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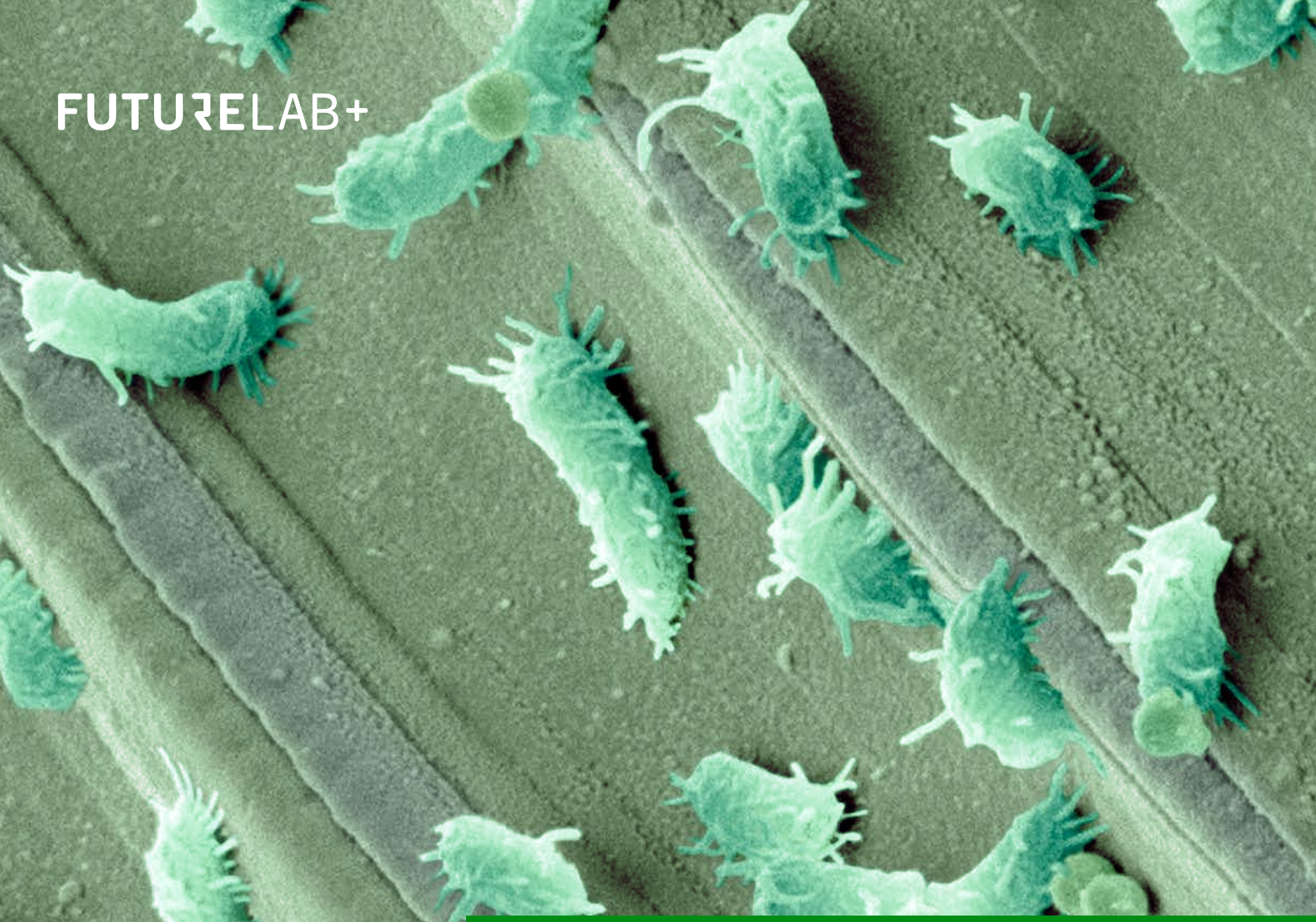

AG/ENVIRONMENTAL

Community Science

Decision Tree Creation

Developed in partnership with:

Discovery Education and Ignited

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

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Cover Image
Bacteria in a water sample is a potential source of environmental DNA (eDNA).

AG/ENVIRONMENTAL / COMMUNITY SCIENCE

Decision Tree Creation

ACTIVITY DURATION

Three class sessions
(45 minutes each)

DRIVING QUESTION

Which DNA identification technique should be used to answer a given question?

ESSENTIAL QUESTIONS

How do the three major DNA identification techniques differ from one another?

What are the major factors that must be considered in selecting a DNA identification technique?

OVERVIEW

A decision tree is a visual model used in many industries and governmental agencies to support and guide decision-making processes. Decision trees can have a range of complexities (with many converted into computerized algorithms that allow users to enter in appropriate inputs), and generate an outcome based on the model. Decision trees make the factors involved in decision making explicit and provide evidence to support choices made by organizations.

In this lesson, students will reflect on the previous lessons about different DNA identification techniques and identify major differences among them. They will also reflect on what factors need to be considered in selecting a DNA identification technique. Students will discuss their ideas in small groups, exchange ideas with representatives from other groups, and create and revise a final visual decision tree to guide the selection of techniques. The decision tree will be used in their final unit project to identify the appropriate tool to use to answer their question.

OBJECTIVES

Students will be able to:

Describe the pros and cons of Sanger sequencing analysis, digital PCR analysis, and NextGen sequencing.

Identify factors that must be considered in selecting a DNA identification tool.

Create a decision tree to guide the selection of appropriate DNA identification techniques.

Materials

Technology Overview Capture Sheet, Part 1: DNA Identification

Technology Overview Capture Sheet, Part 2: Decision Tree Creation

Materials for creating a decision tree (depending on option chosen, may include paper/markers, whiteboards, online collaborative whiteboard apps, etc.)

Decision Tree Feedback Capture Sheet

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 must use self-discipline and self-motivation to stay on task and manage their time when working in small groups. Students need to communicate clearly with their groups and with other groups to produce the decision tree and provide feedback. This lesson also asks students to listen actively, cooperate, work collaboratively to problem solve, negotiate conflict constructively, and seek or offer help when needed. Students will work on making a reasoned judgment on the technique to use after analyzing information, data, and facts.

CULTURALLY AND LINGUISTICALLY RESPONSIVE INSTRUCTION

This lesson connects to real-world issues identified by students in their own communities, while not shying away from difficult conversations identifying and addressing possible biases. Students will use their decision tree to identify potential DNA identification technologies that can be used to develop solutions to those issues. While developing those solutions, students will need to make sure they are properly collaborating with a diverse group from those local communities.

ADVANCING INCLUSIVE RESEARCH

Students have the opportunity to incorporate previously-explored ideas of disparities in healthcare services for underrepresented groups, both increasing relationships with and collecting data from those groups in their decision tree. In order to develop solutions that help all people, researchers must gather and respond to data that have as diverse a participant pool as possible.

COMPUTATIONAL THINKING PRACTICES

Students use the learning from the previous lessons to create a decision-making tool for DNA identification technologies. This tool requires critical thinking to develop and then can be used as a problem-solving device for the final project.

CONNECTION TO THE PRODUCT LIFE CYCLE

In this lesson, students are developing a decision tree that guides which DNA identification technology is appropriate in certain contexts. This connects to the **discover** stage of the product life cycle, as students deepen their knowledge of existing technology, and to the **develop** stage as students define which GE technology should be used to solve specific problems.

Have you ever wondered…

How do professionals make sure they comply with all of the rules and regulations that apply to a company?

People in a variety of fields must make sure that their work adheres to relevant local, state, national, and international regulations. Assuring that these regulations are followed is often designated to a regulatory affairs manager, who must track changes to regulations and assure that all decisions and products follow current guidelines. Decision trees, often in the form of computer algorithms, are tools used by those professionals to guide their work.

MAKE CONNECTIONS!

How does this connect to the larger unit storyline?

This lesson follows completion of the four DNA technology lessons. Students will use their summary tables from the earlier DNA technology lessons as a starting point for developing the decision tree.

How does this connect to careers?

Regulatory affairs managers are tasked with assuring that all aspects of a project adhere to relevant guidelines and laws. Regulatory affairs managers work in a variety of settings, including businesses and governmental agencies such as the Food and Drug Administration (FDA) and United States Department of Agriculture (USDA). These managers use tools, such as decision trees, to help guide the organization in making decisions in line with relevant regulations.

How does this connect to our world?

DNA identification technology is used to address many questions related to human health and safety, environmental issues, and human interests. The decision tree generated in this lesson will be used to determine which of the major identification technologies could be used to answer a question related to their own communities.

Day 1

LEARNING OUTCOMES

Students will be able to:

Describe the pros and cons of Sanger sequencing analysis, digital PCR analysis, and NextGen sequencing.

Identify factors that must be considered in selecting a DNA identification tool.

INDUSTRY AND CAREER CONNECTION

This lesson establishes the foundation for the career of Regulatory affairs manager. People in this career need to deeply understand the technologies and their pros/cons/uses, and students build this knowledge on Day 1.

Procedure

Whole Group (5 minutes)

1 Recap the major DNA identification techniques using the summary tables students completed in Tech Lessons 2 to 4. See *Technology Overview Capture Sheet Recap, Part 1: DNA Identification.*

Small Group (35 minutes)

1 Hand out the *Technology Overview Capture Sheet, Part 2: Decision Tree Creation*. Divide the class into small groups or partner groups for a short discussion. Student groups will respond to the two discussion prompts (Step 1 of the Part 2: Decision Tree Creation Capture Sheet).

- **Discussion Question 1:** What are the major differences in what the three DNA identification techniques can do? Can some technologies provide information that other ones cannot?
- **Discussion Question 2:** What are some of the major factors that a scientist or researcher would need to consider in selecting a DNA identification technique?

2 Direct each student in the small group to meet with representatives of other groups Jigsaw-style to share answers to the discussion questions with each other. Students will add notes to Step 2 of the Part 2: *Technology Overview Capture Sheet, Part 2: Decision Tree Creation*. In this discussion, students will also identify several key ideas or factors that must be considered when selecting a DNA identification technology to use.

Whole Group (5 minutes)

1 Conclude the day's activity by making a class list of the key ideas or factors identified in the small group discussions.

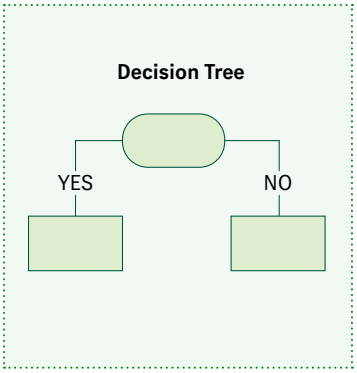
Day 2

Procedure

LEARNING OUTCOMES

Students will be able to:

Create a decision tree to guide the selection of appropriate DNA identification techniques.



Teacher Note > *This activity may be extended into two class days, depending on student needs. For a multi-day lesson, consider having a short session at the end of Day 1 for students to observe the work of other groups. Students can then complete the more in-depth feedback activity at the end of Day 2.*

Small Group (35 minutes)

1 Place students into groups of three to five. Each group is tasked with creating a flowchart that can be used to select the appropriate DNA technology to answer a research question. Students use Step 3 of the *Technology Overview Capture Sheet, Part 2: Decision Tree Creation* to guide their planning. Student groups can select from a number of tools to create their decision trees (paper, collaborative whiteboard apps such as Jamboard, Google Drawing, etc.). Flowcharts should include the following:

- All three DNA identification technologies (Sanger sequencing, digital PCR, NextGen sequencing)
- Major factors to consider in making a selection
- Yes/No questions to answer to lead to a technology choice
- Arrows or other visuals to guide the user through the process

2 Students will include this *Technology Overview Capture Sheet, Part 2: Decision Tree Creation* in their Final Artifact Portfolio of Supporting Evidence they will create in Lesson 11.

Small Group (10 minutes)

1 Students prepare a summary of the initial decision tree to share with the whole group.

Options for sharing:

- Short one-minute presentation summary
- Flipgrid/Voicethread posting
- Written list of key ideas with decision tree

Day 3

LEARNING OUTCOMES

Students will be able to:

Evaluate proposed decision trees by providing and using constructive feedback.

INDUSTRY AND CAREER CONNECTION

This lesson highlights the skills of Regulatory affairs managers. Students communicate their decision-making process for specific genetic sequencing tools, and critique others; all of which is part of the "regulations" aspect of this career.

Procedure

Whole Group (25 minutes)

1 Select a method for groups to analyze the work of others and provide feedback for improvement.

Options for feedback:

- *Decision Tree Feedback Capture Sheet* completed during in-person presentations
- Flipgrid/Voicethread commenting following feedback guidelines on the *Decision Tree Feedback Capture Sheet*
- Silent Gallery Walk of written summaries while filling in the *Decision Tree Feedback Capture Sheet* or leaving comments following feedback guidelines

Small Group (15 minutes)

1 Student groups revise their decision trees based on feedback.

Teacher Note > *The class could select one decision tree to use for the whole class after the feedback activity. Alternatively, students could vote on which decision tree to use and then that tree could be revised during a whole-group discussion.*

National Standards

Next Generation Science Standards	**ETS1-2 Engineering Design** Design a solution to a complex real-world problem by breaking it down into smaller, more manageable problems that can be solved through engineering. **Science and Engineering Practices** Using mathematical and computational thinking Use mathematical, computational, and/or algorithmic representations of phenomena or design solutions to describe and/or support claims and/or explanations. Constructing explanations and designing solutions Apply scientific reasoning, theory, and/or models to link evidence to the claims to assess the extent to which the reasoning and data support the explanation or conclusion.
Career and Technical Education (CTE)	**A1.0** Define and assess biotechnology and recognize the diverse applications and impact on society. **A1.6** Explore and outline the various science and non-science fields and careers associated with biotechnology. **A3.0** Demonstrate competencies in the fundamentals of molecular cell biology, including deoxyribonucleic acid (DNA) and proteins and standard techniques for their purification and manipulation. **A5.2** Use a variety of methods, including literature searches in libraries, computer databases, and online for gathering background information, making observations, and collecting and organizing data. **A8.7** Determine which equipment is appropriate to use for a given task and the units of measurement used.

Technology Overview Capture Sheet

Part 1: DNA Identification

ANSWER KEY **Do not share with students**

Directions

After each technology lesson, use the corresponding table to summarize what you learned about that DNA identification technique. Save this page for comparison in Lesson 9.

This capture sheet was assigned to students in Tech Lesson 2. Students should keep this sheet and others for use in Lesson 9.

Tech Lesson 2		**Sanger Sequencing**	
Describe	Summarize how this technique works.	This process determines the sequence of DNA nucleotides through PCR. As the PCR reaction copies the fluorescent chain, terminator nucleotides mark the end of different segment lengths. The segment lengths are put in order and a program reads the end nucleotide fluorescence to determine sequence.	
Discuss	List the pros and cons you identify for the technique.	Pros	Cons
		Easily accessible	Slow
		Most established technology	Expensive per region you want to sequence
		Good at cloning individual genes	Can only sequence the target region because you have to design a primer
		Easily manipulated for initial plasmid research	
		Good for checking that insertion of a gene in a plasmid worked	
Support	Provide examples.	Forensics—animals or humans Genotyping—Determining presence of different alleles (sequences) Determining viral variants Other examples not mentioned in the lesson do exist	

Technology Overview Capture Sheet

Part 1: DNA Identification

ANSWER KEY **Do not share with students**

Directions

After each technology lesson, use the corresponding table to summarize what you learned about that DNA identification technique. Save this page for comparison in Lesson 9.

This capture sheet was assigned to students in Tech Lesson 3. Students should keep this sheet and others for use in Lesson 9.

Tech Lesson 3		**Digital PCR**	
Describe	Summarize how this technique works.	Digital PCR is a technique used to detect low levels of DNA or other nucleic acid. It can also be used to quantify the amount of DNA found in a sample. It can be used to detect the presence of species (find a needle in a haystack).	
Discuss	List the pros and cons you identify for the technique.	Pros	Cons
		Only need a small amount of DNA	Specialized and expensive equipment
		Can be used in large bodies of water where DNA could be diluted	Can only do a few samples at a time (96)
		Accurate in detecting species	Need to know what kind of DNA you want to detect
		It can detect low levels of the target DNA sequence	Can be inhibited by mutations because primers don't work
Support	Provide examples.	Finding invasive species in bodies of water or plant matter Accurately determining amount of virus in a sample (can be used to correlate viral symptoms with amount of virus in the infected individual) Detecting SARS-CoV-2 in sewage Other examples not mentioned in the lesson do exist	

Technology Overview Capture Sheet

Part 1: DNA Identification

ANSWER KEY **Do not share with students**

Directions

After each technology lesson, use the corresponding table to summarize what you learned about that DNA identification technique. Save this page for comparison in Lesson 9.

This answer key is for the current lesson, Tech Lesson 4. Students should keep this sheet and others for use in Lesson 9.

Tech Lesson 4		NextGen Sequencing	
Describe	Summarize how this technique works.	NextGen sequencing is a method to sequence DNA using short sequencing reads. The fast speed of the sequencing allows for all the DNA to be sequenced from the collection sample. Then the detected DNA sequences can be compared to a library to determine the species of origin.	
Discuss	List the pros and cons you identify for the technique.	Pros	Cons
		Do not have to know the species	Cannot quantify how much DNA is there, just if it is there
		Can do targeted sequencing to look for specific sets of sequences, such as SARS-CoV-2 variants	Need to have high enough quantities to sequence it (no detection of low-level quantities)
		Can do blanket general sequencing	Expensive instruments
		Not impacted by mutations	Short reads—if you do not have a full genome to compare it to, then you may not detect what it is
Support	Provide examples.	Detecting foodborne illnesses Detecting microbial water pollution or water contamination Determining viral variants Determining a breed of cat or dog, population ancestry analysis Forensics—animals Genotyping—Determining presence of different alleles (sequences) Other examples not mentioned in this lesson may exist	

Technology Overview Capture Sheet
Part 2: Decision Tree Creation

ANSWER KEY **Do not share with students**

Directions
Create a decision-tree flowchart with your group to help guide someone in selecting the appropriate DNA identification technology.

1 Step 1: Group Discussion and Brainstorm

Discuss the following with your group and record your ideas:

a. Discussion Question 1: What are the major differences in what the three DNA identification techniques can do? Can some technologies provide information that other ones cannot?

Sanger sequencing—Identify known species, slow and inefficient, but easily accessible

Digital PCR—Identify known species, sample can be diluted

NextGen sequencing—Identify unknown species, need to compare sequence to a library

b. Discussion Question 2: What are some of the major factors that a scientist or researcher would need to consider in selecting a DNA identification technique? Make a list on the lines below.

What technology might I have access to?

Do I know the species of my sample?

How "much" DNA is in my sample? Am I collecting it from the species or just an area in which the species might be?

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Technology Overview Capture Sheet
Part 2: Decision Tree Creation

ANSWER KEY **Do not share with students**

Continued

2. Step 2: Cross-Group Feedback

   Work with representatives from other groups to compare and contrast the DNA identification technologies.

   Make a list of similarities and differences among them. Then note any other key idea or factors that should be considered.

Similarities	Differences	Key Ideas/Factors
Answers will vary.	Answers will vary.	Answers will vary.

Continues next page >

Technology Overview Capture Sheet
Part 2: Decision Tree Creation

ANSWER KEY **Do not share with students**

Continued

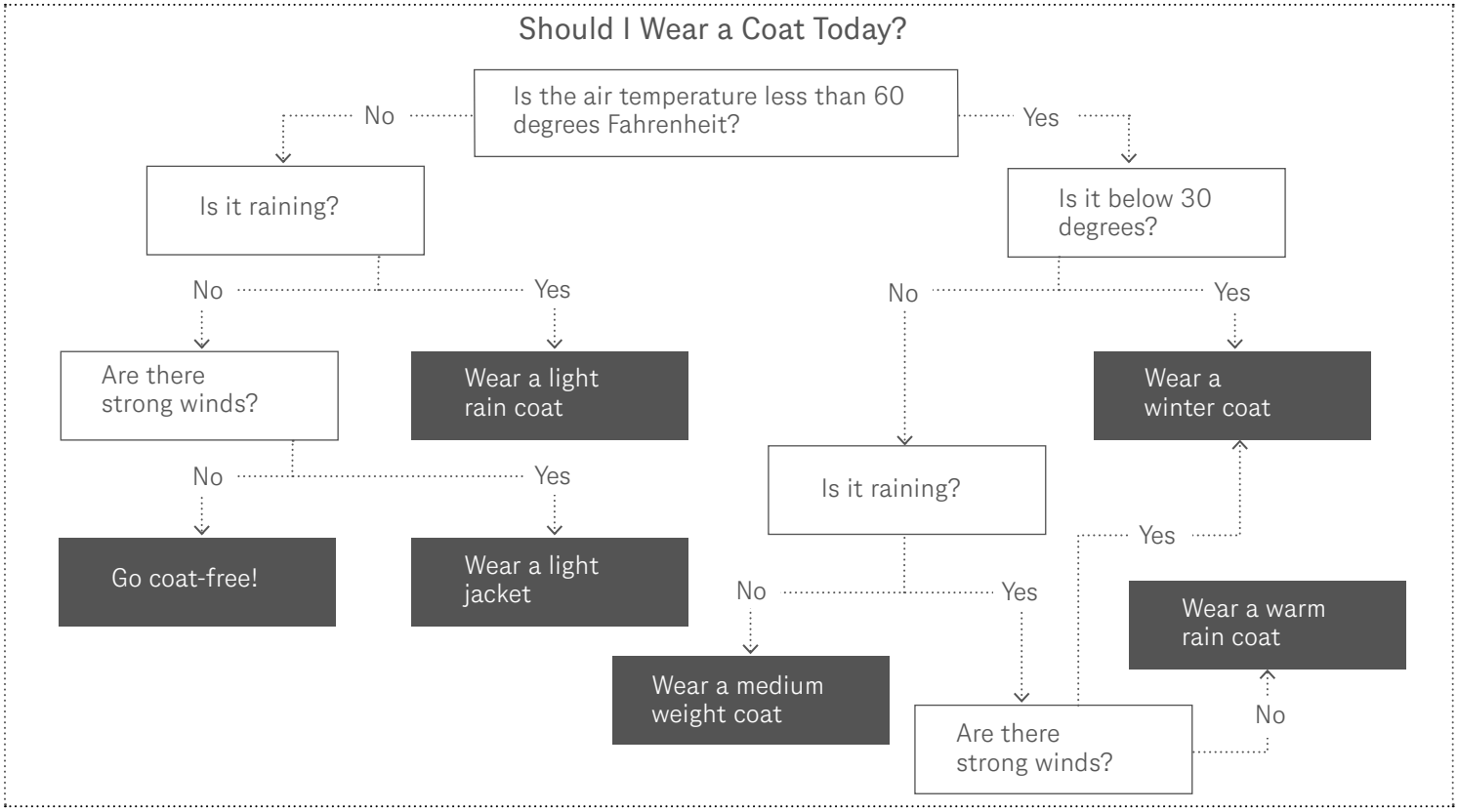
3. Step 3: Decision Tree Creation and Flowchart Construction

   Create a flowchart that can be used to select the appropriate DNA technology to answer a research question.

   Your flowchart should include the following:

— All three DNA identification technologies (Sanger sequencing, Digital PCR, NextGen sequencing)
— Major factors to consider in making a selection
— Yes/No questions to answer to lead to a technology choice
— Arrows or other visuals to guide the user through the process

Flowchart Example



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Technology Overview Capture Sheet
Part 2: Decision Tree Creation

ANSWER KEY **Do not share with students**

Continued

Your Flowchart

Student answers will vary. However, the flowchart should include the following:

— All three DNA identification technologies (Sanger sequencing, Digital PCR, NextGen sequencing)
— Major factors to consider in making a selection
— Yes/No questions to answer to lead to a technology choice
— Arrows or other visuals to guide the user through the process

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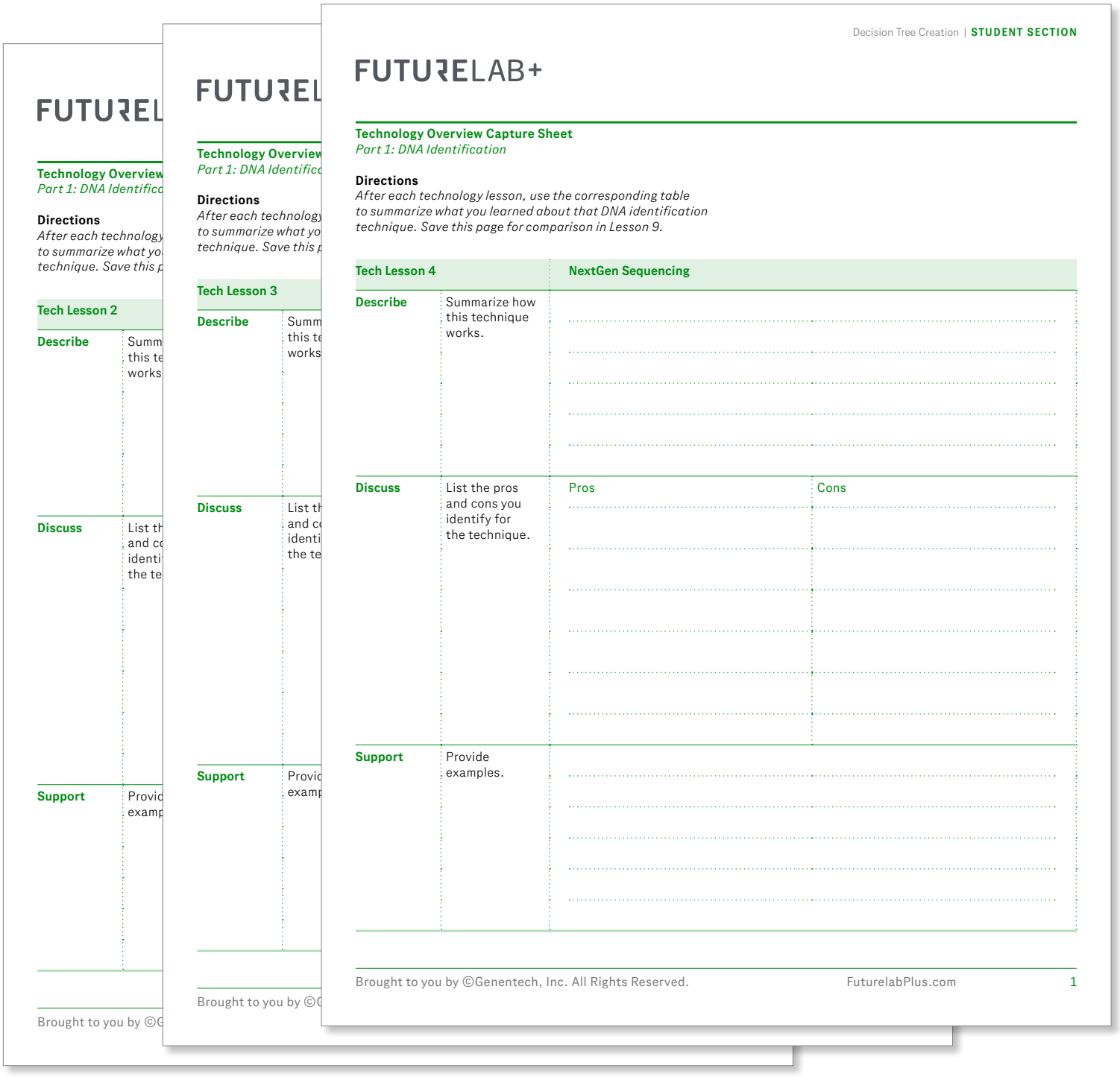
Technology Overview Capture Sheet Recap

Part 1: DNA Identification

Directions

Recap the major DNA identification techniques using the summary tables you completed in Tech Lessons 2–4.



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Technology Overview Capture Sheet
Part 1: DNA Identification

Directions
After each technology lesson, use the corresponding table to summarize what you learned about that DNA identification technique. Save this page for comparison in Lesson 9.

Tech Lesson 4		NextGen Sequencing	
Describe	Summarize how this technique works.		
Discuss	List the pros and cons you identify for the technique.	Pros	Cons
Support	Provide examples.		

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Technology Overview Capture Sheet

Part 2: Decision Tree Creation

Directions

Create a decision-tree flowchart with your group to help guide someone in selecting the appropriate DNA identification technology.

1 Step 1: Group Discussion and Brainstorm

Discuss the following with your group and record your ideas:

a. Discussion Question 1: What are the major differences in what the three DNA identification techniques can do? Can some technologies provide information that other ones cannot?

b. Discussion Question 2: What are some of the major factors that a scientist or researcher would need to consider in selecting a DNA identification technique? Make a list on the lines below.

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Technology Overview Capture Sheet

Part 2: Decision Tree Creation

Continued

2. Step 2: Cross-Group Feedback

   Work with representatives from other groups to compare and contrast the DNA identification technologies.

   Make a list of similarities and differences among them. Then note any other key idea or factors that should be considered.

Similarities	Differences	Key Ideas/Factors

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Technology Overview Capture Sheet

Part 2: Decision Tree Creation

Continued

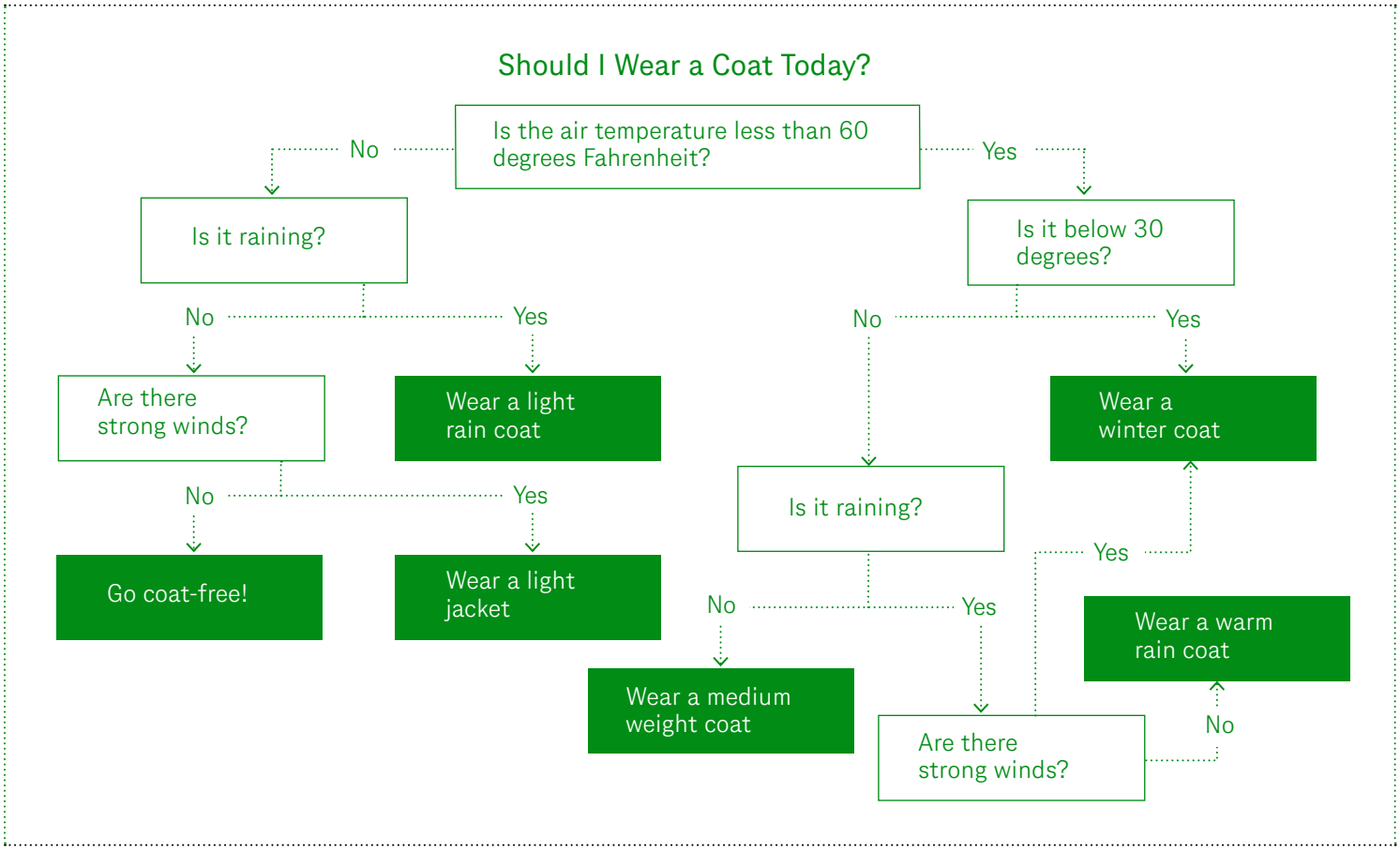
3. Step 3: Decision Tree Creation and Flowchart Construction

   Create a flowchart that can be used to select the appropriate DNA technology to answer a research question.

   Your flowchart should include the following:

— All three DNA identification technologies (Sanger sequencing, Digital PCR, NextGen sequencing)
— Major factors to consider in making a selection
— Yes/No questions to answer to lead to a technology choice
— Arrows or other visuals to guide the user through the process

Flowchart Example



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Technology Overview Capture Sheet

Part 2: Decision Tree Creation

Continued

Your Flowchart

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Decision Tree Feedback Capture Sheet

Directions
Use this sheet to capture feedback of the other groups' projects. Remember that the best feedback is kind, specific, and helpful.

Reviewer Name	*Peer Names*
Project Name	

Feedback Area	What did the group do well for this component?	What could the group improve upon?
All three DNA identification technologies (Sanger sequencing, digital PCR, NextGen sequencing) are included.		
Major factors to consider in making a selection are clear and appropriate.		
Decision tree uses clear and logical yes/no questions to lead to a technology choice.		
Arrows or other visuals to guide the user through the decision tree are shown in a well-organized and logical way.		

Observations of another group's decision tree to help you revise your own.

List one or more ideas that you would like to include in your decision tree here. Keep this list for yourself; give the feedback to your classmates' group.