

FUTURELAB+

BIOMED


*Crowdsourcing Innovations
in Biotechnology*

**Data Generated by
Healthy and Diseased
Patients**

Developed in partnership with:
Discovery Education and Ignited

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A doctor pushing a button for data service which represents virtual healthcare.

Cover Image

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

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.

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BIOMED / CROWDSOURCING INNOVATIONS IN BIOTECHNOLOGY

Data Generated by Healthy and Diseased Patients

DRIVING QUESTION

How can data collection from scientific, insurance, and social sources help us prevent or manage diseases?

OVERVIEW

Detection of biomarkers in our bodily fluids to diagnose debilitating diseases, or assess fitness levels, is the newest medical craze and the fastest growing domain of biotechnological expansion. Biotechnology and insurance companies are benefiting greatly from the abundance of data available from patients and scientists to develop diagnostic test kits and health insurance plans. What type of data are available online and where can we find them? Can we use these online resources to create new ways of preventing or managing diseases? This also raises a few questions in terms of data privacy. Who should have access to the data? Can someone refuse to share their biometrics?

In this lesson, students will examine how biomarkers can be used for commercial applications. They will debate whether everyone should have access to this information and find options for using biomarkers to improve well-being through personalized healthcare while at the same time avoiding compromising critical personal data.

ACTIVITY DURATION

Three class sessions
(45 minutes each)

ESSENTIAL QUESTIONS

How can the presence of substances in the blood indicate that a patient has a specific disease?

What types of substances are considered biomarkers?

How can biomarkers influence individual insurance prices and plans?

What are the challenges and concerns associated with keeping biometric data private?

OBJECTIVES

Students will be able to:

Identify various biomarkers and sources that link biomarkers in healthy and diseased patients.

Discover how to use their knowledge to source specific information about biomarkers from the Internet.

Apply their knowledge of Internet data collection to source specific information about biomarkers.

Develop a method to select the most efficient biomarker in terms of disease prevention and management.

Create a database designed to compare data from different sources and consider who could access it.

BACKGROUND INFORMATION

Familiarity with common genetic diseases is required to understand how biomarkers may be used to determine the propensity of such diseases and to also help guide their treatment. Being familiar with some common terms used by health insurances would provide an additional advantage. A certain level of general awareness about biometric data and its associated advantages and challenges would also be helpful.

***Materials (all days)*****Chart Paper****Internet Access****Racial Bias and Its Effect on
Healthcare Capture Sheet****Tuskegee Guided Research
Capture Sheet****Tuskegee Poster Rubric****Design Journal**

Have you ever wondered...

Why are white blood cells measured in the blood when suspecting leukemia, and d-dimer proteins measured when suspecting a blood clot?

An abnormally high level of d-dimer is associated with a blood clot, while a high level of white blood cells can be a sign of cancer. These are two types of biomarkers linked to different diseases.

How can vitamins contained in fresh food be considered as biomarkers?

Vitamins are nutritional biomarkers and when we lack certain vitamins, such as Vitamin C and D, we feel tired.

Why do insurance companies have different packages for different clients?

Insurances are a financial safety net in case something happens health wise. Some people have a history of anemia or genetic diseases. They might want to get insured for these diseases, while generally healthy people will not necessarily require the same protection.

MAKE CONNECTIONS!

How does this connect to the larger unit storyline?

Biomarkers help define specific measurements associated with a body function. When the level of these biomarkers is changed, it can indicate a disease. Biomarkers can even predict if a disease might develop in a person, even if this individual is asymptomatic.

Students will investigate the link between biomarkers and diseases. They will identify different sources online, providing information about biomarkers and diseases.

How does this connect to careers?

Data scientists will communicate complex data from external partners to internal teams. They will keep up with all the different sources of data.

Laboratory managers will collaborate with patients and industries. They will help patients manage their disease based on data management and keep track of progress.

How does this connect to our world?

Our world is well connected digitally, and data sources multiply every day. The medical, scientific, and biotechnological fields need scientists and specialists who know where to source information and how to use this information to better understand how to control and treat diseases, and ultimately, help people live better lives.

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

Biomarkers provide a treasure trove of information that scientists can use to study diseases, but the collection of biomarkers raises privacy concerns. Students use the social-emotional learning skills of social awareness and self-awareness to participate in discussions on race, ethnicity and socioeconomic status.

CULTURALLY AND LINGUISTICALLY RESPONSIVE INSTRUCTION

This lesson employs answering strategies such as “shoutouts” in order to allow all students to participate in sensitive discussions about diabetes while retaining some anonymity. The “turn and talk” technique allows students to share their thinking or ask any clarifying questions with a peer, instead of calling attention to themselves in the whole group. There are opportunities for affirming and validating the contributions of culturally and linguistically diverse people in relevant research and other scientific endeavors.

ADVANCING INCLUSIVE RESEARCH

Students examine the importance of informed consent in the use of biospecimens for research. They also explore options to protect privacy of individuals’ biometrics. Students engage in dialogue around mistrust in the medical community and discuss ways to rebuild trust with BIPOC groups that have been exploited for medical research. This lesson also involves an in-depth analysis of the medical community’s historical maltreatment

of BIPOC communities, and women. Students conduct independent research and craft a presentation on one of the most well-known examples of BIPOC exploitation— the Tuskegee Syphilis study. Through readings, students connect the Tuskegee tragedy with the pervasive sense of mistrust in medicine that remains among historically marginalized communities.

COMPUTATIONAL THINKING PRACTICES

In this unit, students see how the computational thinking strategy of collecting data can help us find patterns in diseases. However, students also examine how collecting data raises concerns about patient privacy, especially among communities that have been exploited in the past in the name of science. Students also learn about how bias impacts the development of algorithms used in healthcare artificial intelligence (AI).

CONNECTION TO THE PRODUCT LIFE CYCLE

This lesson connects to the **discovery** phase of the product life cycle, as students use their knowledge of data collection to source specific information about diseases. Students also examine the **manufacture** and **commercialize** life cycle phases as they study the use of biometrics by private enterprises.

Day 1

LEARNING OUTCOMES

Students will be able to:

Identify the biomarkers of stress.

Recognize situations where these biomarkers of stress are being expressed.

Find solutions for keeping data private on wearable devices.

COMPUTATIONAL THINKING IN ACTION

In this activity, students use the computational thinking strategy of abstraction to read summaries of research and draw a representation of stress. Students are also using the computational thinking strategy of finding patterns to draw connections between chronic stress and disease.



Procedure

Whole Group (15 minutes)

- 1 Let students deliberate on the different sources of stress. The causes of stress can be related to school, family, or society relationships.
- 2 Ask students to draw an outline of the human body on a sheet of paper.
- 3 Ask students to read the abstract *Stress Biomarkers, Mood States, and Sleep during a Major Competition: "Success" and "Failure" Athlete's Profile of High-Level Swimmers*. Point out that the authors of the paper show a range of cultural diversity and comment about the collaborative nature of modern research.
- 4 Have students write down the biomarkers of stress listed in the abstract on the head of the outline of the human body they just drew. Explain that all biomarkers of stress are produced by the brain.

Individual (5 minutes)

- 1 Prompt students to think about a time when they found themselves in a stressful situation and ask them to identify any stress biomarkers they produced. Was I sweating? Was my heart racing? Was my throat dry? Did my stomach hurt?
- 2 Prompt students to think about how likely it is that chronic stress causes diseases, such as cancer. Is there a significant link between cancer and stress? Ask students to read the article *How Stress Affects Cancer Risk*. Have them consider the question, "What can one do to reduce the stress and, therefore, decrease the probability of developing cancer?"

Small Group (10 minutes)

- 1 Using the instructional strategy *Take a Walk*, students will share their stressful moments and discuss the biomarkers being produced.
- 2 Have students form groups of 4–5. Students will create a short 15–30 second skit to reenact a stressful situation to showcase symptoms in front of the class. Each student should mimic at least one personal biomarker or symptom. The rest of the class should respond to the skit with guesses about whether the stress might be chronic or situational only.

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Day 1

Continued

COMPUTATIONAL THINKING IN ACTION

In this exercise, students discuss the ethical implications of using the computational thinking strategy of collecting data to examine biomarkers.



Procedure

Whole Group (5 minutes)

- 1 Use the discussion protocol Whip Around to lead students in a discussion about wearable devices. Ask students to recall the wearable sock device from a previous lesson.

- 2 Devices are increasingly used to monitor biomarkers in real time. Using the instructional strategy *Conga Line*, ask students the following questions, changing the line for each:
 - a. Would a wearable device that measures biomarkers of stress be useful in diagnosing and preventing disease?

 - b. Could a wearable device detect if someone is about to have a heart attack?

 - c. Would a wearable be able to detect if someone was exposed to or infected with a disease in real time?

Small Group (10 minutes)

- 1 Prompt students to read the article, in pairs, about a wearable device that could capture real time data to indicate if a person has become infected with COVID-19: *Researchers Testing If Wearable Wristwatch Can Detect COVID-19*. Use a *Think-Pair-Share* during the last 2–3 minutes of the time for students to brainstorm solutions for keeping private data safe on wearable devices.

- 2 Have them consider the following questions while reading:
 - a. Could those devices help curb a pandemic?

 - b. What if a person does not have access to the Internet and gets infected?

 - c. What if a device gets hacked and data leaked onto Instagram or another mode of social media?

 - d. Who could use this information?

 - e. Would the government be able to use these data to catch a criminal?

 - f. What can be done for these devices to be ethically used?

Teacher Note > The questions here should be available while the students are reading, perhaps posted on the board or in a handout. These questions can also be posted in a freestanding plastic sign holder on group tables.

Day 2

LEARNING OUTCOMES

Students will be able to:

Understand the risk of privacy invasion.

Appreciate the importance of informed consent in use of biospecimens for research.

Be aware of the various bioethical concerns in biomedical research.

Explore options to protect privacy of individuals' biometrics.



Procedure

Whole Group (10 minutes)

- 1 Use the participation protocol *Raise a Righteous Hand* to begin a discussion around data privacy. Start the activity by asking students: “What personal data would you not want to share on social media?” Write a few answers on the board. Then ask students: “Who do you worry might read this information?”
- 2 Pose the question: “Do you see advertisements appear after a search you have done on the Internet?,” using the participation protocol *Give a Shout Out*.

Small Group (15 minutes)

- 1 Allow students to spend 8–9 minutes reading the article *Health Data Privacy*. Ask them to consider the following questions as they read:
 - a. Which agency owns information about your health?
 - b. Who should have access to your biometrics?
 - c. Do you want commercial enterprises and insurance companies to have access to these data? If not, why?
 - d. Could this information be used to sell products according to a biometrics profile?
- 2 Students should be able to articulate two solutions mentioned in the article to prevent misuse of these data. In the last few minutes of this activity, ask them to “Turn and Talk” with a neighbor to discuss the solutions and their thoughts about them.

Teacher note: *If time permits, students can do further research on privacy and data policies of popular wearable devices.*

Whole Group (25 minutes)

- 1 Listen to an excerpt (0-15:00 min) from the podcast episode “*The Impact of Race on Data*” to allow students to learn more about the implications of race on data collection. Comment on the diversity of contributors to the episode and how their perspectives influence it. Students will use the instructional strategy *Sketchnotes* to take notes and answer the questions below:

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Day 2

Continued



Procedure

- a. What are some examples of why certain populations may have apprehension around data collection?
- b. What are the benefits of collecting data?
- c. What connection do you see between what you learned about how HeLa cells were collected and how they were used?
- d. What is the need for data?

- 2 Explain to students that along with fearing the risk of misuse of data, some communities also have mistrust surrounding equitable healthcare services. Have them consider how they could impact their community, in this area, now and in the future.

Small Group (10 minutes)

- 1 Ask students to form groups of 3–5 and give each group a sheet of Poster Board or large chart paper and markers. Each group should set their Poster Board or chart paper up to create a CER poster as follows:

Claim
Evidence
Reasoning

- 2 Provide the claim: There are racial disparities in healthcare.

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Day 2

Continued

Procedure

3 Students should spend 7–8 minutes to research this claim using laptops or tablets. Remind students that it is important to record their evidence as they compile it. Once they have decided the most important pieces of evidence to support their claim, students should write the claim and their evidence in the appropriate sections on the Poster Board or chart paper.

4 Finally, students should record the reasoning that connects the claim and the evidence. Give a 2-minute warning before starting the next step of the activity.

Suggested Student resources:

- [What Is Population Health?](#)
- [COVID-19 Lessons](#)
- [Howard University, AARP Launch Age-Tech Partnership to Address Health Disparities Confronting Persons Age 50+](#)
- [Disparities](#)

Whole Group (10 minutes)

1 When the CER posters are finished, a representative from each group will share the information with the whole group. Posters may be displayed in the classroom.

2 To end the activity, ask students to use the information they have been given from each group along with their own thoughts to discuss the following question with a simple “Turn and Talk” to their neighbor: Can systemic racism impact health and lead to disease or inability to be diagnosed?”

Teacher Note: *Student responses to this question following the “Turn and Talk” can be used as an exit ticket with students asked to share the three most compelling pieces of evidence they used or heard in that class to support the claim.*

Day 3

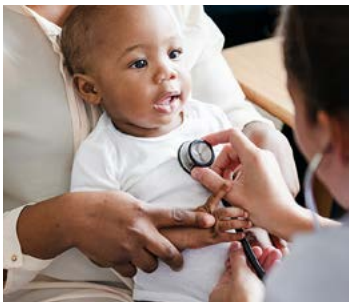
LEARNING OUTCOMES

Students will be able to:

Summarize the importance of including minorities and women in medical studies.

Conduct research into historical disparities in medical treatment of minorities.

Create a presentation on the Tuskegee Syphilis study and its impact on contemporary healthcare.



Procedure

Whole Group (7 minutes)

Begin the class by sharing the video on minority participation in clinical trials [Diversity in Clinical Trials](#). Discuss how the National Institutes of Health is working to ensure clinical trial diversity.

- a. Have students summarize the video using the instructional strategy “Six Word Story.”

Small Group (25 minutes)

- 1 In groups of 2–3 have students read [Healthcare AI Systems Are Biased](#). After reading, have groups come up with 2 ways in which algorithms based on flawed and unrepresentative data may present hazards for patients. Ask them to consider whether the authors of this article might be a part of an unrepresentative group that is of interest.
- 2 Call on teams to volunteer one of their answers and record them on the board.
- 3 Next, distribute copies of the Harvard School of Public Health interview [“Racial Bias and Its Effect on Healthcare.”](#)
- 4 Let students work in groups of three to five taking turns reading paragraphs from the article.
- 5 After each section, ask students to record main points on the [Racial Bias and Its Effect on Healthcare Capture Sheet](#).

Individual Work (13 minutes)

- 1 Ask students to research the Tuskegee Syphilis experiment using the guided questions in the [Tuskegee Guided Research Capture Sheet](#).

Teacher Note > Some suggested websites include:

[Tuskegee Study—Timeline](#)

[Tuskegee Experiment: The Infamous Syphilis Study—HISTORY](#)

[The Terrible Toll of the Tuskegee Study](#)

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Day 3

Continued

Procedure

- 2 Dispense the *Tuskegee Poster Rubric* to the class. Students should use the research questions and the rubric to create an online poster using software of their choice.

Teacher note > *Students will start this assignment in class but complete it at home. Create a central location for students to present their work such as a Padlet, Google slides, or Canva. Make sure to highlight the voices and agency of the survivors of the Tuskegee experiments as well as their descendants.*

- 3 Students will respond anonymously to at least three other students' projects online, generating comments and discussion about what they have learned, how they feel about the experiments, and how abuses like these can be avoided in the future. (The responses should be posted online before the class begins.)
-

- 4 Invite students to use their **Design Journal** to capture how content learned in this lesson connects to the overarching problem we are investigating. Students should summarize the importance of critically assessing trends in biomarker data and be able to determine if biomarker data are significant enough for the biomarker to be considered unique for a disease.

National Standards

Next Generation Science Standards

HS-ETS1-1: Engineering Design

Analyze a major global challenge to specify qualitative and quantitative criteria and constraints for solutions that account for societal needs and wants.

HS-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.

HS-ETS1-3: Engineering Design

Evaluate a solution to a complex real-world problem based on prioritized criteria and trade-offs that account for a range of constraints, including cost, safety, reliability, and aesthetics as well as possible social, cultural, and environmental impacts.

LS1.A: Structure and Function

Feedback mechanisms maintain a living system's internal conditions within certain limits and mediate behaviors, allowing it to remain alive and functional even as external conditions change within some range. Feedback mechanisms can encourage (through positive feedback) or discourage (negative feedback) what is going on inside the living system.

Science and Engineering Practices

Engaging in Argument from Evidence

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.

Evaluate the claims, evidence, and/or reasoning behind currently accepted explanations or solutions to determine the merits of arguments.

Crosscutting Concepts

Cause and Effect

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

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National Standards

**Career and
Technical
Education (CTE)**

A1.4

Research and identify public misunderstandings related to biotechnology and discern the source of these misunderstandings.

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.

4.1

Use electronic reference materials to gather information and produce products and services.

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

Racial Bias and Its Effect on Healthcare Capture Sheet**ANSWER KEY****Do not share with students****Directions**

After reading each section, record what you think are the key points.

1. Unconscious bias in healthcare

Popular media often displays people of color in a bad light, sending signals that support prejudice. This causes people to develop unconscious bias and leads to biased treatment recommendations, poorer doctor-patient communication, and lower ratings about the quality of care.

2. Socioeconomic status and healthcare

People of color in low socioeconomic areas often face illnesses earlier, experience illnesses more severely, deal with more rapid progression of illnesses, and suffer higher rates of impairment and death before they even enter into the healthcare system for help. This socioeconomic status puts them at a disadvantage.

3. The role of stress

Facing discrimination, or even the threat of it, on a regular basis can lead to higher levels of stress. This stress can cause serious health issues and potentially develop in to damaging behaviors.

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Racial Bias and Its Effect on Healthcare Capture Sheet

Directions

After reading each section, record what you think are the key points.

1. Unconscious bias in healthcare

2. Socioeconomic status and healthcare

3. The role of stress

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Tuskegee Guided Research Capture Sheet

Directions

Answer the questions below as you research the Tuskegee Syphilis experiment.

1. What were the Tuskegee Syphilis experiments?

2. How was the study a violation of the test subjects' trust?

3. Find two other examples of historical medical studies or initiatives that exploited or harmed BIPOC communities and/or women?

3a. Example 1

3b. Example 2

4. What have been the long-term effects of these incidents on the relationship between BIPOC communities and the medical community?

5. How do you think the medical community can work to repair this relationship?

FUTURELAB+**Tuskegee Poster Rubric**

Score	3	2	1
Overall Appearance	Professional appearance, colorful, includes appropriate visuals.	Some effort demonstrated, minimal color or visuals used.	Sloppy, little effort, missing multiple parts, no effort.
Explanation of experiments	Great explanation on the Tuskegee study including good detail.	Brief explanation of the Tuskegee study, missing details or inaccurate.	Missing an explanation of what the Tuskegee study was.
Explanation of controversy	Poster gives a good explanation of how the study violated participants' trust and caused physical harm.	Poster mentions problems with the study.	Poster does not address violations committed against participants.
Other historical examples	Two other historical examples included.	One other historical example included.	No other examples of problematic medical studies.
Effects of relationship	Good explanation with detail or examples explaining how the study bred mistrust in minority communities.	Partial explanation of how the study has impacted minority communities' relationship with the medical community.	No attempts at explaining the study's impact on minority communities.
Repairing the relationship	Explanation includes details and/or examples, along with well-thought out ideas.	Incomplete ideas about how the medical community can hope to repair the relationship.	Missing information about how the relationship may be repaired.
Final Score			