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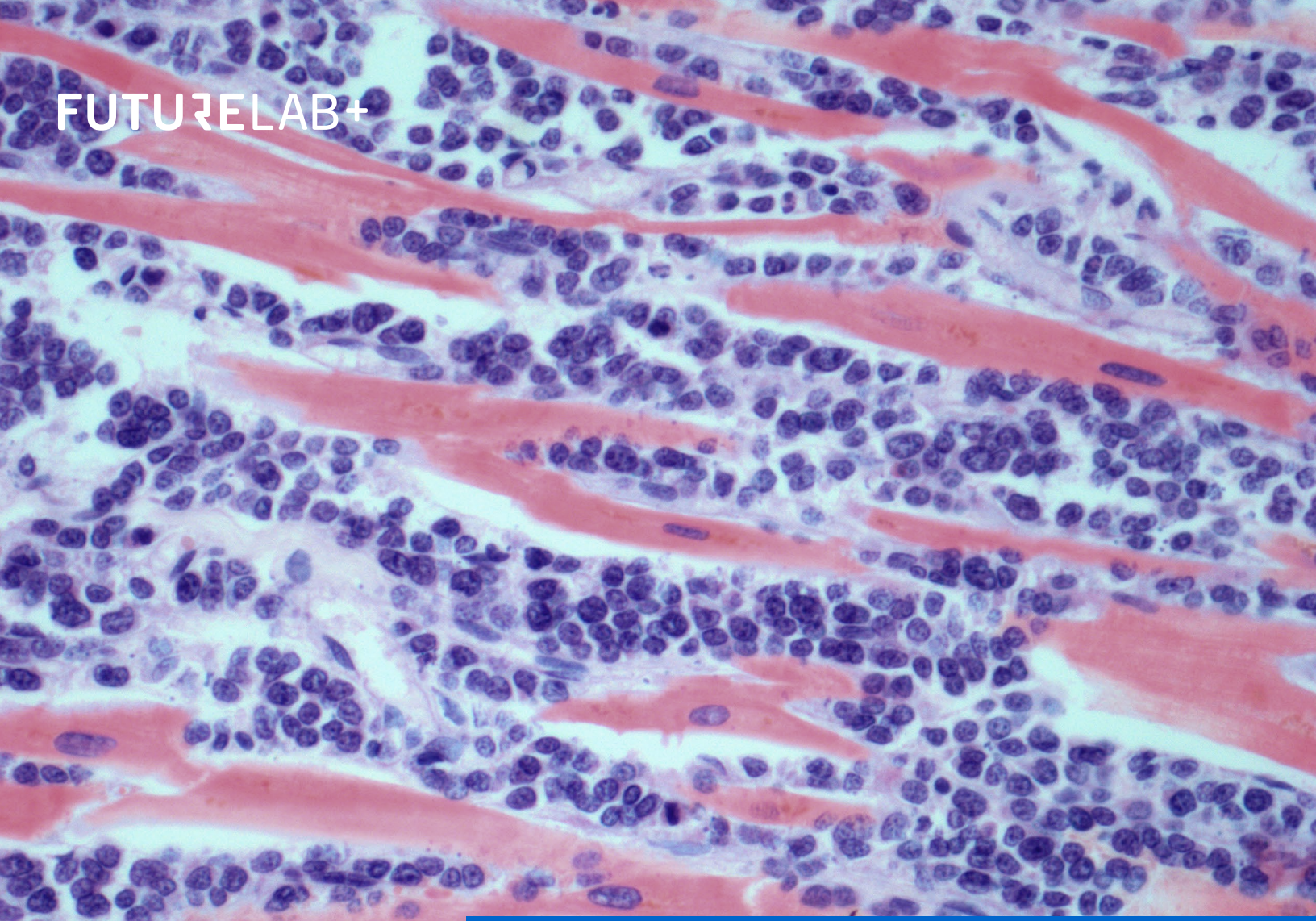

CHEMISTRY IN THE EARTH SYSTEM

*Tumor Cell Biomarkers*

# Cancer and Companion Diagnostics

Developed in partnership with:

**Discovery Education**

# 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

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**Cover Image**
A light micrograph of a section through cardiac muscle showing heart cancer.

CHEMISTRY IN THE EARTH SYSTEM / TUMOR CELL BIOMARKERS

# Cancer and Companion Diagnostics (Tumor Cell Biomarkers)

## DRIVING QUESTION

*How can we best advocate for people who are at risk of getting certain medical conditions?*

## OVERVIEW

Some molecules, such as proteins, can serve as an early warning system and an indicator of disease. Scientists refer to these molecules as biomarkers. In oncology (the study of cancer), scientists have discovered that mutations can serve as valuable biomarkers that can predict what a person's body might do next. These mutations can thus indicate the best course of treatment and give scientists an idea of what a patient's outcome might be. To begin, students review how mutations in DNA can lead to the production of misshapen proteins in and on the surface of a cell. In this review, students create paper proteins that will fold into specific 3D shapes based on the sequence of amino acids and the interactions between them. Then, they add a mutation associated with a tumor cell and discover how the shape and function of the protein changes. Next, students select which medical condition they will focus on for a Biomarker Digital Campaign. Students then discover the power of biomarker testing by participating in a jigsaw activity where they learn about biomarker tests, the different types of biomarkers, and how biomarker testing can lead to more effective individualized medical treatment. Using this knowledge, students identify the biomarkers for the medical condition they are focused on and select a specific person who is at risk of the condition. This is the person to whom they will

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## ACTIVITY DURATION

Three Days (45-minute sessions)

## ESSENTIAL QUESTIONS

***How can mutations in our DNA lead to medical conditions?***

***How can biomarker testing be used to help prevent or treat a disease?***

## OBJECTIVES

*Students will be able to:*

**Construct** a mutated DNA sequence and explain how mutations can lead to medical conditions.

**Explain** how the different types of biomarker tests can prevent or treat diseases and help individualize medicine.

**Advocate** for biomarker testing through a presentation to an individual who is at risk for a specific medical condition.

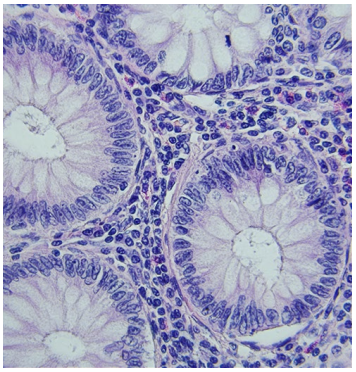

Image showing a microscopic photography of colon cancer.

## OVERVIEW (CONTINUED)

present their Biomarker Testing Digital Campaign. Finally, students create a digital campaign to encourage people to be tested for genetic biomarkers in order to prevent or help treat a disease. Each group will choose a disease that has known genetic biomarkers and work together to research and understand what the biomarkers can reveal about a patient's risk of disease. Their campaign should include data about the prevalence of the disease, an explanation of what biomarkers are, and a description of how the biomarkers are detected in the laboratory to spread awareness about potential prevention or treatment for their disease.

## STUDENT TASKS

| *Day 1* | *Day 2* | *Day 3* |
|---|---|---|
| Mutations review<br><br>Mutate a DNA sequence activity<br><br>Mutations & Medical Conditions review homework | Students identify the medical condition they will focus on for their Biomarker Testing Digital Campaign<br><br>Biomarker testing jigsaw article review and discussion<br><br>Students identify who they will focus on for their Biomarker Testing Digital Campaign | Student create digital biomarker testing campaign presentation |

# MAKE CONNECTIONS!

### *How does this connect to careers?*

***Nurse educators*** help medical professionals learn how to treat patients. They teach, provide mentorship, and offer students hands-on opportunities to practice techniques and receive feedback.

***Public health marketing specialists*** create marketing campaigns that spread awareness about issues and motivate people to act. They use different formats like videos, social media, printed signage, radio, and more to reach a wide audience.

***Internal medicine specialists*** are also known as doctors of internal medicine. They are general practitioners who work with patients over the long term. They use biomarkers to identify signs of disease, refer patients to specialists when necessary, and advise patients on how to best practice preventive care.

***Social workers*** are licensed professionals who are trained to help people cope with problems in their everyday lives. Social workers can help patients identify care they need and work to remove any barriers, like cost or access to transportation, that might stand in the way of receiving that care.

***Phlebotomists*** collect blood samples from patients and prepare samples for testing. They are often on the front lines when it comes to collecting valuable biomarkers from patients. They work in a wide variety of settings, from hospitals to home care.

### *How does this connect to our world?*

Biomarkers are indicator molecules that help scientists understand the full picture of a patient's health. Often, when someone is diagnosed with a disease, it is because a biomarker acted like a flag and informed a doctor that something was wrong. The more data we collect, the better we can become at knowing how to identify and prevent diseases. In this lesson, students take on the role of marketing specialists in order to explain to others why biomarker testing is a crucial part of good health care. As students do this, they will be introduced to the concepts of health literacy and health disparities. These ideas are central to making medical care more accessible and appealing to all people.

# 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 practice self-management by facilitating a discussion using a Roundtable protocol that encourages everyone to participate. They will be working as an advocate for Biomarker Testing and will need to use social awareness about such topics as the lack of access to healthcare and certain treatments for groups disproportionately affected by chronic disease. Students may have had experiences involving family members or friends with certain diseases, so they must demonstrate empathy and respect for others in their interactions.

## CULTURALLY AND LINGUISTICALLY RESPONSIVE INSTRUCTION

Equitable practices allow students to safely discuss sensitive topics like health disparities. This lesson employs the Raise A Righteous Hand protocol in order to ask students about their prior knowledge about cancer. This strategy invites students to silently raise their hand if they would like to share, and allows students who do not have prior knowledge on a subject (or who are personally impacted by the sensitive nature of the topic) to take space. In order to explore the importance of biomarkers in disease detection, students use the Jigsaw cooperative learning strategy. This technique provides time for internal processors to develop their thoughts before sharing with their group. By finding themes in their responses, students strengthen their sense of community.

## COMPUTATIONAL THINKING PRACTICES

Biomarkers are measurements of body systems that scientists can use to identify patterns of disease. The computational thinking strategy of finding patterns is a crucial tool that scientists and medical professionals use to make sense of data. In this lesson, students will also practice using the computational thinking strategy of developing algorithms by participating in a hands-on activity around DNA mutations.

## ADVANCING INCLUSIVE RESEARCH

Biomarkers are one of the next frontiers in personalized medicine. As scientists learn more about the promise of biomarkers, they are also learning about how our bodies respond to treatment in incredibly diverse ways. In order to develop therapies that work for everyone, it's important that clinical trials are as diverse as possible.

## CONNECTION TO THE PRODUCT LIFE CYCLE

Personalized medicine is the cutting edge of healthcare, and it is gaining more ground every day. Personalized medicine and its affiliated technologies are in the **commercialization** phase of the product life cycle, where they are being marketed to consumers.

## Day 1

# Slides 1–9

### Slides 1–6

Generate a list of student questions about Biomarker Testing. (10 minutes)

| | |
|---|---|
| 1 | Introduce the Driving Question to students for this lesson. |
| 2 | Tell students they will identify a person, fictional or real, who is at risk of a medical condition. They will be tasked with helping protect this person from the student-chosen medical condition. |
| 3 | Based on this information, ask students to write down their questions about this work using this prompt, *"What do you need to know in order to do this work?"* |
| 4 | Have students share their questions with *Raise a Righteous Hand* protocol. As students share, add the questions to a large piece of chart paper titled Biomarker Testing Advocate Need to Know Questions. |

### Slides 7–9

Students learn how mutations can change a protein and lead to medical conditions. (10 minutes)

| | |
|---|---|
| 1 | Tell students they first need to understand how certain medical conditions can develop. |
| 2 | Play the *What is a Mutation video*. As you play the video, pause and play to allow time for students to write down questions they have. |
| 3 | After the video, have students share their questions in a quick *Whip Around*. Add these questions to the Biomarker Testing Need to Know Question poster. |

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# Day 1

*Continued*

# Slides 10–12

**COMPUTATIONAL THINKING IN ACTION**

*DNA is an example of an algorithm, or a set of instructions on how to complete a task. Here, students are using the computational thinking strategy of developing algorithms to see how mutations impact our genetic code.*

## Slides 10–11

Students deepen their understanding of how mutations can change a protein and lead to medical conditions. (25 minutes)

| | |
|---|---|
| 1 | Place students into pairs. Have each pair mutate a sequence of DNA to identify the impact on the protein that is built. Students use the *Mutate a DNA Sequencte Cutouts* and the *Mutation Instructions* to do this activity. |
| 2 | Review the directions with the students. |
| 3 | When complete, have student pairs answer the *Gene Mutation Activity Reflection Capture Sheet* using the *Human HLA-B Information Sheet*. |

## Slides 12

For homework, students learn how mutations can lead to cancer cells.

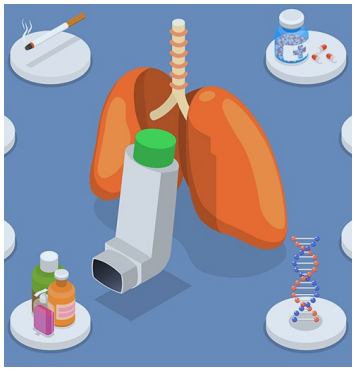
| | |
|---|---|
| 1 | Share with students the article: *Examples of Multifactorial Disorders*. |
| 2 | Pass out the *Biologic Research Capture Sheet*. |
| 3 | Review the questions and have students complete this as homework. |

# Day 2

# Slides 13–17

**INDUSTRY AND CAREER CONNECTION**

*As students select a disease and create a campaign around it, they are employing skills used by marketing and public relations professionals. These skills include developing key messages, educating others, and persuading their audience.*



**COMPUTATIONAL THINKING IN ACTION**

*Biomarkers are measurements of our body function, such as temperature or blood pressure. When enough biomarker measurements are collected over time, they establish a pattern. This is an example of the computational thinking strategy of finding patterns! Doctors and scientists use the patterns in our biomarker data to spot indicators of potential disease.*

## Slides 13–15

Students identify which medical condition they want to focus on for their digital campaign. (10 minutes)

1. Have students select a disease for which they want to create their digital campaign in Part 1 of the *Biomarker Digital Campaign Background Capture Sheet*.

2. To help students select their medical condition, tell students they can choose a disease based on:
   - **a.** Family history
   - **b.** Impact on your community
   - **c.** You've heard of this disease before, and want to learn more about it
   - **d.** You haven't heard about it before, and you are curious to learn more about it

3. Have a few students *Stand and Share* which disease they selected and their reasons why.

4. Using the Student Need to Know Questions as a reference, tell students that they will need to know how we can help people determine if they are at risk of the disease they selected. Use this conversation to transition and introduce the biomarker *Jigsaw* discussion activity.

## Slides 16–17

Students participate in a biomarker *Jigsaw* discussion activity. (20 minutes)

1. Have students form pairs for this discussion activity. Provide a digital or print version of the article *Biomarkers in Cancer: An Introductory Guide for Advocates*.

2. Tell students that they will divide up the article in order to discuss the information within it. Inform students that each person will read the section titled "What is a Biomarker" and divide the other two sections amongst themselves:
   - Article Section: "Types of Biomarkers"
   - Article Section: "Biomarkers and Individualized Medicine"

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# Day 2

*Continued*

# Slides 16–18

| | |
|---|---|
| 3 | Pass out the *Biomarker Jigsaw Discussion Capture Sheet*. Tell students they will need to take notes while they read using the Note Catcher in order to guide their conversation. |
| 4 | During the conversation, tell students to complete the notes for the section that their partner shared. |
| 5 | When done, have student pairs complete the Big Question together. |
| 6 | Have all student pairs share their responses to this question with a *Round Robin* discussion protocol. Use this conversation to transition into the final section of this day's lesson where students use the article to identify the biomarker information connected to the disease they selected. |

**Slide 18**

Students research the biomarker for their disease. Then, students identify to whom they will present their Biomarker Digital Campaign presentation. (15 minutes)

| | |
|---|---|
| 1 | In the article, there is a box titled "Examples of Some Biomarkers." Have students use this box and the information they discussed with their *Jigsaw* partner to complete Part 2 of the *Biomarker Digital Campaign Background Capture Sheet*. |
| 2 | When complete, place students into groups of four or five and ask them to consider the Big Decision question at the bottom of the *Biomarker Digital Campaign Background Capture Sheet* using the *Roundtable* discussion protocol. |
| 3 | To help students identify who they will share their Digital Biomarking Campaign presentation with, tell students to consider why they selected the medical condition at the beginning. Is it because their family has a history with this condition, or because the condition has impacted their community? Have students create the campaign for a fictional person or they may choose a real person that they know based on who might be at risk for the condition. |
| 4 | Tell students it's time to decide for which fictional or real person they will be a Biomarker Testing Advocate. Have a few students volunteer to share their choices and reasons for the choices. |

**CULTURALLY AND LINGUISTICALLY RESPONSIVE INSTRUCTION**

*There is almost universal participation in a Roundtable discussion. The goal is for all students to write and contribute to the group's ideas.*

*It is important that the ideas be vocalized so that culturally diverse learners have an opportunity to hear and reflect on other ideas before it is their turn to contribute. Group members are encouraged not to skip turns and to support each other in expressing their ideas.*

# Day 3

# Slides 19–23

## Slides 19–20

Review the Biomarker Testing Need to Know Questions with students. (10 minutes)

1. With their group from the previous activity, have students review the questions from the list and identify questions they can answer based on the content and work from the previous day.
2. Ask students to identify what new questions they have and add them to the list as they work.
3. Remind students of the Driving Question for the lesson. Now, ask students to *Stand and Share* which questions from the list they will need to answer next to get closer to solving this challenge. Use this activity to transition to the next section of the class.

## Slides 21–23

Students create their Digital Biomarker Testing Campaign (35 minutes)

1. Tell students:
   - **a.** They will independently create a digital slideshow campaign to communicate the importance of biomarker testing for the person they identified in the previous class.
   - **b.** They will present to the teacher (for a fictional person), or send in an email (for a real person) the slideshow they create.
2. Introduce the *Biomarker Testing Campaign slideshow template* and *Biomarker Campaign Rubric* to students.
3. Review the slide notes that contain the information that goes into slides 3–7.
4. Review the Slideshow template menu starting on slide 8 for students to make their slideshow presentation.
5. Pass out the *Biomarker Testing Advocate Presentation Reflection Capture Sheet*. Students complete this reflection after they have communicated with the person they selected.
6. Now, have students use the remainder of the class to create their presentation.

# National Standards

## Next Generation Science Standards

### Science Engineering Practices (SEP)

**Practice 6**
**Constructing Explanations and Designing Solutions**

Evaluate a solution to a complex real-world problem, based on scientific knowledge, student-generated sources of evidence, prioritized criteria, and trade off considerations.

### Disciplinary Core Ideas (DCI)

**LS1.A**
**Structure and Function**

All cells contain genetic information in the form of DNA molecules. Genes are regions in the DNA that contain the instructions that code for the formation of proteins, which carry out most of the work of cells.

**ETS1.B**
**Developing Possible Solutions**

When evaluating solutions, it is important to take into account a range of constraints, including cost, safety, reliability, and aesthetics, and to consider social, cultural, and environmental impacts.

### Crosscutting Concepts (CC)

**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.

**Connections to Engineering, Technology, and Applications of Science**

New technologies can have deep impacts on society and the environment, including some that were not anticipated. Analysis of costs and benefits is a critical aspect of decisions about technology.

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## Gene Mutation Activity Reflection Capture Sheet

**Directions**
*Use the Human HLA-B Information Sheet to answer the questions.*

| | | |
|---|---|---|
| 1 | What differences does your mutated protein have? | |
| 2 | What changes in the DNA sequence led to those differences? | |
| 3 | How does the HLA-B gene impact our health? | |
| 4 | How did the mutation in the HLA-B gene for the protein you built impact the person's health? | |

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## Biologic Research Capture Sheet

**Directions**
*Use the article Examples of Multifactorial Disorders to answer the questions.*

| | | |
|---|---|---|
| 1 | What is Alzheimer's disease and how do mutations lead to Alzheimer's disease? | |
| 2 | What are breast and ovarian cancer and how do mutations lead to breast and ovarian cancer? | |
| 3 | What is colon cancer and how do mutations lead to colon cancer? | |

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## Biomarker Digital Campaign Background Capture Sheet, Part 1

Condition Selection

**Directions**

*After selecting a medical condition to research, answer the questions on the next page.*

*Select one of the conditions because:*

- *it connects to your family history*
- *it impacts your community*
- *you have heard of this disease before, and want to learn more about it*
- *you have not heard about it before, and you are curious to learn more about it*

| | | |
|---|---|---|
| **1** | Choose a medical condition to research. | |
| | ☐ | Cardiovascular disease |
| | ☐ | Melanoma |
| | ☐ | Breast cancer |
| | ☐ | Ovarian cancer |
| | ☐ | Alzheimer's disease |
| | ☐ | Stroke |
| | ☐ | Schizophrenia |
| | ☐ | Huntington's disease |

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## Biomarker Digital Campaign Background Capture Sheet, Part 1

Condition Selection

*Continued*

| | | |
|---|---|---|
| **2** | Which condition did you select? | |
| **3** | Why did you select this condition? | |
| **4** | Based on your research, what are the effects of this condition? | |
| **5** | Based on your research, who is most at risk of this condition? | |

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## Biomarker Digital Campaign Background Capture Sheet, Part 2

Biomarker Information

**Directions**

*Identify the biomarker information connected to the disease you selected.*

| | | |
|---|---|---|
| **1** | What is the biomarker for the disease you are focused on? | |
| **2** | What type of biomarker is this? | |
| **3** | Do an internet search for the biomarker of your disease. What important information about this biomarker did you find? | |

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## Biomarker Digital Campaign Background Capture Sheet, Part 3

Big Decision

**Directions**

*Based on what you learned about the condition and the group of people who are most at risk, select who you want to be a Biomarker Testing Advocate for.*

| | | |
|---|---|---|
| 1 | Based on the reason why you selected the medical condition, who do you want to be a Biomarker Testing Advocate for?<br>This will be with whom (fictional or real person) you share your Digital Biomarker Campaign presentation. | |
| 2 | Why did you select this person (fictional or real)? | |

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## Biomarker Jigsaw Discussion Capture Sheet

**Directions**
*Using the article Biomarkers in Cancer: An Introductory Guide for Advocates, summarize the big ideas of the concepts below.*

| | Biomarker Article Section | Notes |
|---|---|---|
| 1 | "What is a Biomarker?" | |
| 2 | "Types of Biomarkers" | |
| 3 | "Biomarkers and Individualized Medicine" | |

| | Big Question | Response |
|---|---|---|
| 4 | Why do you want to act as an advocate for people to get Biomarker Testing? | |

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## Biomarker Testing Advocate Presentation Reflection Capture Sheet

**Directions**

*Answer the questions after you have communicated with the person who was selected.*

| | | |
|---|---|---|
| **1** | If you presented to a real person, how did he or she respond when you gave your presentation on the importance of getting a biomarker test? | |
| **2** | Did he or she commit to getting a biomarker test? | |
| **3** | How does it feel to be an advocate for biomarker testing? | |

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## Biomarker Campaign Rubric

**Directions**

*Evaluate the campaign by responding with reflective comments based on the expectations below. Use the space in the center column to share evidence with the group. Use the Feedback column for areas of growth and the Exceeded column for areas that excel.*

| Feedback<br>How can this campaign be improved? | Baseline<br>How does this campaign meet expectations? | Exceeded<br>How does the campaign exceed expectations? |
|---|---|---|
| | **Content**: campaign is thorough and has lots of good information. | |
| | **Style**: campaign is clear and easy to understand. | |
| | **Accuracy**: campaign includes facts and cites sources. | |
| | **Format**: campaign shows prior preparation and uses visual aids and tools as necessary. | |