BIOTECHNOLOGY!

Part 7:

Biotechnology and Security

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PART 7: BIOTECHNOLOGY AND SECURITY

Part 7

Find out More!

For additional resources and activities, please visit the _Biotechnology!_ StoryMap at https://bit.ly/3pQUDpc.

Planner

Activity	Description	Materials and Technology	Additional Materials	Approximate Timing	Page Number
Task 1: How can biotechnology help with security?					
Discover	Explore how biometrics work and how you use them.	• Paper • Pencils • Clear adhesive tape		25 minutes	256
Understand	Model facial recognition technology and consider any issues with how it is used.	• Paper • Pens or pencils • Straight edge	Printouts of Figures 7-8 and 7-10 (optional)	25 minutes	262
Act	Draft a set of rules for when and how you think biometrics should be used.	• Paper • Pens or pencils	*Ethical Concerns List* (Part 1)	20 minutes	268
Task 2: What are the threats to security presented by biotechnology?					
Discover	Explore possible outcomes of bio-threat scenarios.	• Paper • Pens or pencils		20 minutes	273
Understand	Investigate bio-threat vulnerabilities within your community and think about possible ways to prevent problems.	• Paper • Pens or pencils • Computer (optional)		30 minutes + investigation time	276
Act	Share information about bio-threats with your community.	• Paper • Pens or pencils • Computer (optional)		15 minutes + action time	280

Task 1: How can biotechnology help with security?

Humans have many individual physical differences. We use these physical differences to help identify one another. **Biometrics** is when this identification is automated by measuring the physical differences of individuals. Biometrics can be very useful, but there are concerns that they can also be used in a harmful way. In this task you will first *discover* more about how you and your community are already using biometrics. Then you will *understand* more about how biometrics work and design your own biometric system. Finally, you will consider the consequences of widespread biometrics use and decide how you will use that information to *act*.

Meet Your Research Mentor

Meet Dr. Monique Mann. Monique (pronounced mo-NEEK) is one of the many researchers around the world trying to harness **biotechnology** to ethically improve security. As action researchers you are also trying to ethically improve security through new technology. Monique will be your research mentor to help you understand more about the role biotechnology can play in security.

Monique is a senior lecturer on criminology. She has a PhD in the human rights impacts of organized crime policing. However, she also has knowledge and perspectives that came from other parts of her identity. Since Monique is now working with you, it is important to understand who she is.

To help you, Monique filled out an identity map, just like you did in Part 1. Monique's identity map includes the following things.

- 34 years old
- Caucasian
- Female
- Lives on the beach in Victoria, Australia
- Interested in new technology, surveillance, and human rights
- Likes yoga, surfing, going on adventures in nature, and camping
- Longsighted, so wears glasses to read, has green eyes

- Curious
- Dog lover: "I have two dogs that I love very much—Maxi is a Dalmatian and Felix is a German Shorthaired Pointer."

Before you begin this task, think quietly to yourself about Monique's identity map.

- Are there things you have in common with Monique?
- Are there ways in which you are different from Monique?
- Can you see anything about Monique's identity, in addition to her university degrees, that would help her understand different perspectives or ideas about security?

Throughout this task you will notice Monique sharing ideas and experiences with you. She may help you understand better ways to do your research or share some of the research she has done.

Discover: *How do you use biometrics?*

There are billions of people on Earth, and each person is unique. This **variation** is useful in many ways. For example, variations among **genes** make it more likely for the human population to have people who can resist a disease or live in a harsh environment. Variations among cultures can provide new approaches to problems. Variations among ideas can offer new solutions or breakthroughs. Variations in human appearance can help identify you as a specific individual. Using your biology in this way can be a useful tool for security. For example, biometrics can be used to make sure the right people have access to things like a phone, or information such as a bank account statement.

Early humans lived in small groups and may have been able to recognize almost everyone they needed to interact with because they personally knew them. However, in modern times most people interact with many people they do not personally know, often every day. How does someone know that you are you, and why is that important? In this activity you will start thinking about those questions for yourself and for your community.

1. Examine the zebras in Figure 7-1. At first you may think they seem identical, but examine them closely. Do you notice any differences in the markings between the two zebras? Work with a partner and point out any differences you notice.

Figure 7-1: How are these two zebras different?

2. Think quietly to yourself. Each zebra's stripe pattern is unique. This means the pattern can be used to identify a specific zebra. Are there things about your physical appearance that are unique, like a zebra's stripes? Create a list of physical **traits** you think could be used as biometrics to uniquely identify you.

3. One thing you may have listed is your fingerprints. Now you will take a few minutes to explore the differences between your fingerprints and your classmates'.

4. Read *Fingerprinting Activity Instructions.*

Fingerprinting Activity Instructions

For this activity you will need a piece of white paper, a pencil, and a few pieces of clear adhesive tape.

a. Near the top of the paper, use your pencil to shade in a small area.
b. Rub your fingertip over the shaded area until the graphite from the pencil is all over the end of your finger.

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c. Press your finger onto the sticky side of a piece of tape.

d. Turn the tape over and stick it onto the bottom of the piece of paper.

e. Repeat with different fingers, if you would like.

f. Examine your fingerprint carefully. There are three main types of patterns you will see—arches, loops, and whorls—but there is variation within these types. Which type or types do you notice in your fingerprints?
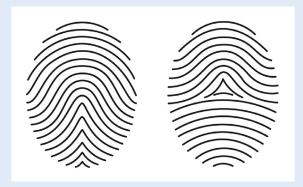

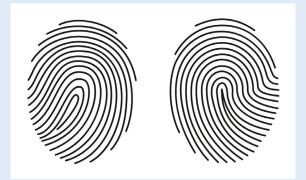*Figure 7-2: Examples of arch patterns in fingerprints.*

Figure 7-3: Examples of left loop and right loop patterns in fingerprints.

Figure 7-4: Examples of whorl patterns in fingerprints.

g. Compare your fingerprints to those of your teammates, especially if they have the same type of pattern as you. Are any of them exactly the same?

5. Discuss with your teammates places or times you have noticed fingerprints being used to identify people. Have you ever had your fingerprints used to identify you?

⚠️ **Emotional Safety Tip**

Sometimes fingerprints can be used by police or other law enforcement officers. You may have had your fingerprints taken or know someone who had their fingerprints taken for this purpose. You may have strong feelings about that experience. That is okay. You will be thinking later in this task about when you think biometrics such as fingerprints should be used. But if you are upset now, it is okay to pause and take a break. If you do not feel comfortable sharing about your experience with fingerprints, you do not need to share.

6. Go back to the list you made of traits about people that could be used to identify individuals. Share your ideas with your teammates and build a group list. Think together about whether there is anything else to add. Be sure to consider:

   a. Can you think of any biometrics that might rely on more than appearance? For example, do you think humans may have unique sounds or smells?

   b. Are there ways to tell people apart if you have a sample of cells from their body, like a drop of blood or a bit of saliva or a hair?

7. Read *Biometrics and Identity*.

Biometrics and Identity

Some people think that physical items like keys or cards, or information like a password or identification number, are not secure. Physical items or information can be lost, stolen, or given to another person.

What if instead you used the variations among humans as a security tool? There are many unique biometrics of humans that can help identify specific people.

Computers can be programmed to identify you using your unique biometric information. The computer does this by comparing a sample of your biometric information (like your fingerprint) against a **database** of many people's biometric information, until the computer finds a match. Some biometric databases, or sets of information, include more than one billion samples.

Physical appearance

Biometrics are most commonly related to physical appearance, such as:

- Fingerprints
- Facial recognition
- Iris (eye) scan
- Palm prints
- The pattern of your veins (vascular biometrics)

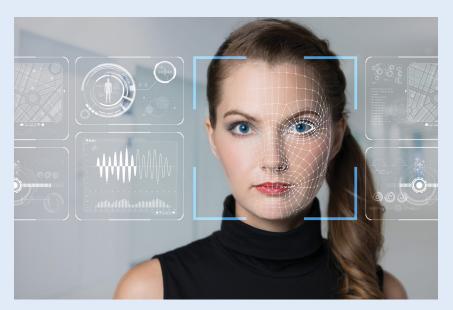*Figure 7-5: Examples of biometric types, including face, voice, and iris.*

Other biometrics

Tools to identify other biometrics are sometimes used as well, such as:

- Voice recognition
- Gait analysis (the way you walk)
- **DNA** analysis

8. Think about the different types of biometrics and your experience with them. If you are comfortable, tell your teammates about a time you had a biometric used to identify you.

9. With your team, discuss any examples you can think of related to how biometrics might be used to:

    a. Allow you to access or not access specific places

    b. Allow you to access specific things that you own or use

    c. Allow you to access or not access specific data or information

    d. Find out who was or is in a specific place

10. Have each team member pick one type of biometric from the _Biometrics and Identity_ box and share with the team the advantages and disadvantages related to:

    a. How accurate you think it is, like could it be used to identify you without mistaking you for someone else

    b. Whether it could be used without your knowledge

    c. Whether there are physical differences that might make this biometric impossible to use for someone, such as if a person is missing a finger and the biometric is a fingerprint

11. Read Monique's thoughts on collecting data through biometrics. Why might people be concerned about having data about themselves collected through biometrics?

Monique says . . .

I think people really need to be aware of what's happening in terms of why their information is being collected and how it's being used, stored, shared, and analyzed. Often when you come to terms of use or service, you just click "accept" and you don't know what that really means. There are definitely positive applications of biometric technology. But we need to think about collecting data for a specific purpose and only that purpose, and then deleting it when that purpose has been met.

Understand: *How is your face used to identify you?*

There are many types of biometrics, but for most of them you have to individually scan something—like an eye, a fingerprint, or a DNA sample. Facial recognition technology is a little different. It can scan many people very quickly. It can be used in a public area and sometimes without people's knowledge. In this activity you will learn more about how it works and think about ways in which it can be used.

1. Read *Facial Recognition*.

Facial Recognition

Think of your face as a map. In facial recognition technology the features that stand out easily, like your nose, eyes, and mouth, are called **landmarks**. Facial recognition works by creating points at different parts of the landmarks and then measuring the space between them. For example, maybe the space between two edges of an eye or the space between an upper lip and the bottom of a nose could be measured. Figure 7-6 shows some examples. The white dots are landmarks, and the lines measure the space between them.
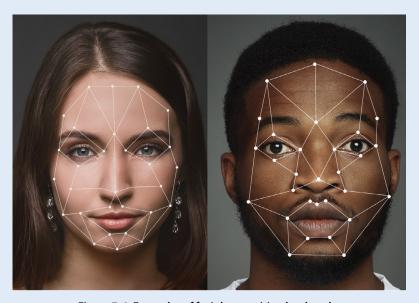

Figure 7-6: Examples of facial recognition landmarks.

Once the distance between landmarks is measured, this is compared to existing data to locate a match.

Sometimes it is compared to one existing biometric scan to verify that the scanned person is the right person. This is called one-to-one facial recognition. This is the way facial recognition on phones works, for example. Your phone contains a stored copy of your facial recognition scan that it matches to your face to unlock your phone.

Figure 7-7: Using a phone for facial recognition.

Sometimes an image is compared to a large database of images to identify someone. This is called one-to-many facial recognition. An example of this would be using facial recognition in law enforcement to identify someone suspected of committing a crime.

2. Think like a biometric designer and share your answers to these questions with your team.
   a. What would be some of the difficulties in measuring landmarks on a face?
   b. Which landmarks do you think you would use on a human face?
3. Now you will have a chance to create a facial recognition biometric using non-human faces. Pick one of the wild cat pictures shown in Figure 7-8.
4. If you are using a printed version of these pictures, either lay a piece of paper that you can see through over the picture you picked or hold the picture up to the window and put a piece of paper over it. If you are using this guide digitally, put a piece of paper over the screen. Use a pencil to lightly mark dots on the edges of major facial landmarks. Use 10 dots or less. Do not show anyone else which cat you are using to create your biometric scan.

Tiger

Cheetah

Lion

Leopard

Black Panther

Snow Leopard

Cougar

Lynx

Manul
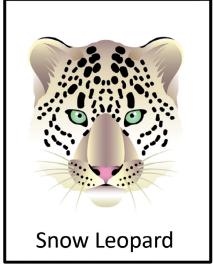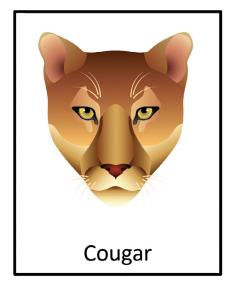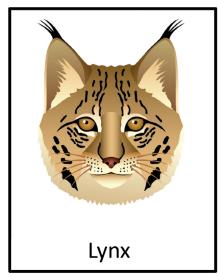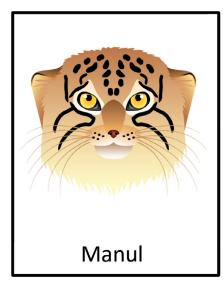
Figure 7-8: Wild cat pictures.

5. Put your paper back on a flat surface and use a straight edge to connect the dots to create a biometric scan. Figure 7-9 shows an example.
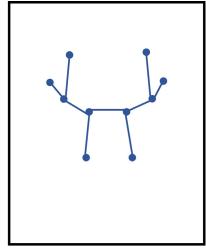
Figure 7-9: A facial recognition biometric of the tiger picture.

6. Switch biometric scans with a partner. Can you both identify which cat you used to create your biometric scan?

7. Discuss with your team:
    a. What was difficult about this activity?
    b. Do you think some of the cats are harder to create facial scans of than others? If so, why?

8. Now create a biometric scan of the tiger face in Figure 7-10. You may need to use more dots to create landmarks. Try to use as few as possible.

Figure 7-10: Tiger face.

9. Compare your biometric to the animals shown in Figure 7-11. Can you find a match? Do not use the picture to compare—only your biometric scan. Compare your answer to those of your teammates.

Figure 7-11: Wild cat biometric database.

10. Read *Bias and Facial Recognition*.

> ### *Bias and Facial Recognition*
>
> Facial recognition currently does not work equally well for all groups. For example, for people with darker skin or wearing makeup, many facial recognition scanners may have trouble figuring out where to place the facial landmarks. Computers scan many reference photos to learn to recognize the differences between faces. But if these reference photos are too similar, like the people in them come from largely one ethnic group or gender, then sometimes the computer will become better at identifying the differences among people from that group than among people from other groups. These problems with the technology creates **bias**, a situation in which specific groups are treated unequally.
>
> There is also another problem of bias in facial recognition. If there are many people who look like you in a database, you are more likely to be falsely identified as a match, known as a **false positive**.
>
> You may have just created a false positive in the last activity. Did you find a match for your tiger biometric? None of the tigers in Figure 7-11 match your biometric scan. Yet, because there were so many tigers present in the database, you or someone in your team may have identified a match.

11. Consider the following scenario: A law enforcement database has a lot of people from one specific racial or ethnic group. Discuss with your team:

   a. Would you be more likely to have a false positive if you were part of that racial or ethnic group?

   b. What impact do you think those false positive identifications might have?

   c. Read Monique's ideas. What problem does she identify?

Monique says . . .

One-to-many facial recognition uses databases to identify unknown persons. Often one-to-many is also used in a changing, live environment, like tracking someone as they move in a public space through CCTV (closed-circuit television) or security cameras. In those situations, facial recognition has been demonstrated to be biased against people of color and particularly women of color. Part of this is due to the **algorithms** and the data sets used to train the computer to make a match. The other issue is the data used to create the database. For example, if you use photos taken when people are arrested, if you have groups, like people of color, that are disproportionately overrepresented in things such as the criminal justice system, then that bias also becomes part of the database and the facial recognition system.

12. Discuss with a partner:

   a. What are your thoughts about the advantages and disadvantages of using facial recognition technology?

   b. What are some opportunities to use facial recognition in a positive way?

   c. How could facial recognition be used to track where people go and what they do? Do you think that is a problem?

   d. Read Monique's ideas. Do you share her concerns?

Monique says . . .

We are all under surveillance and it is not just from the government and law enforcement; the ones who are really the best at facial recognition is companies, like social media companies. If you have a social media account where you upload pictures, often these pictures can be used to create a biometric template and added to a facial recognition database. Sometimes these databases can be accessed by law enforcement agencies.

Companies also use this information to develop profiles about people to target advertising at them to convince them to buy things. Biometrics have the potential to link your physical presence in real life and potentially all this other information out there about you that's held in databases or on the Internet.

Act: *How should we be using biometrics?*

Biometrics can be a useful tool to identify people. In this activity you will consider ethical concerns with using biometrics and create a set of rules for when and how biometrics should be used.

1. Look at the *Ethical Concerns List* you created in Part 1 and then read what Monique says. Are there any ethical concerns that might relate to using biometrics? Use these ideas in the next activity.

Monique says . . .

We must be really mindful of the context and purpose of using a technology and what that means for individuals in society. With biometrics there are clear risks in terms of violation of fundamental human rights: not only the right to privacy, but many others, like freedom of political expression, anti-discrimination, and **freedom of association** [the freedom to join together with others to express or defend similar interests]. Privacy is a foundational right that is needed for all these other rights.

2. Read *Biometrics Situations*. Assign each team member a situation or create your own situations. Think about the situation and share with your team:
   a. Which ethical issues might be a part of this situation?
   b. Do you think a biometric tool should be used? Why or why not?

c. If you choose to use a biometric tool, which one would you use? For example, would you use facial recognition, iris, palm prints, fingerprints, voice, gait analysis, or DNA?

Biometrics Situations

a. There is a large sporting event that many people attend and you are searching for any wanted criminals.
b. You own a company that has sensitive information stored inside the building where employees work.
c. You design a country's border controls and you want to make sure you know who is entering and leaving your country.
d. You work for local law enforcement and you are searching for a missing child.
e. You have a banking system that people need to securely access online.
f. You own a large shop and would like to make payment options more convenient.
g. You work at a social media site and want to make it easy to identify people in photos that are posted.
h. You want to stop vandalism in a downtown park.
i. You want to find an easy and secure way for people to access their smartphones.
j. You are trying to advertise your products and want to be able to personalize the billboards people see.
k. You want to have your phone or personal home device recognize your voice when you ask it a question out loud.
l. You are a school leader and want to make sure only students and staff are present in the school building.
m. You work for a transit authority and want to find a way to cut down on lines to go through entry control.
n. You are trying to identify bodies of people killed in a natural disaster.
o. You are a government worker and many people are protesting something the government has done. You would like to find out more about who is part of the protest.

3. Think quietly to yourself. Do some people on your team have different perspectives on when biometrics should be used? Why is what others think important when considering biometrics?

4. Different places are making very different rules when it comes to facial recognition. Read Monique's ideas to find out more.

Monique says . . .

Different places have different rules for data protection and privacy. For example, there are proposals in the European Union to ban facial recognition or limit the use of facial recognition in public spaces unless it is in certain extreme conditions, like a missing child or an imminent terrorist attack. Other places it is more unregulated and, for example, companies can film you if they just put a little sign up somewhere saying they are doing it. People may not even be aware, and they may or may not know exactly what's happening.

5. Read these three facial recognition rules. Pick the rule that would make you most comfortable. Discuss with your team why you picked the one you picked.

    a. A country has decided not to use facial recognition at all in public areas to stop any abuses and protect people's privacy.

    b. A country uses some facial recognition in public areas and allows a facial recognition database to be built from the driver's license pictures of some people from the country.

    c. A country uses facial recognition widely. Public spaces and transportation are all monitored using facial recognition to stop any crime and ensure that people are who they say they are.

6. Think to yourself: If you had to make the rules about when and how biometrics could be used, what rules would you make? Write down or find another way to record your answer. Be sure to consider:

    a. Should biometrics be used when people are not aware they are being used?

    b. How do you protect people from false positive identifications?

c. Are there certain places it is okay for biometrics to be used? Do think certain other places are not okay?

d. Is it okay for biometrics to track you as you move around during the day?

e. Who should be able to access collections of biometrics data and how long should the data be kept?

f. How should biometrics databases be built? For example, should you have to agree to participate? Or should the database include only people who have been arrested? Or should you be allowed to pull pictures that were posted on social media to create the database?

7. Why do you think it is important to talk to others about these ideas? Read Monique's thoughts and consider what conversation you would like to have about the use of biometrics.

Monique says . . .

I think we need a broader consultation and community discussion about the role of technology in our lives and the type of society we want to live in. There are both positive and negative applications of biometric technology. We should think about the kind of values we're embedding in technology and the way we're using it. What does it mean if we live in a surveillance state where technology can be used to surveil and control the entire population? What are we trying to achieve in terms of the type of society we want to live in and the appropriate protections for human rights?

8. Discuss your thoughts on biometrics rules with a friend or family member later today or tomorrow. Do they have some ideas or concerns that are different from yours? Listen carefully to understand why they might have a different perspective from you, and carefully explain your perspective.

Task 2: What are the threats to security presented by biotechnology?

Biotechnology uses living things, parts of living things, or things produced by living things to solve people's problems and meet their needs. Sometimes this means engineering new or modified organisms through selective breeding or genetic modification. Sometimes this means moving biological systems or organisms to new places or using them in new ways to create things or perform services that are useful to people. As you have learned, both of these biotechnological approaches create tremendous opportunities for better human health, food, materials, and more **sustainable** resource use. These approaches also create potential threats to a secure future for people and the planet.

In this task you will be learning about those threats and how you can help prevent them. First you will *discover* ways in which biotechnology might cause harm. Then you will investigate vulnerabilities in your community to *understand* more about ways to guard against these threats. Finally, you will *act* to share this information with others in your community.

Meet Your Research Mentor

Meet Dr. Zabta Shinwari. Zabta (pronounced ZAB-tah) is one of the many researchers around the world trying to protect the planet from threats from biotechnology. As action researchers you are doing the same. Zabta will be your research mentor to help you understand more about the possible threats from biotechnology.

Zabta is professor emeritus at Quad-i-Azam University in Pakistan and a former secretary-general of the Pakistan Academy of Sciences. He is a specialist in biotechnology and biosecurity and received the 2015 UNESCO Avicenna Prize for Ethics in Science. However, he also has knowledge and perspectives that came from other parts of his identity. Since Zabta is now working with you, it is important to understand who he is.

To help you, Zabta filled out an identity map, just like you did in Part 1. Zabta's identity map includes the following things.

- Born in the Shinwari tribe on the border of Afghanistan and Pakistan
- Tall, with black hair and fair skin
- Likes to travel, chat with friends, walk in the wilderness
- Funny, kind, and sensitive
- Committed to extending higher education to neglected communities in Pakistan
- Born into a big family—seven brothers and a sister!
- Married another Pakhtoon (his ethnicity) and they have five daughters and two sons
- Four of his daughters got PhDs, which makes him very proud!
- Interested in working with Indigenous communities in Pakistan, trying to safeguard their knowledge and find ways to reduce poverty
- Likes to write—has published nine books and 445 articles

Before you begin this task, think quietly to yourself about Zabta's identity map.

- Are there things you have in common with Zabta?
- Are there ways in which you are different from Zabta?
- Can you see anything about Zabta's identity, in addition to his university degrees, that would help him understand different perspectives or ideas about biotechnology and security?

Throughout this task you will notice Zabta sharing ideas and experiences with you. He may help you understand better ways to do your research or share some of the research he has done.

Discover: *How could biotechnology be harmful?*

Every day you probably think about the future and risk. For example, if you are thinking about your day and know that you are going to be out at lunchtime, you may think there is a risk you will be hungry and so you take a snack. Or if you are walking near a busy road you may think there is a risk you will be injured by a car, so you stay away from the edge. Thinking about what is likely to happen in the future is called

foresight. In this activity you will use foresight as a tool to think about possible futures of different biotechnology tools.

1. Take a paper and divide it into two columns. Title the first column "Helpful." Title the second column "Harmful."

2. Read *Scenario One* quietly to yourself. Each scenario in this section is based on a real-world event. For more information, see the *Biotechnology!* StoryMap.

Scenario One

A group of scientists is researching ways that viruses might mutate to become more dangerous. They use biotechnology tools to produce targeted mutations to create viruses that are more harmful to humans so they can understand how to fight these viruses. These genetically engineered viruses and the information about them are kept in secure labs. If the viruses were out of the lab and spreading in the population, there would be risks to human health.

3. Discuss with your team the possible future **outcomes** you can think of for this scenario. An outcome is the end result or consequence of something. Think about the possible ways the situation described in the scenario could create outcomes that benefit or hurt people and the planet. Write or draw your ideas in the appropriate column.

   a. *Helpful:* What are the possible future outcomes that could help people or the planet? List them on this column.

   b. *Harmful:* What are the possible future outcomes that could harm people or the planet? List outcomes might harm a few people or other living things in this column, or could hurt many people or whole ecosystems.

> ⚠️ **Emotional Safety Tip**
>
> Thinking about terrible things that might happen in the future can be scary and stressful. No bad outcomes or catastrophic outcomes are already decided. By understanding issues that concern you now, you can become part of the effort to prevent these outcomes. Scientists and others around the world are also working hard to prevent these types of outcomes.

4. Read Zabta's thoughts. Do his ideas make you think of any additional possible helpful or harmful outcomes? If so, add those to your list now.

Zabta says . . .

Using biotechnology and gene editing is getting easier. It is getting easier to modify viruses. This means more researchers have access to this technology and there is more possibility of viruses getting out of a research setting. It is important to make people aware of ways that biotechnology can be misused, to understand how it can become dangerous. Viruses don't respect borders. Once a virus is circulating in a population, it can go anywhere, as we learned with COVID-19.

5. Read *Scenarios Two*, *Three, Four*, and *Five* by yourself. For each scenario, record things that could be helpful and harmful in the appropriate column on your paper. Make sure you consider how diseases, pests, and misinformation can spread and how that can affect human and animal health, the environment, and economies.

Scenario Two

Many farms around the world raise pigs for meat. Sometimes equipment, people, or feed goes from one farm to another. Recently some pigs have been getting very sick with a disease that kills most of them within 20 days. The disease does not harm humans, even if they eat meat from infected pigs. There is a risk that this disease could spread between pigs in different farms, affecting farmers, consumers, and the whole economy.

Scenario Three

In one country the main staple food is maize (or corn). Although they grow a lot of maize, this country also imports it from other places. One of those places is on another continent. Maize growers on that continent are struggling because there is an insect that attacks and eats their crops. There is a risk that this insect could spread to the country through the imported maize.

Scenario Four

Scientists are able to use biotechnology to rapidly create useful and safe vaccines, drugs, and therapies to help prevent and cure illnesses. However, there is misunderstanding and misinformation about these technologies, leading to a lot of fear and suspicion about using the vaccines, drugs, or therapies. There is a risk that this misinformation could spread among people and lead them to make decisions that are not good for their health.

Scenario Five

The ability to rapidly sequence DNA and develop therapies that target specific sequences of DNA is revolutionizing medicine. Yet there is a risk that scientists could use DNA sequences to create a **bio-weapon** that would target a specific person or a group of closely related people, such as a family or ethnic group.

6. Compare your *Helpful* and *Harmful* lists with your team members.
    a. Are there some outcomes other team members thought of that you would like to add to your lists? You can do that now.
    b. How could some of the things that might happen help or harm you personally?

7. Consider the harmful outcomes you listed. Examine your _Futures Mood Board_ from Part 1. Add any new concerns you now have. In the next activity you will be thinking about how to stop those outcomes from happening.

Understand: *How can we keep ourselves safe?*

Some biotechnology tools and research can be called **dual use technologies**. Dual use technologies can be used for a good or helpful purpose, like to prevent and fight illness, to make people healthier, or to protect food systems. These biotechnologies can also have the potential to create harm, like to create viruses that could causes diseases in humans or other living things.

The harmful outcomes you identified in the Discover activity can also be called **bio-threats**. Bio-threats can be caused by mistakes people make, or **bio-error**. They can also be caused deliberately to create harm; this is called **bio-terror**.

1. Reread the *Scenarios* from the Discover activity. You are going to create a *Process Map* of steps that might lead to the harmful outcomes you identified.

2. Divide your team into four groups and assign each group a scenario from one to four. For each scenario, map out the process of different steps that might lead to harmful outcomes. Figure 7-12 shows an example using *Scenario Five*. Use a different scenario to create your own *Process Map*.

A person, group, or government decides they want to harm a specific ethnic group → Find scientists to help design a bio-weapon → Find a space to do high-level laboratory research → Get needed materials → Genetically engineer a bioweapon → Use the bioweapon

Figure 7-12: Mapping the process that leads to harmful outcomes from Scenario Five.

3. For each step in this process, consider ways this might happen. Write or draw them on the *Process Map*.

   a. Think about bio-error possibilities—ways mistakes might be made that lead to harmful outcomes. List or draw those ideas above your *Process Map*. You may want to use another color pen or marker.

   b. Think about bio-terror possibilities—ways someone might deliberately cause a harmful outcome. List or draw those ideas below your *Process Map*. You may want to use another color pen or marker.

4. Now examine your *Process Map*. For each step think about how you could prevent the next step from happening if:

    a. The problem was bio-error: Write or draw those ideas next to the bio-error possibilities on the *Process Map*.

    b. The problem was bio-terror: Write or draw those ideas next to the bio-terror possibilities on the *Process Map*.

5. Have each group share their *Process Map* with the rest of the team.

6. Discuss with your team:

    a. Are there ways you personally might be able to help stop bio-error or bio-terror?

    b. Are there other people, organizations, or governments you think could help stop bio-error or bio-terror?

Zabta says . . .

Education is important. Science is a public good. We need to think together about how to be good citizens and good human beings. We need to think carefully about the information we spread; information itself can become a weapon if it stops people from acting safely.

I work with international organizations to help coordinate scientists working to stop bio-threats. I work with groups of scientists around the world. But I also work with students in my country because everyone needs to understand that they have a part to play in keeping our world safe.

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7. Sit in a circle with your team. One by one go around the circle and list places or things in your local community that might be vulnerable to bio-threats such as disease or invasive pests. Be sure to consider:

    a. Human health

    b. Shared food or water sources

    c. Your local economy

    d. Your local natural environment

    e. Places in your community, like laboratories, where biotechnology research is happening

8. Pick one vulnerability to investigate further. Then read the _Bio-Threat Vulnerability Investigation Instructions_.

Bio-Threat Vulnerability Investigation Instructions

Consider how you can find out more about the vulnerability your team picked. Make sure you find out:

1. What are the bio-threats to this vulnerability?
2. How serious are they?
3. How can they be prevented?
4. How might you help?

Possible methods to find this information

a. Online: Check for government, scientific, or news websites that contain details about the vulnerability you are thinking about. For example, if you are investigating what might threaten a crop lots of farmers in your area grow, you could search for potential diseases or invasive pests that would hurt that crop.

b. In print: Many bio-threats have been around for years. You may be able to use a library or other place to learn more.

c. Contact a local organization: Is there an organization in your community that helps support the thing or place you are investigating? They might have a lot of useful information. You can search for any documents they share with the public. Or you can contact them and ask to interview them.

d. Interview a scientist: A scientist who studies the bio-threat might be a good source of information. You can contact them and ask to interview them.

e. Another method: Be creative. Maybe you know another way to get the information you need.

Tips for conducting an interview

a. Make sure to ask permission to record a person's answers.

b. Ask permission to share the interview with the rest of your team, class, or other people in the community. People might be more willing to share if their interview is anonymous.

c. If it feels as if someone didn't answer your question, don't be afraid to ask the question again in a different way.

d. Let the person you are interviewing answer the questions in the way they want. Be patient. Listen carefully. Understand that they might give answers you didn't ask for or expect.

Safety tips for interviewing people

Ask your teacher for guidelines. They will know what is safest in your community.

⚠ **Physical Safety Tip**

Never conduct an interview alone and always be aware of your surroundings. You might want to suggest recording the interview in a quiet public place.

⚠ **Emotional Safety Tip**

It can be hard to communicate with other people in the community. You may feel shy or nervous. Someone may tell you they don't want to talk. That's okay! It doesn't have anything to do with you. It just means they don't want to share. You can show them respect by thanking them and moving on to another person.

9. Pick one or more methods to conduct your investigation.

a. Decide who on your team will do what. Remember, including everyone is important. Try to pick methods that allow everyone on your team to participate in some way.

b. Make notes or find other ways to record what you learn about the bio-threat during your investigation.

Act: How can we work toward a safe future?

Having foresight and understanding the threats to your community is important. This allows you and others to take action to combat these threats. In this activity you will think about how to share what you have learned with others.

Zabta says . . .

Youth can be change managers. People need to gain awareness and realize that they can anticipate things and take responsibility for the future. We need to think as a whole species, what will help us survive and do well? I wish the world leadership would change the phrase "national interest" into "human interest," because we are all connected.

1. Take out your notes from your bio-threat investigation in the Understand activity.

2. Discuss with your team, who in your community do you think should know more about this vulnerability? Pick one audience to focus on. For example, do you want to share what you have learned with other young people, with adults, with people who work in a specific type of job, people who live in a specific place, or another group?

3. Consider the audience you chose. What is your goal in communicating with them? For example, do you want them to just be more aware of the threat, do you want them to be more careful, do you want them to create a law or regulation, do you want them to understand how their actions affect other people, or do you want them to do something else?

4. Decide on your message. What are the most important ideas to share? Think about the information you gathered and the harmful outcomes you listed in the Discover activity. Choose information that will lead your audience toward your goal.

5. Design the message. What would be the best way to share this information? Be creative! For example, maybe you could create a poster or infographic, you could record a short video to share on social media, you could use a podcast to tell a story about the vulnerability, you could create a meme, or choose another way to reach your audience.

6. Take the message you designed and share it with your audience.

7. Reflect with your team about the process of creating and sharing your message. Discuss:

    a. What went well?

    b. What could have gone better?

    c. What would you do differently next time?

Congratulations!

You have finished Part 7.

Find out More!

For additional resources and activities, please visit the *Biotechnology!* StoryMap at https://bit.ly/3pQUDpc.

Glossary

This glossary can help you understand words you may not know. You can add drawings, your own definitions, or anything else that will help. Add other words to the glossary if you would like.

Algorithm: A process or set of rules followed to solve a problem or do a calculation, often by a computer

Bias: A situation where different groups are treated unequally

Bio-error: A bad outcome of biotechnology caused by a mistake someone made

Biometrics: Identifying someone by measuring the physical differences among individuals

Biotechnology: Using living things, parts of living things, or things produced by living things to solve people's problems and meet their needs

Bio-terror: A bad outcome of biotechnology caused intentionally to harm others

Bio-threat: A harmful outcome from biological agents or biotechnologies

Bio-weapon: Viruses, bacteria, fungi, or other living things or toxic substances from living things released to deliberately cause harm

Database: A large set of information stored digitally

DNA: A molecule in all living things that transfers and stores genetic data

Dual use technologies: Products and tools that can be used for a helpful or a harmful purpose

False positive: When a match is incorrectly identified as present

Foresight: Thinking about what is likely to happen in the future

Freedom of association: The freedom to join together with others to express or defend similar interests

Gene: A section of the base pair sequence in DNA that codes for specific traits

Landmarks: In facial recognition technology, these are the features that stand out easily on your face, like your nose, eyes, and mouth

Outcome: The end result or consequence of something

Sustainable: An approach that balances different perspectives and can keep working for a long time

Traits: Characteristics

Variations: Differences in living things