FUTURELAB+

BIOMED

Crowdsourcing Innovations in Biotechnology

Cell Biology and Biomarkers

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:

Single Pages (use a comma): T3, T6

Page Range (use a hyphen): T3–T6

Cover Image
The image shows a cell that has been divided by mitosis.

BIOMED / CROWDSOURCING INNOVATIONS IN BIOTECHNOLOGY

Cell Biology and Biomarkers

ACTIVITY DURATION

Four class sessions
(45 minutes each)

DRIVING QUESTION

How are cells a source of biomarker data?

ESSENTIAL QUESTIONS

What are cellular organelles and how does their structure and function influence their role?

What is the difference between prokaryotic and eukaryotic cells?

What are biomarkers and how do doctors use them to help patients?

OVERVIEW

All living organisms are made up of cells. Cells are the basic unit of life. If you lined up all of the cells in a human body, they would circle the Earth nearly 19 times! Because cells are often referred to as the "building blocks of life," we study them and use them as biomarkers. Biomarkers are characteristics of the body you can measure. Examples include everything from blood pressure and heart rate to genetic blood tests and X-ray findings. Various types of molecules, such as DNA (genes), proteins, and hormones, can serve as biomarkers. They are important to medicine because biomarkers are measurable and can tell us information about our body.

In this lesson, students will identify different cellular organelles and describe their structure and function in a cell. This includes a discussion on the two basic cell types, prokaryotic and eukaryotic. Students will also define what a biomarker is and how scientists use them in drug discovery.

As a kickoff to their Unit project, students will learn how crowdsourcing can be a valuable tool to help solve local and global problems. They will explore the connection between biomarkers and wearable technology. Finally, students will be introduced to mock innovation challenges to solve by the end of the unit.

OBJECTIVES

Students will be able to:

Differentiate between prokaryotic and eukaryotic cells.

Describe the structure and function of cellular organelles.

Define what a biomarker is and **explain** how scientists use them in drug discovery.

BACKGROUND INFORMATION

Cells are the building blocks of all living things and our bodies have trillions of cells. There are smaller pieces that make up cells, such as organelles, that have specific jobs to keep an organism alive and successful. Living things may be single-celled or more complex like humans. Because cells are often referred to as the "building blocks of life," we study them and use them as biomarkers. Biomarkers are characteristics of the body you can measure. Examples include everything from blood pressure and heart rate to genetic blood tests and X-ray findings. Various types of molecules, such as DNA (genes), proteins, and hormones, can serve as biomarkers. They are important to medicine because biomarkers are measurable and can tell us information about our body. They do not define how a person feels or functions but provide data of how well the body responds to treatment for a disease or a person's risk factor. Biomarkers are also critical to drug development and scientists are always trying to improve the success rate and efficiency of biomarkers.

Materials

- **What Are Biomarkers?**
- **Biomarker Rundown Capture Sheet**
- **Cell Type Graphic Organizer**
- **Paper Slide Video Rubric**
- **Markers, Colored Pencils, or Crayons**
- **24 Plastic Cups (4 Different Colors, 6 of Each)**
- **4 Rubber Bands**
- **8 Wooden Craft Sticks**
- **String**
- **Blank Paper**
- **Crowdsourcing for Science Jigsaw**
- **KWL—Is Stress Something to Stress About?**
- **Innovation Challenges**
- **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

Socio-emotional learning techniques help students establish a personal connection to the material presented. In this lesson, students are encouraged to learn more about biomarkers by selecting a disease of their choice to research. By selecting their own disease to investigate, students become stakeholders in the learning process. This leads to a sense of purpose and an investment in the work.

CULTURALLY AND LINGUISTICALLY RESPONSIVE INSTRUCTION

Culturally and linguistically responsive instruction encourages students to bring their cultural framework into the learning process. This leads to a more equitable classroom experience for all learners. In Lesson 1, students participate in a think-pair-share exercise where they discuss how people they know might benefit from wearable tech devices. This culturally and linguistically responsive strategy centers students' learning in their personal experience. Throughout the lesson there are opportunities for the teacher to identify resources and technology that have been created by CLD scientists, students, and researchers.

ADVANCING INCLUSIVE RESEARCH

In this unit, students learn that biomarkers are measurable indicators of wellness and disease. With the advent of wearable devices that collect wearers' biomarker data constantly, scientists have the opportunity to build the broadest, most diverse dataset of biomarker data ever. This could be crucial in identifying how genetic differences affect responses to treatment. However, the use of these data raise privacy concerns, especially in communities that have been historically mistreated by science and medicine.

COMPUTATIONAL THINKING PRACTICES

Students learn that biomarkers are data points that doctors and scientists collect to identify patterns in a patient's health. Pattern recognition is a core component of computational thinking—by finding patterns in problems, computer scientists can develop a string of code that fixes many errors at once. Similarly, by finding patterns in data from biomarkers, doctors can identify diseases and develop treatments. Students get a hands-on understanding of how scientists use biomarkers by participating in an activity where they will track their heart rate before and after a period of strenuous exercise and identify patterns in the data they collect.

CONNECTION TO THE PRODUCT LIFE CYCLE

In this unit, students watch a video about an entrepreneur who designed a wearable device that assists patients with Alzheimer's disease and their caregivers. The device is innovative, but it does have a hurdle to overcome—currently, it can only be used by patients wearing socks. Students will brainstorm ways that they could make this device work for people who do not want to wear socks. This exercise is characteristic of the **discovery** phase of the product life cycle, where new product ideas are researched.

Have you ever wondered…

How are diseases or illnesses diagnosed?

The human body contains normal levels of molecules such as specific proteins and hormones. When certain diseases occur, these levels can change, either increasing or decreasing. The abnormal levels of these biomarkers can be used to detect possible diseases.

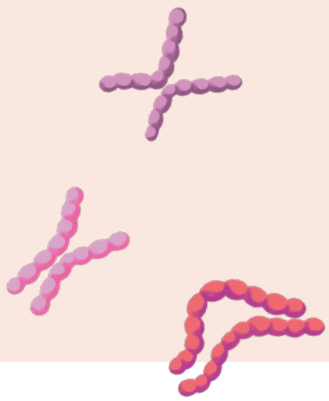
MAKE CONNECTIONS!

How does this connect to the larger unit storyline?

Our cells generate biomarker data.

Ultimately, this will assist students with defining a wearable device or using available data to prevent and/or help treat diseases.

Students will be introduced to the mock innovation challenge, where they will create a wearable device that will help diagnose, monitor or treat a patient. Students will be asked to consider how their device will help solve problems around access and/or health disparities in their community.



How does this connect to careers?

Academic researchers use various databases that house peer-reviewed articles, such as PubMed or EBSCO, in order to locate important information on a certain topic. Information such as data in the form of graphs, tables or even pictures, assist academic researchers with finding evidence to help initiate an experiment or support experimental findings.

Bioelectronics engineers use the principles of Biology, medicine, behavior or health and apply them to electrical engineering in order to create innovative devices. These devices assist in the prevention, diagnosis or treatment of patients.

How does this connect to our world?

Wearable devices are utilized for both necessary health and non-necessary health reasons. Watches can collect data on heartbeat, while heart monitors can help a doctor determine whether a patient has an irregular heart rhythm. Scientists are discovering more ways to utilize these devices. Our cells generate biomarker data. This booming industry requires computer scientists and engineers who can think critically and create devices that can monitor and inform the customer about various health factors. These devices have the potential of saving lives and creating healthier communities.

Wearable devices provide the possibility of giving healthcare workers a full patient profile, which allows proper diagnosis and monitoring. These possibilities may allow more personalized healthcare and pave the way towards advancing inclusive research, therefore closing health disparities.

Day 1

LEARNING OUTCOMES

Students will be able to:

Define what a biomarker is and how doctors use them to help patients.

Identify different cellular organelles and describe their structure and function in a cell.

Procedure

Whole Group (10 minutes)

1 Show students the TedYouth video, *My Simple Invention Designed to Keep My Grandfather Safe*.

Teacher Note > *It is very helpful for Culturally and Linguistically Diverse (CLD) students to see themselves represented in scientific endeavors. Here is a link to information about this TED talk speaker: Kenneth Shinozuka.*

As students are watching the video, they will use the instructional strategy AEIOU. Invite students to jot down their thoughts related to the following categories:

A = Adjective: List a word or two that describes something you saw or learned.
E = Emotion: Describe how a particular part of the segment made you feel.
I = Interesting: Write something you found interesting about the topic.
O = Oh!: Describe something that caused you to say "Oh!"
U = Um?: Write a question about something you learned or want to learn more about.

2 Invite students to work in pairs to discuss the big ideas of the video. The speaker remarked that he needed to find a way his invention could work with people who do not want to wear socks. Ask students to spend two minutes discussing these questions and ideas:

a. Do they know someone in their family or community who might need some kind of device like this?

b. Brainstorm a few ways that his invention might work without socks. (These conversations do not need to be monitored or reviewed for accuracy. This simply serves to focus students on building a shared home and community experience and to incite curiosity about the possibilities of wearable technology in healthcare.)

CULTURALLY AND LINGUISTICALLY RESPONSIVE INSTRUCTION

This strategy serves to focus the students on building a shared home and community experience and to elicit curiosity and possibilities of wearable technology in healthcare.

3 Tell students to refer back to their *AEIOU*. What was their "Um?" What is something that they want to learn more about? Remind students that they will have an opportunity to research and prototype a wearable device similar to the device in the video. Explain to students that wearable technology in healthcare can monitor everything from walking patterns to blood pressure. Wearable technology gives scientists and physicians the opportunity to have a full profile of a patient's health and to provide personalized healthcare. The devices capture what is happening in a cell or organism, using something called biomarkers.

Continues next page >

Day 1

Continued

Procedure

Small Group (15 minutes)

1 Distribute the *What are Biomarkers?* reading passage and the *Biomarker Rundown Capture Sheet*.

2 Have students read the passage, What are Biomarkers?, and complete the Biomarker Rundown Capture Sheet, or discuss as a group and answer the following questions and prompts:

What is a biomarker?

Why do scientists or doctors use biomarkers?

Provide an example of a biomarker.

List one to two reasons why a person may not want their biomarker information to be known.

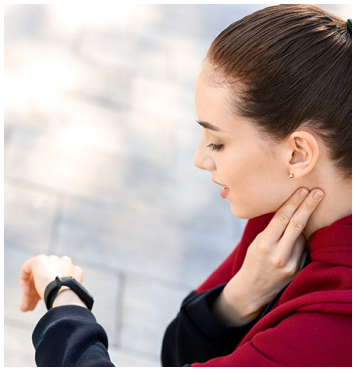
Teacher Note > *In 2001, an NIH working group standardized the meaning of a biomarker as "a characteristic that is objectively measured and evaluated as an indicator of normal biological processes, pathogenic processes, or pharmacologic responses to a therapeutic intervention" and defined biomarker types.*

3 Summarize with students that biomarkers are molecules that indicate normal or abnormal processes taking place in your body. By collecting data on things like blood pressure and heart rate, doctors can find patterns that indicate health or disease. Next, tell students they are going to investigate how cells are a source of biomarker data. Cells provide structure and support to the body of an organism. Organelles in cells perform different functions. When functions are not carried out appropriately, they can serve as biomarkers for disease.

Continues next page >

COMPUTATIONAL THINKING IN ACTION

(optional activity) Give students hands-on experience with collecting data and finding patterns with a brief activity. Instruct students to measure their resting heart rate. Then, direct them to engage in one minute of strenuous activity, such as running in place or doing jumping jacks. Direct students to measure their heart rate immediately after the activity and then once a minute for 10 minutes. Have students chart their heart rate data points. What patterns do they notice?



Day 1

Continued

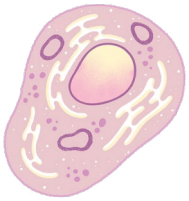
Procedure

Small Group (20 minutes)	
1	Distribute the *Cell Type Graphic Organizer Capture Sheet*.
2	Form students into small groups based on how they will obtain information about cell organelles (website, reading, or game). Each group will use a different option to explore the structure and function of cell organelles and the differences between prokaryotic and eukaryotic cells.
	a. Website: *Cell Organelles*
	b. Read: Textbook (if available) *Cell and City*
	c. Simulation: *Cell Anatomy Viewer*

Teacher Note > *Be sure to point out that innovative scientific and technical ideas are not limited to mainstream America. It is important for culturally diverse students to see other people like themselves involved in scientific endeavors. See The Cell Anatomy Viewer Credits.*

INDUSTRY AND CAREER CONNECTION

In this activity, students will be tasked with using the academic researcher soft skills of openness to learning and time management. They will need to display openness to learning as they will be placed in groups with other students and required to take notes using one of five or six different methods. They will also need to stay on task and manage their time wisely because they will be working together in groups. Lastly, being detail-oriented and clear note-keeping is essential, as they will be utilizing these notes to complete a cell type graphic organizer.



Day 2

LEARNING OUTCOMES

Students will be able to:

Define what a biomarker is and how scientists use them in drug discovery.

Distinguish between prokaryotic andeukaryotic cells.

Procedure

Whole Group (5 minutes)

1. Show students the video *Drawn to Science: Biomarkers in Drug Discovery* by Roche. While students view the video they will use the strategy *Three Truths and a Lie* to determine which three statements are true and which is false:
   - **a.** Biomarkers can be used to diagnose a patient with a disease.
   - **b.** The detection of sugar in urine is an example of a biomarker.
   - **c.** Biomarkers do not play a role in drug discovery and development.
   - **d.** Biomarkers provide information that is the cornerstone of personalized healthcare.
2. Ask students how this video connects to the information about cell structure and function they learned yesterday.

Small Group (25 minutes)

1. Divide the class into groups of three to four students. Students will work together to create a *Paper Slide Video* of one of the options below. Review the *Paper Slide Video Rubric* prior to students beginning their project. Have students assign roles such as scriptwriter, slide designer(s), and director. When complete, students should post their group video on *Flip*, *Padlet*, the classroom website, or another platform. This will allow all students to view and comment on final videos.
   - **a.** Option 1: Differences between prokaryotic and eukaryotic cells
   - **b.** Option 2: Differences between animal and plant cells
   - **c.** Option 3: The form and function of each part of a cell
   - **d.** Option 4: Defining a Biomarker and how they help diagnose/treat patients

Teacher Note > *Recording devices, such as cell phones, are needed to create Paper Slide videos. If recording devices are not available, have students create models of cell structures and functions using post-its or other classroom materials. Afterwards, have groups present their models to the class. Groups should use their models to explain cell functions and give examples of how cells serve as biomarkers for disease.*

Continues next page >

Days 2

Continued

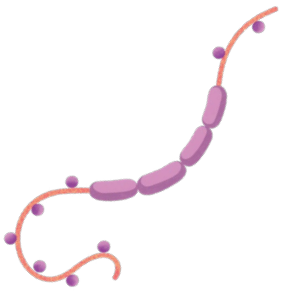
Procedure

COMPUTATIONAL THINKING IN ACTION

Decomposing Problems: Centrifuges are instruments that help scientists practice the computational thinking strategy of decomposition. Scientists use centrifuges to break down a solution like blood into its component parts and identify biomarkers at the cellular level. Decomposing a solution into component parts makes it easier to identify and treat disease.

Individual Work (15 minutes)	
1	Share with students that a *centrifuge* is a device used in the laboratory to separate the components, most often of cells, based on their size. Demonstrate the use of a centrifuge if one is available. If a centrifuge is not available, students can view *this video* that a team of culturally diverse students and faculty from the NC State Undergraduate Organic Chemistry Teaching Laboratories created.
2	Explain that cell sample data have been collected but some of it appears to be incomplete. Students will use their organelles table to complete the missing fields in the *Cell Type Graphic Organizer Part 2 Capture Sheet*.
3	Review answers with students or collect as an exit ticket.
4	Invite students to use their *Journal* to capture how content learned in this lesson connects to the overarching problem they are investigating. Students should summarize how cells are sources of biomarker data.

Teacher Note > *A centrifuge is a device that is found in most labs throughout the world. However, not all countries have the infrastructure to support large labs to diagnose and treat patients. It is important for students to know that innovation is needed to provide equitable healthcare across the globe. If time permits, share with students how Stanford bioengineers created a low-cost human powered centrifuge. This was created by CLD researchers: Manu Prakesh—Assistant Professor of Bioengineering, Stanford, and Saad Bhaml—Postdoctoral Scholar, Stanford. Have students consider how the device they will create will address healthcare equity and access issues. How could their device help close gaps in health disparities?*



Day 3

LEARNING OUTCOMES

Students will be able to:

Connect their team-building collaboration to the idea of crowdsourcing.

Explore current crowdsourcing challenges.

Procedure

Whole Group (20 minutes)

Teacher Prep > *Randomly scatter all 24 solo cups on a designated area of the classroom floor, with the cups laying on their sides. Place one of the following on each student desk: a rubber band (4 total), a pair of string pieces (12 total pairs, 10–15 cm in length), or a wooden craft stick (8 total). For a class larger than 24, some student desks could have one string instead of two.*

1 Begin the lesson by writing or displaying the following challenge on the front board or overhead screen along with the image below: "Challenge: Stack the cups into pyramids, using only the materials provided on your desks. DO NOT directly touch the cup using your hands."

2 Explain to students that their challenge is to work together to create a pyramid stacked three rows high. Each pyramid should have a bottom row of three cups, then two cups, then one. All cups in the pyramid should be the same color. Pyramids could be created on desks, lab tables, or on the floor; the instructor can choose where students should stack the cups.

3 Tell students that they may only use the materials on their desks (rubber bands, string, and wooden craft sticks) to complete this challenge within 15 minutes. Remind them that they should work together and that they should think about how their materials can function as a tool or as part of a tool to help them achieve their goal.

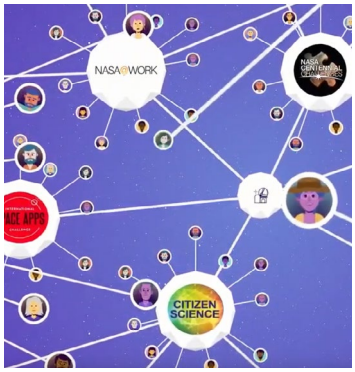
Continues next page >

Day 3

Continued

Procedure

4	Tell groups they have five minutes to formulate a plan to stack the cups. (Students should realize that they can tie the strings evenly around the rubber band to make a grappler tool. This design will allow them to pull the strings evenly to stretch the rubber band over the bottom of the cup to move it. They should also see that the craft sticks can be used to flip the cup upside down in preparation for the grappler tool to stack them.)
5	After five minutes, set a timer for 15 minutes and ask the class to begin the challenge. Students will likely organize themselves into small groups, with each group focusing on a different color cup. Those with the wooden craft sticks should focus on flipping the cups upside down. The instructor should feel free to give guidance or hints if students need it.
6	Once all the cups are stacked correctly, congratulate the class on completing the challenge! Ask students to sit at their desks for a group discussion.
7	Ask students if they think they would have been able to complete this challenge by themselves. How would it be different if they were in groups of 3 or less? Students should report that they could not have completed it as quickly on their own using only the materials provided. Allow students to share what made them successful. Ask if their success was due to the ideas and input of one person or of a group with a common goal.



Small Group (20 minutes)

1	Introduce the term “crowdsourcing” to students by showing them the following video clip: *Technical Problem Solving Crowdsourcing Projects*.
2	As students view the video, ask them to think about how the challenge they just completed relates to crowdsourcing. Allow students to share how the cup-stacking activity relied on crowdsourcing in the classroom to complete the challenge.
3	Next, ask students if they can think of any examples of crowdsourcing they are familiar with or that they might use in their lives. Examples may include Wikipedia, the Waze traffic app, Zooniverse, and Airbnb. Ask students to explain how each example uses crowdsourcing to solve a problem.

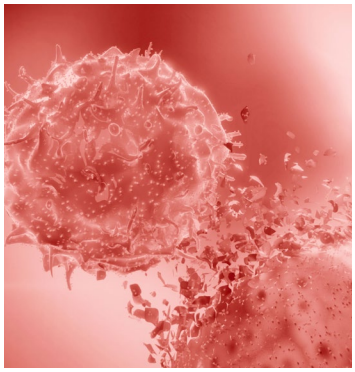
Continues next page >

Day 3

Continued

Procedure

4	Give each student a copy of the *Crowdsourcing for Science Jigsaw Capture Sheet* and ask students to visit *Challenge.gov*.
5	Explain to students that Challenge.gov is a crowdsourcing platform that government agencies can use to issue challenges to the public. Anyone can submit their ideas and solutions and win money, while helping to solve scientific and social problems.
6	Ask students to explore current and past challenges on Challenge.gov. Past challenges can be accessed by searching through "archived challenges" in the menu bar. Students should choose one challenge about a scientific problem that interests them. They should read about the challenge and complete their section of the jigsaw capture sheet. Give students 5–10 minutes to complete this.
7	Ask students to form groups of four. Each group member should have researched a different challenge. Students should share information about their crowdsourcing challenge with other group members and record information about all group challenges on the capture sheet.



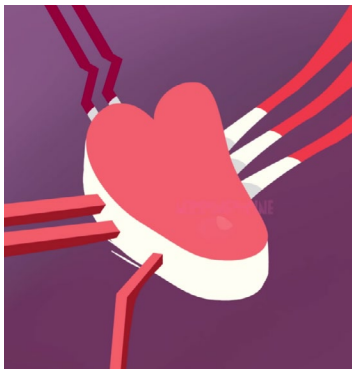
Day 4

LEARNING OUTCOMES

Students will be able to:

Identify how the body reacts to stressful situations.

Brainstorm initial thoughts on the mock innovation challenge.



Procedure

Small Group (15 minutes)	
1	Begin by asking students to raise their hands if they have ever felt stressed or anxious. Ask students to share how they recognize when they are feeling this way. Students will likely report physical symptoms such as sweating, chest tightness, and an increased heart rate. Next, ask students if they think that chronic or frequent stress can be dangerous to a person's health or even life-threatening.
2	Give students a copy of the KWL capture sheet: *Is Stress Something to Stress About?* Ask students to take two minutes to write down what they already know about stress in the K column.
3	Show students the video *How Stress Affects Your Body*. Afterwards, instruct students to write down things they learned in the L column and things they want to know in the W column.
4	Ask students to identify what happens first in the body when someone is in a stressful situation. They should report that the kidneys produce hormones such as cortisol and adrenaline. Explain that these hormones cause the symptoms of stress, such as increased heart rate, that can lead to an increased chance of heart attack and stroke.
5	Explain to students that both heart rate and the levels of hormones produced by the body are **biomarkers**, which are measurable indicators of the state of a body. Students will learn much more about biomarkers in future lessons throughout this unit.

Day 4

Continued

Procedure

Small Group (20 minutes)	
1	Ask students to think about the following scenario: Imagine that you have joined a crowdsourcing challenge looking to create an early stress detection method for people who are chronically stressed. Guidelines for the project include: the device must give an indication of stress by measuring biomarkers before the person has visible symptoms (such as increased heart rate and blood pressure); and it must be a device that can be used on their own without having to see a doctor or medical professional.
2	Tell students they have two to three minutes to write down initial ideas about potential solutions to the challenge. They can use the information from their KWL chart about the body's response to stress to help them brainstorm. Give students two to three minutes to complete this task silently, without talking to those around them.
3	Next, ask students to go to *Poll Everywhere* and type in the code you give them to join an interactive brainstorm for this fictional crowdsourcing challenge. Display the activity on the overhead screen and ask students to add their ideas to this open-ended brainstorm.

Teacher Note > *Have the interactive poll set up before the lesson. Students can create free accounts at Poll Everywhere, and should choose the "open-ended" activity. They can type in the challenge (as seen in step 3 above) and click "create." Poll Everywhere will then provide a code for students that they can use to submit answers on a laptop or tablet, or they can text their ideas via their cell phone.*

4	When students are finished submitting their solutions, ask the class to reflect on the ideas. Pose the following questions to students: Are any ideas similar? Which ideas did you find most creative or novel? Can some ideas be combined to come up with a potential solution?
5	Next, show students the video *Wearable Tech Detects Stress* that highlights a solution for this challenge created by a group at Caltech.
6	Ask students to share feedback from the video with the class. Compare the ideas from the Caltech group to students' ideas. Did the the students identify cortisol as a potential early warning biomarker of stress? How could they make the Caltech solution more usable for people?

Continues next page >

Day 4

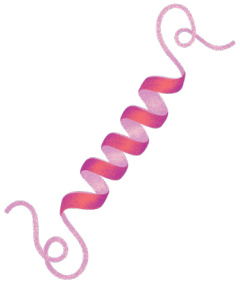
Continued

Procedure

Whole Group (10 minutes)	
1	Explain to students that at the end of this unit, they will be putting their design skills to the test by joining a mock crowdsourcing innovation challenge. Their goal will be to create a piece of wearable technology that will help someone who is dealing with a specific health-related problem. The wearable technology should detect and/or monitor specific biomarkers for their disease.
2	Ask students if they are familiar with wearable technology and if any of them are using it right now. Students may say they are familiar with devices to track exercise or heart rate. Play the *One-Minute Challenge: Digital Biomarkers* video to give students a deeper understanding of how wearable technology can use biomarkers to help prevent and monitor disease.
3	Display or hand out paper copies of the four mock innovation challenges to students. Ask students to read through the four challenges to begin thinking about what human health issue they might be interested in learning more about and the products that they will be creating in the future. Distribute the *Design Journal* for students to use throughout the unit. Students will refer back to this journal after each lesson and use guided questions to reflect on the learning objectives related to their mock innovation challenge.

Teacher Note > *You may want to share local statistics about how different demographics may be disproportionately impacted by the four selected mock challenge health issues.*

4	End by showing students the video of a *teen who created a ring for people with Parkinson's disease*.
5	After viewing the video, ask students to report what biomarkers are being used and, how the data can help both patients with Parkinson's and the doctors that treat them. Explain that in this unit, students will learn about diseases, biomarkers, and benefits and tradeoffs of wearable technology development.



National Standards

Next Generation Science Standards

LS1.A: Structure and Function
Systems of specialized cells within organisms help them perform the essential functions of life.

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
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.

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)

A4.1
List and describe the structure and function of cellular organelle.

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

Biomarker Rundown Capture Sheet

ANSWER KEY **Do not share with students**

Directions
Answer the following questions using the information in the What are Biomarkers? reading passage.

1. In your own words, what is a biomarker?

A biomarker is a characteristic that is used as an indicator of health or disease, or a response to an exposure or therapeutic intervention.

2. Why do scientists and doctors use biomarkers?

Biomarkers are used to help diagnose a disease or predict future disease severity outcomes, identify the best treatment for a patient, monitor safety of a therapy, or to find out if a treatment is having the desired effect on the body.

3. Provide an example of a biomarker.

An example of a biomarker includes blood pressure measurements used as an indicator of cardiovascular risks or blood sugar measurements, which can be used as an indicator of diabetes.

4. List two reasons why a person may not want their biomarker information to be known.

A person may not want their biomarker information to be known because it may affect whether they qualify for health or life insurance. It may also affect the price of that insurance. In addition, people may view or treat them differently, if the biomarkers are know.

Cell Type Graphic Organizer: Part 1

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

Directions
Describe the structure and function of each cell organelle and indicate the type of cell in which it is found.

Organelle	**Structure** *Describe what the cell organelle looks like.*	**Function** *Describe how the structure of the cell organelle influences its ability to do its job.*	**Found in:** *Prokaryotic, Eukaryotic (Plant) or Eukaryotic (Animal)*
Nucleus	Answers will vary.	Answers will vary.	Eukaryotic (Plant and Animal)
Cell Membrane			Prokaryotic, Eukaryotic (Plant and Animal)
Cell Wall			Prokaryotic, Eukaryotic (Plant)
Ribosome			Prokaryotic, Eukaryotic (Plant and Animal)
Rough Endoplasmic Reticulum			Eukaryotic (Plant and Animal)
Smooth Endoplasmic Reticulum			Eukaryotic (Plant and Animal)
Golgi Apparatus			Eukaryotic (Plant and Animal)
Mitochondria			Eukaryotic (Plant and Animal)
Lysosome			Eukaryotic (Plant)
Chloroplast			Eukaryotic (Plant)

Cell Type Graphic Organizer: Part 2

ANSWER KEY **Do not share with students**

Directions

The following data was gathered from various assays performed on samples of cells after being separated using a centrifuge. Complete the missing information for each of the cell samples.

A *centrifuge* is a device used in the laboratory to separate the components, most often of cells, based on their size. These cell components can be separated utilizing both speed and a variety of reagents or solutions that help with isolating a specific organelle. This is helpful in identifying biomarkers.

An *assay* is a specific test that can be performed to determine the activity or function of a molecule or cell.

Sample Components	Assay Results	Cell Type And/Or Organelle
Cell Wall, DNA, Nucleus, Chlorophyll	Photosynthetic Activity	Plant Cell/Chloroplast
Mitochondria	Production of Carbon Dioxide	Plant or Animal Cell
Cell membrane, DNA, Nucleus	Protein Packaging and Movement Around or Out of the Cell	Plant or Animal Cell/Golgi Apparatus
Nucleus, DNA, Cell Membrane, Low pH	Digestion of Old Cellular Parts	Plant or Animal Cell Cell/Lysosome
Cell Wall, DNA, Nucleus, Ribosomes	High Protein Synthesis Activity	Prokaryotic/Ribosomes

FUTURELAB+

What Are Biomarkers?

In the United States, people depend on the U.S. Food and Drug Administration to certify that the biologics, drugs, or devices they use have allowable risks and will assist them in feeling better or living longer. Clinical trials are carried out to show that brand new medical products supply this well-needed balance of positives and tradeoffs.

bi·o·mark·er | ˈbīōˌmärkər | *noun*

a measurable substance in an organism indicative of some phenomenon such as disease, infection, or environmental exposure: *A biomarker may predict aggressive disease recurrence in liver transplant recipients.*

About Biomarkers

The human body has 250 biochemical markers that can provide information about a broad range of the body's organic systems. These biomarkers are molecules that indicate normal or abnormal process taking place in your body. Various types of molecules, such as DNA (genes), proteins, or hormones, can serve as biomarkers. All of these molecules indicate something about your health, so we use biomarkers as measurements of health or disease.

Biomarkers can help diagnose a disease. They can also determine whether or not someone may develop a disease in the future. For example, measurements of blood pressure are biomarkers of cardiovascular risk and measurements of blood sugar are biomarkers for early onset of diabetes.

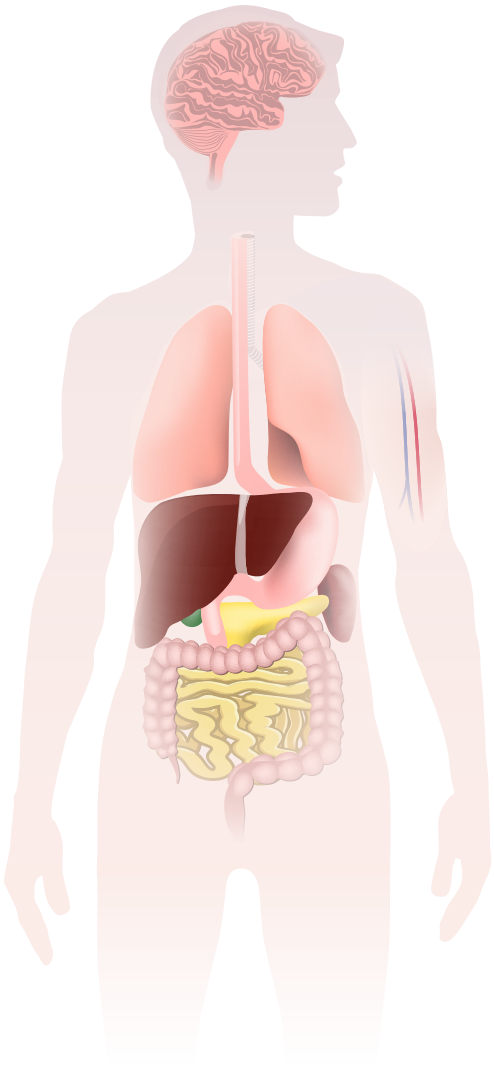
Biomarkers are also used as diagnostics. They can help identify the best treatment for a patient, to monitor therapy safety, or identify the effect of a certain drug or treatment on the body.

Blood, urine, or tissue can be used to measure the presence of a biomarker. Additional sources include tests such as an echocardiogram that produces images of the heart, a CT scan that produces images of the body, or measurements as simple as blood pressure.

Biomarkers can show a diversity of health or disease attributes. These attributes include the amount or kind of exposure to an environmental factor, genetic vulnerability, genetic exposure response, subclinical or clinical disease markers, or measures of therapy response.

Biomarkers help assess and measure:

- disease trait (risk factor or markers)
- disease state (preclinical or clinical)
- disease rate (advancement)



FUTURELAB+

Biomarker Rundown Capture Sheet

Directions
Answer the following questions using the information in the What are Biomarkers? reading passage.

1. In your own words, what is a biomarker?

2. Why do scientists and doctors use biomarkers?

3. Provide an example of a biomarker.

4. List two reasons why a person may not want their biomarker information to be known.

FUTURELAB+

Cell Type Graphic Organizer: Part 1

Directions
Describe the structure and function of each cell organelle and indicate the type of cell in which it is found.

Organelle	**Structure** *Describe what the cell organelle looks like.*	**Function** *Describe how the structure of the cell organelle influences its ability to do its job.*	**Found in:** *Prokaryotic, Eukaryotic (Plant) or Eukaryotic (Animal)*
Nucleus			
Cell Membrane			
Cell Wall			
Ribosome			
Rough Endoplasmic Reticulum			

Continues next page >

FUTURELAB+

Cell Type Graphic Organizer: Part 1

Continued

Organelle	**Structure** *Describe what the cell organelle looks like.*	**Function** *Describe how the structure of the cell organelle influences its ability to do its job.*	**Found in:** *Prokaryotic, Eukaryotic (Plant) or Eukaryotic (Animal)*
Smooth Endoplasmic Reticulum			
Golgi Apparatus			
Mitochondria			
Lysosome			
Chloroplast			

FUTURELAB+

Cell Type Graphic Organizer: Part 2

Directions

The following data was gathered from various assays performed on samples of cells after being separated using a centrifuge. Complete the missing information for each of the cell samples.

A *centrifuge* is a device used in the laboratory to separate the components, most often of cells, based on their size. These cell components can be separated utilizing both speed and a variety of reagents or solutions that help with isolating a specific organelle. This is helpful in identifying biomarkers.

An *assay* is a specific test that can be performed to determine the activity or function of a molecule or cell.

Sample Components	Assay Results	Cell Type And/Or Organelle
Cell Wall, DNA, Nucleus, Chlorophyll	Photosynthetic Activity	
	Production of Carbon Dioxide	
Cell membrane, DNA, Nucleus		
Nucleus, DNA, Cell Membrane, Low pH		
	High Protein Synthesis Activity	Prokaryotic/Ribosomes

FUTURELAB+

Paper Slide Video Rubric

Score	4	3	2	1
Originality	Content is original and in the students' own words.	Most content is original. All content is in the students' own words.	Some content is original. All content is in the students' own words.	Content is not in the students' own words.
Spelling and Grammar	No spelling or grammatical mistakes	Minor spelling or grammatical mistakes	Some serious spelling or grammatical mistakes	Spelling or grammar hinders clear communication of ideas.
Voiceover	Narrator of the Paperslide video is heard clearly.	Narrator's voice is somewhat muffled or too loud.	Narrator's voice is muffled and lacks clarity.	Narrator is inaudible.
Graphics — Relevance	All graphics are related to the topic and make it easier to understand.	All graphics are related to the topic and most make it easier to understand.	All graphics relate to the topic.	Graphics do not relate to the topic.
Clarity and Neatness	Paper slide is easy to read and all elements are clearly written, labeled, and drawn.	Paper slide is easy to read and most elements are clearly written, labeled, and drawn.	Paper slide is hard to read with rough drawings, labels, and color.	Paper slide is hard to read and one cannot tell what the illustrations represent.
Production and Filming	Students recorded their video in one take, without editing.	Students needed two takes, without editing.	Students needed more than two takes and some editing.	Students needed multiple opportunities to film or edit.
Final Score				

FUTURELAB+

Crowdsourcing for Science Jigsaw

Directions

Explore current and past challenges on Challenge.gov.
Choose one challenge about solving a scientific problem.
Read about it and complete the section below. Then complete the other sections as other group members share their challenge.

	Challenge Title	**Issuing Agency**	**Why is this necessary?** *What problem is it helping to solve?*	**Challenge Goals** *Summary*
1				
2				
3				
4				

FUTURELAB+

KWL—Is Stress Something to Stress About?

Directions

Before viewing the video, complete the K column of this chart with all the things you already know about stress and the impact it can have on a person's health. After you watch the video, add any information you want to know more about in the W column and anything you've learned in the L column. Be prepared to discuss your answers!

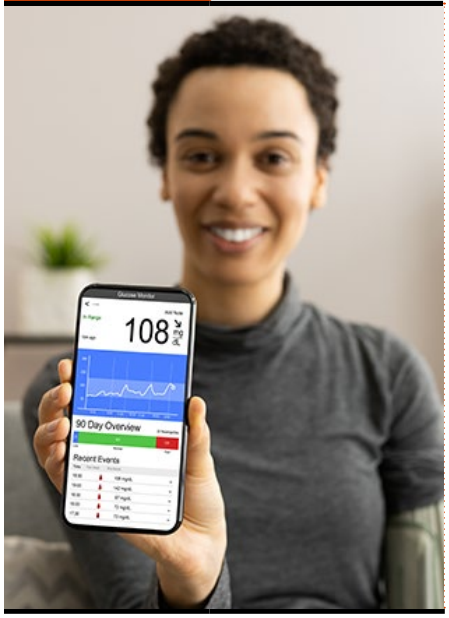
K *All things I already **knew** about stress*	**W** *All things I **want** to know about stress*	**L** *All things I have **learned** about stress*

FUTURELAB+

Mock Innovation Challenge 1

Innovative Ways to Monitor Hypertension and Encourage Healthy Choices in Young People

Award	
Active Solvers	0
Deadline	
Challenge ID	000001



Challenge Overview
According to the CDC, heart disease is the leading cause of death for people of most racial and ethnic groups in the United States. In fact, it is estimated that one person in the United States dies from complications related to heart disease every 36 seconds. Hypertension, or high blood pressure, is one of the leading risk factors for heart disease. If hypertension can be prevented or managed, it can certainly prolong or even save a person's life by preventing heart attack and stroke.

A recent CDC study revealed that one in 25 young people, ages 12–19, have been diagnosed with hypertension and one in 10 has elevated blood pressure, known as "prehypertension." While far too many adults are diagnosed after the effects of hypertension have already caused serious heart issues, the prevention and monitoring of hypertension in young people may be the key to fewer heart disease diagnoses in the future.

There are many important biomarkers that can provide clues about heart health and the risk of hypertension. This innovation looks for wearable, noninvasive ways to give the user data and feedback about their risk of developing high blood pressure. It should also provide encouragement and education to help them make healthy lifestyle choices that can prevent or reverse hypertension in this age demographic.

Submission Guidelines
The submission to the Challenge should include the following:

1. A detailed description of the proposed solution addressing the requirements presented in the overview of the Challenge. This description should include data and cite literature that supports the validity of the specific biomarkers used in the monitoring of the disease through the innovation.

2. A two- or three-dimensional prototype model of the innovation, along with a detailed demonstration of how someone would use the innovation to collect and interpret medical data.

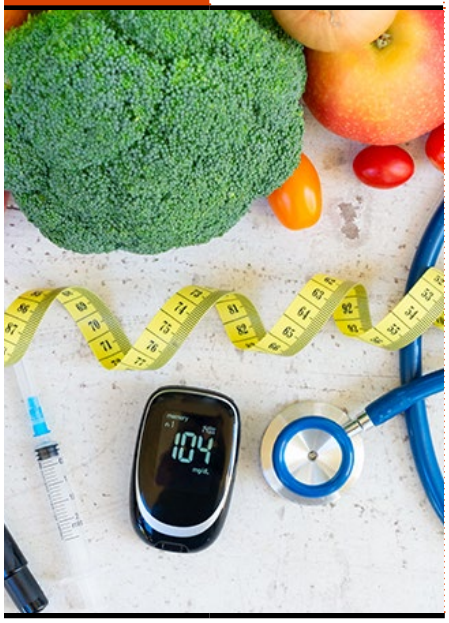
The submission will be presented via a multimedia presentation uploaded to a video streaming site.

FUTURELAB+

Mock Innovation Challenge 2

Innovative Ways to Monitor Biomarkers for Prediabetes

Award	
Active Solvers	0
Deadline	
Challenge ID	000002



Challenge Overview
In 2020, it was reported that just over one in 10 adults in the United States are living with diabetes, and an alarming one in three adults have prediabetes. Prediabetes is a serious condition where blood sugar levels are higher than normal in the body, which if left unmonitored and untreated can lead to type II diabetes, heart disease, and stroke. A major problem with this is that 84% of people are unaware that they have prediabetes. The goal of this challenge is to provide people at risk of type II diabetes the ability to monitor biomarkers of the disease and make the necessary changes to prevent this diagnosis.

The most common way to test blood glucose levels is through an invasive blood test. This innovation looks for wearable, noninvasive ways to give the user data and feedback about diabetes biomarkers. It should also encourage and motivate them to make lifestyle choices that will decrease the chances of developing type II diabetes.

Submission Guidelines
The submission to the Challenge should include the following:

1. A detailed description of the proposed solution addressing the requirements presented in the overview of the Challenge. This description should include data and cite literature that supports the validity of the specific biomarkers used in the monitoring of the disease through the innovation.

2. A two- or three-dimensional prototype model of the innovation, along with a detailed demonstration of how someone would use the innovation to collect and interpret medical data.

The submission will be presented via a multimedia presentation uploaded to a video streaming site.

FUTURELAB+

Mock Innovation Challenge 3

Innovative Ways to Use Antibodies as a Biomarker for Tracking Viral Spread and Vaccine Efficacy

Award	
Active Solvers	0
Deadline	
Challenge ID	000003

Challenge Overview
News about all things viruses dominated the globe in 2020 as the emergence of COVID-19 created a scientific race to understand this new virus and to create a vaccine to help stop its rapid spread. Traditionally antibodies have been an important tool in understanding the body's response to viruses. As the body learns to identify these viral invaders, proteins called antibodies are produced and released to find the virus, then attack and destroy it. Detection of antibodies and the levels found in a person's body are a good indication that they have come in contact with the virus. This information can be used to help gauge a person's response to the virus from a vaccine.

The most common way to measure antibodies is by drawing a blood sample which can only be done at a doctor's office or hospital. This makes it difficult to get rapid feed-back on the spread and response to a novel virus, such as COVID-19, on a large scale from a large population. A solution to this problem is wearable technology that can detect antibodies in a person in a noninvasive way. That is the challenge. The solution should collect data that gives the user an indication of their exposure to a virus and can also be shared with databases such as the CDC or WHO.

Submission Guidelines
The submission to the Challenge should include the following:

1. A detailed description of the proposed solution addressing the requirements presented in the overview of the Challenge. This description should include data and cite literature that supports the validity of the specific biomarkers used in the monitoring of the disease through the innovation.

2. A two- or three-dimensional prototype model of the innovation, along with a detailed demonstration of how someone would use the innovation to collect and interpret medical data.

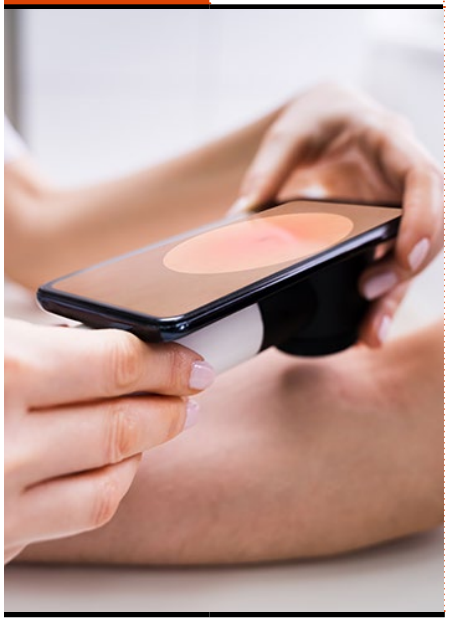
The submission will be presented via a multimedia presentation uploaded to a video streaming site.

FUTURELAB+

Mock Innovation Challenge 4

Monitoring Clinical Trials of Cancer Treatment through the use of Biomarkers via Wearable Technology

Award	
Active Solvers	0
Deadline	
Challenge ID	000004



Challenge Overview
In early 2020, The National Cancer Institute estimated 1.8 million people would be diagnosed with cancer that year, and more than 600,000 would lose their lives to cancer. Cancer has been a leading cause of death in the United States and billions of dollars have been spent on researching cancer and creating treatments to fight it. Clinical trials—research studies performed in people that are aimed at evaluating a medical, surgical, or behavioral intervention—are important players in the fight against cancer. The data provided by clinical trials are used to develop cancer drugs and treatments. The studies give invaluable information about cancer cells and help scientists understand how the body responds to this disease.

Many cancer patients enrolled in clinical trials already have the burden of fighting the disease. The development of a wearable technology that provides data in an easy or noninvasive way could be a crucial factor in collecting the data needed to provide better treatment for cancer. Cancer biomarkers, such as the level of certain proteins or mutations in tumor cells, can give doctors important and fast information about how well a treatment is working against cancer cells or how prolific the cancer cells are. Also, once a patient is considered to be in remission, long-term monitoring of biomarkers is important for early detection of a recurrence of cancer. This challenge seeks the creation of wearable technology that will use biomarkers of cancer to help provide information during and after clinical trials in cancer patients.

Submission Guidelines
The submission to the Challenge should include the following:

1. A detailed description of the proposed solution addressing the requirements presented in the overview of the Challenge. This description should include data and cite literature that supports the validity of the specific biomarkers used in the monitoring of the disease through the innovation.

2. A two- or three-dimensional prototype model of the innovation, along with a detailed demonstration of how someone would use the innovation to collect and interpret medical data.

The submission will be presented via a multimedia presentation uploaded to a video streaming site.