

The Microbiome and Mental Health

Objectives

Students will:

- Explore the function of various microbes in a person's microbiome.
- Evaluate information and data examining the influence of the microbiome on a person's mental health and function.
- Create a portion of a giant infographic.
- Present the information they have learned to the whole group for feedback and evaluation.

OVERVIEW

In this lesson bundle, students will evaluate a growing body of evidence showing that the tiny microbes living in your gut may have a major influence on your brain. Students will first take an interactive survey to determine what they already know about depression and anxiety and the impact they have on our mental and physical health. Students will then learn about what their microbiome is—the collection of bacteria and other microbes that take up residence in a person's body.

Next, they will be asked the question *“is there evidence to support the claim that our microbiome may influence our mental health?”* Students will be asked to form groups that will work together to create a giant classroom infographic that pieces together evidence that gut microbes may affect the immune and nervous system and play an important role in helping us regulate our mental health. Each group will be assigned a topic associated with research surrounding the gut-brain connection, such as prebiotics and probiotics, the vagus nerve, serotonin, dopamine, and beneficial microbes.

Students will then research how their topic connects to the microbiome and mental health. Each student group will create a large 2-D informational graphic on a poster board that contains pictures, diagrams, and information explaining their topic's connection to mental health and the microbiome. Groups will present their informational graphic to the class and add it as a piece of the infographic on the classroom wall. To conclude this activity, the class will evaluate each piece of evidence in the infographic and discuss which one(s) they feel best supports the claim that the microbiome influences mental health.

The accompanying presentation was created with PowerPoint so that it can be used in a variety of classrooms. Modifications for distance learning or use in virtual classrooms are included throughout this lesson. If you are using a laptop with a projector, simply progress through the

PowerPoint by clicking to advance. All of the interactive aspects of the presentation are set to occur on click. This includes images, text boxes, and links to outside videos, which will appear in your web browser. If you are using an interactive whiteboard, tap on each slide with your finger or stylus to activate the interactive aspects of the presentation. It does not matter where you tap, but you can make it appear as if you are making certain things happen by tapping them. There are notes for the instructor in the notes for each slide.

CONTENT AREAS

Human Health, Medicine, and Microbiology

ACTIVITY DURATION

4 class sessions (45–50 minutes each)

GRADE LEVEL

Grades 9–12

ESSENTIAL QUESTIONS

- What makes up a person's microbiome?
- What are some of the mental and physical consequences of depression and anxiety?
- How does the gut-brain connection influence our mental health?
- Could altering or supporting your microbiome through foods help prevent poor mental health?

MATERIALS

All days

- Device with the ability to project
- Student 1–1 devices (laptop, iPad)

Day 1

- Investigating the Microbiome capture sheet (1 per student)

Day 2

- Gut-Brain Connection Research and Planning capture sheet (1 per group)

Day 3

- Materials for creating infographic sections including (but not limited to)
- Poster board (1 per group)
- Hot glue and glue sticks
- Scissors, craft knife

- Paint or markers
- Old magazines to cut images or text from
- Printer to print images from the Internet

Day 4

Student access to <https://info.flipgrid.com/> on devices (laptop, iPad, cell phone)

For virtual classrooms or use in distance learning, student devices should have access to Powerpoint (or Google Slides), Padlet, Zoom, YouTube, Google Docs, Tinkercad, or Google Forms.

Links to Virtual Classroom student tools:

- <https://zoom.us/>
- <https://www.youtube.com/>
- <https://www.tinkercad.com/>

BACKGROUND

Mental health is certainly an important topic in today's society. In the last decade, there has been a rapid and significant rise in anxiety and depression in teens and adolescents. Counseling, medication, and lifestyle choices such as exercise can help young people reduce the risk of and overcome mental health challenges. However, scientists have recently been exploring the influence that our microbiome—the collection of trillions of microbes that make our bodies their home—has on our brain function and the role it may play in reducing the risk of anxiety and depression, among other things. Studies on mice have shown that, without a healthy and diverse population of microbes in our digestive system, the production of important mood-regulating molecules such as serotonin and dopamine from the cells are decreased. People taking prebiotics and probiotics show improvement in struggles with mental health, and the American Gut Project has found that those with a more diverse diet have a more diverse set of gut bacteria, which send essential signals to the brain. With a poor diet leading to a lack of diversity in the microbiome, scientists believe communication from the gut to the brain is compromised, likely resulting in some of the anxiety, depression, and mental health challenges that adults, teens, and children face today.

This guide gives educators a collection of resources designed to help students investigate the concept of the human microbiome and what we are learning about its influence on human health. It provides slide-by-slide instructions to ensure educators are prepared to explain, discuss, and facilitate the hands-on content in the presentation. The presentation is designed to cover four class sessions, but it can be flexible depending on the students' needs and the time available. Additional extension ideas are included at the end of the guide.

This lesson plan follows the inquiry-driven 5E instructional model: Engage, Explore, Explain, Elaborate, and Evaluate.

ENGAGE | Slides 1–3

OVERVIEW

Instructor will open with an interactive survey for students that will help determine their existing knowledge of the frequency of anxiety and depression in teens and adolescents. Students will be given the opportunity to discuss their reaction to the results of the survey and think about what factors may contribute to the mental health crisis we are seeing today.

DAY 1 | SLIDE 1

To open the lesson and activate students' previous knowledge, ask them to complete a short survey on depression and anxiety in young people using their devices. Ask them to go to <http://tophat.com> and provide a code for the survey.

*Prior to having the students answer survey questions, the instructor should create an account at <http://tophat.com> and create a survey about students' preconceived ideas about depression and anxiety. Below is a list of sample questions (some will be true/false questions, and some will be multiple choice, the instructor may add or reduce questions as they choose—correct answers are highlighted):

- 1 The rate of depression and anxiety seen in teens and adolescents is higher now than ever before.
 - a. True
 - b. False
- 2 According to the National Institutes of Health, nearly _____ of all adolescents ages 13 to 18 will experience an anxiety disorder.
 - a. 1 in 100
 - b. 1 in 50
 - c. 1 in 10
 - d. 1 in 3
- 3 The rate of diagnosed depression is equal in adolescent boys and girls.
 - a. True
 - b. False *Girls have a higher rate of depression
- 4 Which factor seems to be linked to poor mental health in adolescents?
 - a. Family
 - b. Community
 - c. Healthcare
 - d. All of the above

- 5 The number one cause of teenage suicide is
- Bullying
 - Academic pressure
 - Untreated depression
 - Drug use
- 6 Teen depression and anxiety is more likely if the person's family has a history of it.
- True
 - False
- 7 There is really no way to prevent anxiety and depression in young people; there are only ways to treat it.
- True
 - False

Links for Statistics

<https://cpyu.org/2015/09/15/teen-depression-a-helpful-infographic/>

<https://cpyu.org/2017/05/26/teens-and-anxiety-a-helpful-infographic/>

<https://www.healthychildren.org/English/health-issues/conditions/emotional-problems/Pages/Anxiety-Disorders.aspx>

DAY 1 | SLIDE 2

When students have completed the survey, go through each question and display student answers on the overhead screen. Ask students for their reactions to the correct answers—were they surprised? Next, ask students to raise their hands if they personally know someone who has dealt with anxiety or depression in their life. (Likely most, if not all, students will raise their hands.) Encourage students to look around and see how common depression and anxiety are in the lives of people. What do students think may contribute to the prevalence of mental health issues in young people?

Virtual/Remote Learning adaptation: For real-time class collaboration during a virtual lesson, the instructor can invite students to join a scheduled zoom meeting (<http://zoom.com/>).

DAY 1 | SLIDE 3

Explain to students that in this lesson, they will be focusing on the answer to the last question in the survey □ how can we help prevent anxiety and depression in our lives? While most people will immediately think of prevention such as counseling, exercise, and medication, scientists are learning surprising information about how your mental health may be linked to an unlikely ally—your gut!

EXPLORE | Slides 4-7

OVERVIEW

Students will be introduced to the microbiome. They will use a graphic organizer to take notes with a partner as they view an introductory video and use an interactive online tutorial to learn about one of the microbiome's jobs in the body. They will share what they learned with the whole class to help them understand the many important roles that the microbes in your microbiome play to ensure that person is physically healthy.

DAY 1 | SLIDE 4

Ask students if they have ever heard of the term “microbiome?” Allow students who respond yes to share what they know about the microbiome with the class. Ask students to pair up for the next activity and explain that they will be learning about what the microbiome is and the many ways that it impacts our body and health. Give each pair of students a copy of the “Investigating the Microbiome” capture sheet.

Virtual/Distance Learning adaptation: The “Investigating the Microbiome” capture sheet can be posted as a shared google doc that all students have access to on the google classroom platform, or as a shared document on a preferred online platform.

DAY 1 | SLIDE 5

Explain to students that in this capture sheet, they will first be watching a short video to learn about the general function of the microbiome. As (or after) they watch, they should work together to complete the “definition” and “model” sections. In their own words, they should define “microbiome,” and create a sketch that represents what the microbiome is in the model section. Play the video You Are Your Microbes (<https://www.youtube.com/watch?v=1X8p0vhsWRE>) for the class, and give student pairs time to complete these two sections when the video concludes. Give students the opportunity to share their definition and models to the class to compare and revise if necessary.

Virtual/Distance Learning adaptation: The instructor can create breakout groups for each gene assignment during a zoom meeting to allow students to discuss and collaborate with each other.

Virtual/Remote Learning adaptation: To show videos to students in a virtual lesson, the instructor can use Zoom (<http://zoom.com/>) for a live lesson and use screen sharing to show, pause, and give commentary on an online video. The zoom meeting can also be recorded and be posted as a link for students to view if a real-time option is not possible.

DAY 1 | SLIDE 6

Next, assign each pair one of the following topics that will be added to the “Jobs of Microbes” section of the capture sheet: nutrition, immunity, protection from infection, maintenance of protective barriers, organ development, more functions. (Note: Some groups will have to have the same topic, as there are only 6 topics.) Ask student pairs to go the following interactive website: <https://learn.genetics.utah.edu/content/microbiome/friends/>. They should click through the interactive and find their topic. They should read about what their microbiome job entails to summarize and add this information to the final section—“What This Job Entails” section of the capture sheet.

DAY 1 | SLIDE 7

Once students have completed their capture sheet, ask student pairs with the same topic to take a few minutes to meet and compare the information they recorded about their topic. They should choose one spokesperson to share this information with the whole class. Spokespersons should take turns sharing with the group how microbes do their job. When this activity is complete, students will have a more complete picture of the many things the microbiome is responsible for and involved with in the human body.

Virtual/Distance Learning adaptation: The instructor can create breakout groups for each gene assignment during a zoom meeting to allow students to discuss and collaborate with each other.

DAY 1 | SLIDE 8

Finally, to complete the capture sheet, explain to students that they will look at the impact that a person’s microbiome may have on their genes—how they are expressed—and how this may impact a person’s health. Give students the link to the article “How Trillions of Bacteria in Your Body Can Change Your Genes” at <https://health.clevelandclinic.org/billions-bacteria-bodies-change-genes/>. Ask students to read the article and complete the final section on the microbiome and gene expression in the capture sheet.

EXPLAIN | Slides 9-12

OVERVIEW

Now that students have learned how much the microbiome regulates a person's physical health, they will now explore the role the microbiome plays in mental health regulation. Students will learn about their enteric nervous system (ENS), often referred to as our "second brain" because of its communication with the nervous system and the substances that it produces such as dopamine and serotonin. Student groups will focus on one aspect of the gut-brain connection that scientists are exploring. They will read information from articles, studies, and websites to determine how their topic relates to the microbiome and the regulation of mental health. The information they collect will then be used to create a classroom infographic.

DAY 2 | SLIDE 9

Begin class by explaining to students that now that they have an understanding of the prevalence of anxiety and depression in adolescents and have learned about the many ways the microbiome affects the body, today they will be researching possible links between the two by looking at how the microbiome may influence our mental health.

Explain to students that scientists have been discovering that the microbes that make up our microbiome may have an important influence on our nervous system! To introduce this to students, play the video: What If You Had A Second Brain (<https://www.youtube.com/watch?v=T3Ftj5E90tY>). After viewing the video, ask students for their reactions and initial thoughts. Had they heard of any of this information before? Do they think that our gut and microbiome might really have an influence on our brains?

DAY 2 | SLIDE 10

Explain to students that in this activity, students will begin by investigating a specific area of research looking at how the microbiome and enteric nervous system (ENS) may influence our brain and mental health. Ask students to form groups of four, and give each group a copy of the Gut-Brain Connection Research and Planning capture sheet. Assign or allow students to choose from the following components of this area of study displayed on the screen:

- The Vagus Nerve
- The Potential of Prebiotics and Probiotics
- Microbes Beneficial to Mental Health
- Serotonin and Dopamine and Microbes
- Leaky Gut and the Microbiome
- The Microbiome and Anxiety
- The Microbiome and Depression

Virtual/Distance Learning adaptation: The Gut-Brain Connection Research and Planning capture sheet can be posted as a shared google doc that all students have access to on the google classroom platform, or as a shared document on a preferred online platform.

DAY 2 | SLIDE 11

Explain to students that they will be using their research on the role that each of these topics plays in the gut-brain connection to create a section of an infographic that will inform the reader about the possible links between the microbiome and mental health.

However, this will not be a digital infographic like the ones they may be used to seeing. Instead, this will be a giant infographic that will be displayed on the classroom wall, and each group will use a piece of poster board to design their section. Sections will then be pieced together to create the overall infographic titled “Microbiomes and Mental Health.”

Inform students that they are not limited to the links and articles provided on the research sheet, but they are there for them to use. Most links are not specific to just one topic, so they may have to review the articles to find the information they are looking for.

*If students are not familiar with infographics, or if the instructor feels they need a review over what an infographic is, show students the following video: What Makes An Infographic Effective? (<https://www.youtube.com/watch?v=rI9ZcfKt8sY>) before students begin planning and creating their infographic section.

Virtual/Remote Learning adaptation: Students can use an infographic program such as Canva or Piktochart which will allow them to collaborate and create a digital section of their infographic. These can then be downloaded as images and pieced together digitally to create one class infographic.

DAY 2 | SLIDE 12

For the remainder of the period, students will read through links and articles, compile their research, complete their group research sheet, and begin planning their infographic section.

ELABORATE | Slides 13–15

OVERVIEW

In this culminating activity, students will work with their groups to create and present their section of the “Microbes and Mental Health” class infographic. The team will use what they learned from their research to add terms, facts, evidence, and data to their infographic section on a poster board. Once the infographic sections are completed, groups will take turns presenting their infographic section and securing it to the classroom wall, piece by piece as each group presents. By the time the infographic is complete, students should have a clearer picture of much of the evidence that supports the idea that our microbiome has an influence on not only our physical health, but our mental health as well.

DAY 3 | SLIDE 13

Ask students to get into their groups from the previous day and get out their Microbiomes and Mental Health research and planning sheets. If they feel that their research on their topic and infographic planning is complete, they may get the materials needed to create their infographic.

Give students time to use the classroom materials to create their infographic section.

When students are finished creating their infographic section, they should discuss how they will present the information to the class. A suggestion to involve all group members is that each person is responsible for a section of the research, including background information, summarizing connections, evidence and studies, and statistics and data.

DAY 4 | SLIDE 14

Instruct students to rejoin their teams from Days 2 and 3, and explain that they should use the beginning of the class period for final preparations of the presentations of their infographic sections.

DAY 4 | SLIDE 15

It’s time to create the class infographic about the microbiome and mental health!

Explain that each group will be given 3–5 minutes to present their infographic section. Give the audience an opportunity to ask any questions they may have and give feedback after each presentation has concluded. Once the group is finished they should stick their infographic section to the wall under a heading created by the instructor “Microbiomes and Mental Health.” All sections of the infographic should be touching to create one large infographic.

Virtual/Remote Learning adaptation: Student groups can share their infographic during a zoom meeting, which will allow the instructor to display their infographic section as a shared screen during the meeting.

EVALUATE | Slides 16–17

OVERVIEW

In this evaluation of student learning about the microbiome and its links to mental health, students will use Flipgrid, a free online discussion and video assessment platform to answer the question “How might the microbiome influence a person’s mental health?” They will use the information from the class infographic to help them support their answer to the question. The teacher and students can then watch the responses of all class members to compare their answers and see how the information on the infographic was used.

DAY 4 | SLIDE 16

Now that the presentations and classroom infographic are complete, ask students to go to <https://info.flipgrid.com/> on their student devices or cell phones. Explain to students that for this final part of the lesson, they will be using the information they learned to support the idea that the microbiome plays a role in the genetic expression, brain function, and overall mental health of a person.

DAY 4 | SLIDE 17

Once students have all created and uploaded their Flipgrid videos, allow students to use the remaining time to view the responses of their classmates. They can rate and leave emojis on the responses of others as well give final feedback for this lesson.

EXTENSION

If you have additional time and/or would like to further challenge your students, consider the following extension options:

- In the activity, students learned that the microbiome certainly has an impact on how genes are expressed and the products produced by cells, but does a person’s genetics also play a role in the makeup and regulation of their microbiome? Have students read the article “Genes and Microbes Influence One Another, Scientists Find” at <https://www.scientificamerican.com/article/genes-and-microbes-influence-one-another-scientists-find/>. Ask students to summarize and discuss the article to determine how obesity may be linked to heritable microbes, based on the research provided. Do they think that genes may influence the microbes that play a role in mental health as well?
- Further explore mental health and how it affects young people, have students go to the following website: <https://www.nami.org/Your-Journey/Teens-Young-Adults>. Students can explore strategies to help friends who are struggling with anxiety and depression, read about warning signs of poor mental health, and see more infographics with information and statistics on the teen mental health crisis.

- You may have heard of the microbiome, but did you know that scientists are finding the connection between the microbes in your body and your immune system—and these microbes may be able to influence cancer growth and other diseases? Check it out here!
 - https://www.youtube.com/watch?time_continue=12&v=Q5PgPUvOBzo
 - <https://www.youtube.com/watch?v=A-lqdPch9t0>

NEXT GENERATION SCIENCE STANDARDS (NGSS)

Next Generation Science Standards

- HS-ETS1-3. 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.
- HS-LS1-2 Develop and use a model to illustrate the hierarchical organization of interacting systems that provide specific functions within multicellular organisms.

COMMON CORE STATE STANDARDS FOR ENGLISH LANGUAGE ARTS

Common Core ELA Standards

Grades 9–10

- [CCSS.ELA-LITERACY.RST.9-10.2](#). Determine the central ideas or conclusions of a text; trace the text's explanation or depiction of a complex process, phenomenon, or concept; provide an accurate summary of the text.
- [CCSS.ELA-LITERACY.SL.9-10.1.D](#) Respond thoughtfully to diverse perspectives, summarize points of agreement and disagreement, and, when warranted, qualify or justify their own views and understanding and make new connections in light of the evidence and reasoning presented.
- [CCSS.ELA-LITERACY.SL.9-10.5](#) Make strategic use of digital media (e.g., textual, graphical, audio, visual, and interactive elements) in presentations to enhance understanding of findings, reasoning, and evidence and to add interest.

GRADES 11-12

- [CCSS.ELA-LITERACY.RST.11-12.2](#). Determine the central ideas or conclusions of a text; summarize complex concepts, processes, or information presented in a text by paraphrasing them in simpler but still accurate terms.
- [CCSS.ELA-LITERACY.SL.11-12.1.D](#). Respond thoughtfully to diverse perspectives; synthesize comments, claims, and evidence made on all sides of an issue; resolve contradictions when possible; and determine what additional information or research is required to deepen the investigation or complete the task.

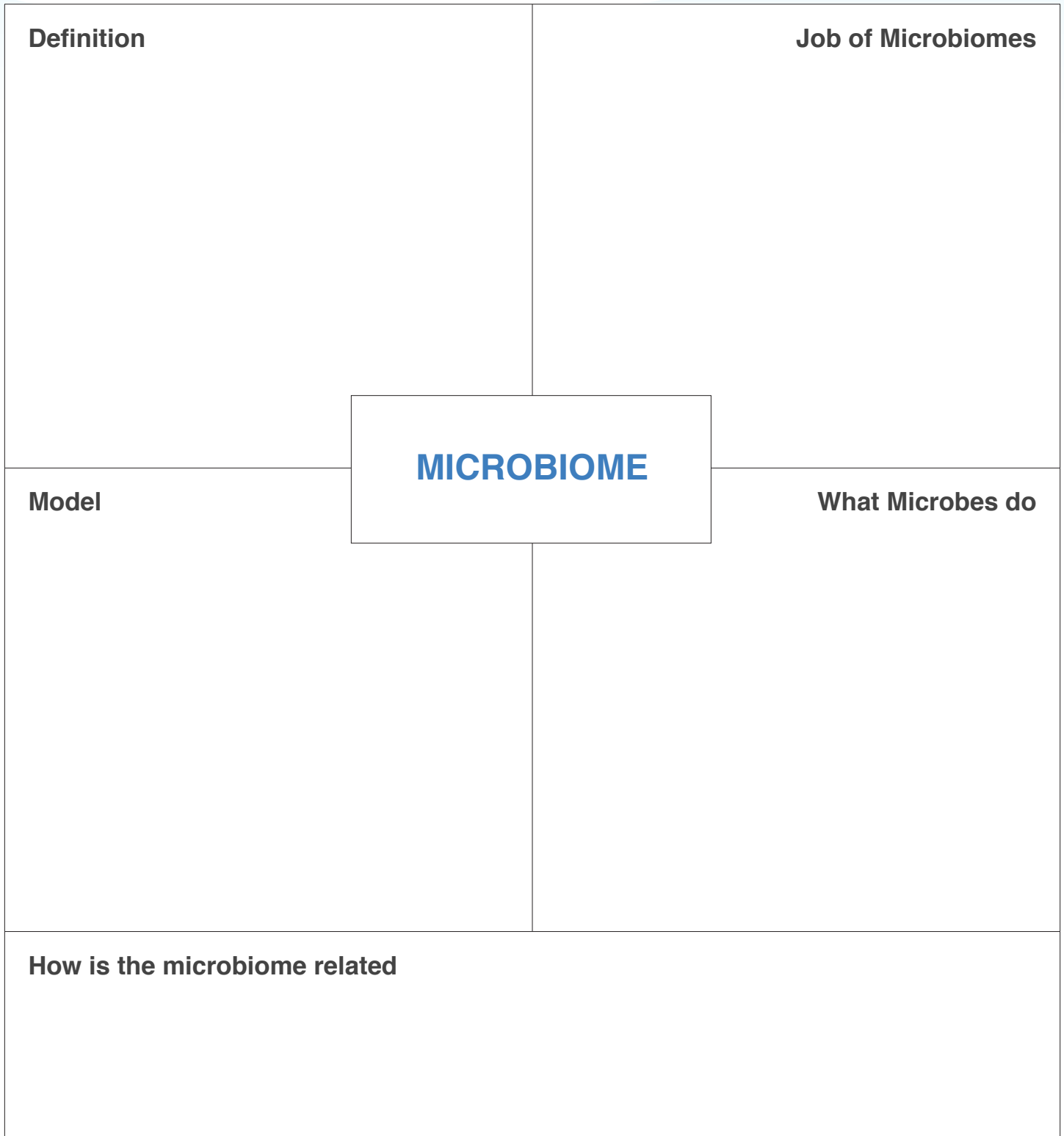
ITEAA STANDARDS FOR TECHNOLOGICAL LITERACY

Technology and Society, Standard 3: Students will develop an understanding of the relationships among technologies and connections between technology and other fields of study.

J. Technological progress promotes the advancement of science and mathematics

Technology and Society, Standard 4: Students will develop an understanding of the cultural, social, economic, and political effects of technology.

I. Making decisions about the use of technology involves weighing the trade-offs between the positive and negative effects.



Research

Directions: Use the space below to record notes from your research that you will use in your infographic section. As you perform your research, do your best to find reputable news sources, and focus on quality over quantity! Your notes do not have to be in complete sentences. Use the links below to help you find the information you are looking for. You are not limited only to these links.

Library of Helpful Links:

- [How your gut might modify your mind](#)
- [Anxiety might be alleviated by regulating gut bacteria: Review of studies suggests a potentially useful link between gut bacteria and mental disorders](#)
- [Friendly bacteria cheer up anxious mice](#)
- [Microbes Help Produce Serotonin in Gut](#)
- [Gut Bacteria Might Guide The Workings Of Our Minds](#)
- [Scientists Find a Possible Link Between Gut Bacteria and Depression](#)
- [How your belly could heal your brain](#)
- [What we do and don't know about gut health](#)
- [Does the Microbiome Program Mental Health in Infancy?](#)
- [Evidence mounts that gut bacteria can influence mood, prevent depression](#)

TOPIC: _____

A. Background information on your topic—define any new terms, explain your topic.

B. Summarize how your topic relates to the gut-brain connection.

C. What evidence or studies support the idea that your topic or that the microbiome influences brain function and mental health?

D. How does your topic show a link between the microbiome and a person's genes? (Do microbes signal a genetic response or influence the expression of genes in some way? Do they aid our genome or help it do something it can't do on its own?)

E. Are there any statistics or data that you could add to your infographic that would support your summary?

A. What types of illustrations (images or graphics) would you like to include in your infographic section? (These can be drawn or printed and pasted to your infographic section).

B. What materials will you be using? You will have access to the following materials:

- Poster board (1 per group)
- Hot glue and glue sticks
- Scissors, craft knife
- Paint or markers
- Old magazines to cut images or text from
- Printer to print images from the internet

C. Use the space below to sketch out or plan where information and illustrations will go on your infographic section before you begin creating it.