support for listening and audio support for reading is important to diverse learners. The Closed Captioning feature allows for more focused attention on facts that might have been missed from the audio. Printed support for listening and audio support for reading is important to culturally and linguistically diverse learners.

INDUSTRY AND CAREER CONNECTION

In this activity, students will take up the role of a computational biologist by answering questions using a genomic approach.

Teacher Note > *On Day 1, students learned about the synthesis of DNA molecules in the cell during replication. Today they will focus on the artificial synthesis of DNA molecules.*

Teacher Note > *Since this topic may be closely tied to religion for some students, it may be helpful to read the article Religion in the Curriculum prior to beginning the lesson.*

Whole Group (10 minutes)

1 Ask students to work with their tabletop group to answer two questions that you have written on the board. A student recorder for the group may record answers on a tabletop white board or a sheet of paper.

- What would a 'perfect' molecule of DNA mean to them? No faulty gene? No disease?
- What if we can synthesize a "perfect" DNA molecule, should we use it? If yes, what for?

2 After five minutes of student discussion, do a *Round Robin* to gather answers from each table. Write down the answers on the board as students relay their thoughts. Tell students that they will investigate how DNA molecules are manufactured synthetically.

Small Group (25 minutes)

1 Prompt students to form groups of four. They should watch the video: *DNA Synthesis Technology* (1:46) and complete *DNA synthesis—Mission Not Impossible! Capture Sheet* by answering the questions based on the video.

Teacher Note > *Tell students that they could benefit from using Closed Captioning to help with unfamiliar scientific terms. Students may need to stop the video along the way to capture information and may also benefit from watching the video more than once.*

Individual Work (10 minutes)

1 Once students have completed *DNA synthesis—Mission Not Impossible!* they should write down a sentence about what they find the most interesting on a sticky note and display it on the board.

2 Ask students to add a skill underneath the sentence they deem necessary for a computational biologist to have when it comes to DNA synthesis.

3 Let students walk around and read what other students wrote.

Day 3

Procedure

LEARNING OUTCOMES

Students will be able to:

Identify the method used to synthesize DNA.

Investigate the different applications of synthetic biology.

Teacher Note > *On Day 2, students learned how DNA could be artificially synthesized. Today, they will learn about the different applications of synthetic DNA. Emphasize to students that synthetic biology and synthetic DNA are not the same. Synthetic biology involves lots of different biological molecules, including DNA.*

Remind students to update their Design Journal to capture how content in this lesson will connect to the information they are investigating and to the creation of their final product.

Whole Group (5 minutes)

1 To introduce synthetic biology, prompt students to watch the video and ask them to identify the three different applications of synthetic biology mentioned in the video: *What is Synthetic Biology?* (2:27). Additionally, have students brainstorm some additional applications that were not mentioned.

The three applications of synthetic biology are:

- cell membrane synthesis
- changing the immune system to recognize tumors and remove them from the body
- degrading plastic

2 Explain to students that DNA synthesizers are machines that can produce short single strands of nucleotides. These can be linked together to create longer strands of DNA or RNA. This is commonly used to make synthetic DNA.

Teacher Note > *Encourage motivated students to develop a short pamphlet on the DNA/RNA Synthesizer Model 394. Have them compare this older model to a newer one used today. Students can use the following site for their research: DNA/RNA Synthesizer Model 394.*

Individual Work (10 minutes)

1 Ask students to read the article: *Synthetic Biology.* While they read, have them make a bulleted list of three or more important statements or quotes from the text.

Teacher Note > *Culturally and linguistically diverse learners and/or struggling students may have difficulty with the text. Pick one out of the four sections to read together with these students and discuss.*

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Day 3

Continued

Procedure

2 Have students complete the *Three Truths and a Lie Capture Sheet*. Then, let them know which one is the incorrect statement and the reason behind it.

3 Ask students to consider where this new information could be used to update their Design Journal and to complete the updates as needed.

Whole Group (5 minutes)

1 Write on the board the color assigned to each nucleotide that composes the DNA: T (blue), A (red), G (orange), and C (green). Ask each student to pick one color randomly.

Small Group (20 minutes)

1 Ask students to form groups of five and show the color nucleotide they chose to the group.

2 Ask each team to form a sequence of DNA with the associated letter to their color. Then, ask them to brainstorm a sentence or words using all these letters with words that are related to genomics.

Teacher Note > *Providing at least one word suggestion starting with each letter T, C, G, or A is recommended as some students might find it hard to find words starting with the given letters.*

3 Ask students to write at least two sentences down and read them to the class.

Whole Group (5 minutes)

Lead students to reflect on the following questions with a quick *Round Robin* strategy, changing questions for each student.

- Is it ethical to modify organisms?
- Who could have access to treatments in priority to cure diseases?
- What would be the consequences of such alterations on the environment?

Teacher Note > *If time runs out, encourage students to respond to these questions outside of class on a digital forum where students can view the responses of their peers.*

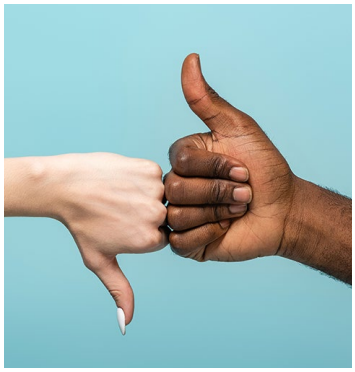
Day 4

LEARNING OUTCOMES

Students will be able to:

Discuss who will have access to synthetic biology.

Explore the boundaries of synthetic biology.



Procedure

Teacher Note > *On Day 3, students learned about the different applications of synthetic DNA. Today they will learn about boundaries that should be respected when artificially synthesizing DNA molecules.*

Whole Group (10 minutes)	
1	Ask students: *What are the boundaries of synthetic biology?* Give each student the checklist *What are the Boundaries of Synthetic Biology? Capture Sheet* and ask them to decide if they believe each example is within ethical boundaries or exceeds the boundaries. Students can work individually or this could be done as a tabletop group to allow student discourse.
2	Instruct students to take note of the four steps leading to the production of a protein of choice based on information given in the video *Synthetic Biology at Northwestern: Computational Synthetic Biology* (1:35).
3	After the video, give each table a copy of *Computational Synthetic Biology Video Sequencing*. Ask the group to cut out each step so that each person has one of the steps to read aloud.
4	Use Thumbs Up, Thumbs Down Ordering, an engagement protocol, to ask each table, one at a time, to stand up and arrange themselves in the proper order and to read their step aloud. Deliberately request two or three groups to line themselves up incorrectly (so the class knows that it might be at your request that they are incorrect). Ask the whole class to show with thumbs up if the order is correct or thumbs down if the order is incorrect. Ask the students who show thumbs down to help them get into the correct order.

Teacher Note > *The four steps are as follows:*

1. *Create the structure of the protein and figure out the amino acids sequence and DNA sequence that would make this exact sequence of amino acids.*
2. *Order the sequence of the desired DNA from a company.*
3. *Insert the DNA into cells.*
4. *Cells produce the desired protein by translating the DNA.*

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Day 4

Continued

Procedure

Individual (20 minutes)

1 Prompt students to read *Guiding Ethical Principles in Engineering Biology Research.*

Teacher Note > *Consider highlighting in any bright color important phrases and/or sentences in the article for struggling students. This article can be incorporated into a jigsaw activity.*

2 Ask students to write one question from the article on a sticky note and stick it to the board. Then ask students to choose a sticky note different from theirs, pick it from the board, and go back to their seats to answer the questions they took.

3 Validate answers from students. Then, display all the valid sticky notes on the wall again and ask students to walk around and read the different answers.

Whole Group (15 minutes)

Teacher Note > *The following whole group activities include ethical considerations to examine. If you feel you need more support in preparation for these discussions, feel free to look over the following sources prior to class: Three SEL Skills You Need to Discuss Race in Classrooms and Racial Awareness.*

1 Lead students in a discussion about who would have access to synthetic biology.

2 Watch the video *Insulin production using synthetic biology* (2:07). Ask students if they feel there are any ethical concerns surrounding creating synthetic insulin, if it gives universal access to people who live with diabetes.

3 Have students work in groups of 3–4 to read the article: *New WHO report maps barriers to insulin availability and suggests actions to promote universal access*. As students read the article, have them answer the questions below:

- Who currently has access to synthetic insulin and why is this an ethical issue?
- Why is it vital for those with diabetes to have access to insulin?
- How do we make insulin access universal?

4 Ask students to consider where this new information could be used to update their **Design Journal** and to complete the updates as needed.

Day 5

LEARNING OUTCOMES

Students will be able to:

Combine all knowledge collected on previous days to create a synthetic organism.

Present their posters to the class and justify their choices.

INDUSTRY AND CAREER CONNECTION

In this activity, students will take up the role of a genomics researcher by creating synthetic organisms.

INDUSTRY AND CAREER CONNECTION

Students will have to be detail oriented and demonstrate good organizational skills as they create their posters. They will carry out these skills in a similar way that computational biologists need to be detail oriented and organized when inventing new technologies and tools.

Procedure

Teacher Note > *Today students will present their creations about a synthetic organism of their choice.*

Small Group (35 minutes)

1. Give students the *Synthetic Organism Poster Rubric*.
2. Form groups of four and have students prepare a poster on creating a new organism with a synthetic genome. Tell students they can invent anything they would like that addresses a serious ethical problem that impacts Earth and its inhabitants. Encourage them to be creative in their invention.
3. They can also add pictures or photos. Tell students to include the following:
   - purpose of their creation
   - method of creation using information they collected on previous days
   - information about which population would be concerned
   - animals or plants affected
   - one or two ethical questions regarding their creation
   - list of benefits and harm their synthetic organism could create in early research stages and in application

Teacher Note > *Allow students to make a physical poster or digital poster (Canva) if they prefer. If they choose a digital one, have them post to a forum available to be viewed by the entire class. Make sure students know the different points on which they will be assessed, using Synthetic Organism Poster Rubric.*

Whole Group (10 minutes)

1. Prompt students to do a *Gallery Walk* by displaying all posters on the wall or on devices and look at their classmates' projects.
2. Students will use sticky notes to write a short individual review for each poster using *Plus/Delta* points and stick it to the poster.
3. Read the reviews aloud on each poster and discuss with the reviewers and the creators. Students should then conclude if that synthetic organism has more potential benefits than drawbacks, and if it should be created.

Teacher Note > *Ask students to consider if any of these inventions may one day be a reality.*

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
Constructing an explanation
Compare and evaluate competing arguments or design solutions in light of currently accepted explanations, new evidence, limitations (e.g., trade-offs), constraints, and ethical issues.

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.

Cause and Effect
Empirical evidence is required to differentiate between cause and correlation and make claims about specific causes and effects.

Career and Technical Education (CTE)

A2.6
Prepare a presentation comparing the benefits and harm that can be the result of biotechnology innovations in both the research and application phases and which course of action will result in the best outcomes.

A5.1
Use the Internet and World Wide Web to collect and share scientific information.

4.3
Use information and communication technologies to synthesize, summarize, compare, and contrast information from multiple sources.

5.4
Interpret information and draw conclusions, based on the best analysis, to make informed decisions.

5.6
Read, interpret, and extract information from documents.

DNA Synthesis: Mission NOT Impossible! Capture Sheet

ANSWER KEY **Do not share with students**

Directions
Answer the questions based on the video.

1. What chemistry is used to synthesize DNA?

Phosphoramidite chemistry

2. What is the name of several nucleotides linked together?

Oligonucleotides

3. Where does the oligonucleotide attach initially?

Controlled pore glass

4. What is used to produce oligonucleotides in large quantities?

Electrodes with a conductive chip

5. Where are the electrodes placed and why?

In a chamber with precise reagent delivery to produce high quality DNA

6. How are the electrodes activated?

Electronically

7. How many nucleotides are added at a time?

A single nucleotide

8. How do scientists control the addition of the wanted nucleotides ?

Each electrode creates a transient acidic environment deprotecting the end of the last nucleotide and allowing only the addition of a nucleotide to the intended oligonucleotides.

9. How many oligonucleotides at a time is called a large scale of oligonucleotides production?

150m oligonucleotide

10. What could be the possible use of these oligonucleotides?

Diagnostic and therapeutic use, such as metabolic pathway engineering, gene editing, and antibody drug development

Three Truths and a Lie Capture Sheet

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

Directions

In each of the numbered boxes below, read the statements and decide whether the contents is true or false. Explain why you support each true statement. Revise the statement you believe is false so that it becomes a "truth."

			Support	Correction
1	Synthetic biology involves changing an organism's genetic code.	☒ True ☐ False		
2	Synthetic biology could be used to synthesize biological weapons, such as viruses, which raises concerns about ethical and social implications.	☒ True ☐ False		
3	Rice is the only organism that cannot be modified.	☐ True ☒ False		Rice can be modified to produce beta-carotene.
4	Genome editing could be used to add or remove stretches of DNA in the genome.	☒ True ☐ False		

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DNA synthesis: Mission NOT Impossible! Capture Sheet

Directions
Answer the questions based on the video.

1. What chemistry is used to synthesize DNA?

2. What is the name of several nucleotides linked together?

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Three Truths and a Lie Capture Sheet

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3	Rice is the only organism that cannot be modified.	☐ True ☐ False		
4	Genome editing could be used to add or remove stretches of DNA in the genome.	☐ True ☐ False		

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What are the Boundaries of Synthetic Biology? Capture Sheet

Directions

Put a check next to each potential use of synthetic biology to indicate if you believe that it is an ethical application of synthetic biology.

	Potential Use of Synthetic Biology	Within boundaries	Exceeds the limit
1	To create a designer baby		
2	To increase human lifespan		
3	To cure a disease		
4	To create an exceptional athlete		
5	To remove tumors from the body		
6	To degrade plastic		

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Computational Synthetic Biology Video Sequencing

Directions
Cut the steps into strips. As a group, put the steps in the correct order after watching the video.

Create the structure of the protein and figure out the amino acids sequence and DNA sequence that would make this exact sequence of amino acids.

Order the sequence of the desired DNA from a company.

Insert the DNA into cells.

Cells produce the desired protein by translating the DNA.

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Synthetic Organism Poster Rubric

Score	4	3	2	1
Content	Addresses all of the required concepts.	Addresses some of the required concepts.	Addresses half of the required concepts.	Addresses no required concepts.
Presentation	Makes excellent use of font, colors, and graphics to enhance the presentation.	Makes good use of font, colors, and graphics to enhance the presentation.	Makes use of font, colors, and graphics to enhance the presentation.	Use of font and colors is minimal.
Method	Sequenced and labelled steps given on the method used to create the model.	Information given on the method used to create the model.	Minimal information given on the method used to create the model.	No information given on the method used to create the model.
Purpose of the creation	The creation has a useful purpose.	The creation has a purpose.	The creation has no purpose.	The creation has a harmful purpose.
Ethical questions	The question addresses a serious ethical problem that impacts Earth and its inhabitants.	The question addresses one ethical problem.	The question does not address an ethical problem.	There are no ethical questions included.
General presentation	Excellent; retains audience attention.	Good; easy to follow.	Can be improved; difficult to follow.	Poor; unable to follow.
Final Score				

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References

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