Meet the Lab

Cancer Detectives: Superpowered by Laser Microscopes

Educator Guide

PBS Wisconsin Education
MORGRIDGE INSTITUTE FOR RESEARCH
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Project Background: *Meet the Lab* and STEAM Identity

Meet the Lab is a series of learning media resources designed to introduce middle school students to scientific research through a human lens. This makes it different from many online science education resources that focus solely on science content learning (the "what" and "how" of science learning). Instead, *Meet the Lab* was created to focus on the "why" and the "who" of science learning, addressing two specific challenges in the science classroom:

As a science teacher, how do I:

- Connect science learning to the community at-large and to real-world problems in a way that resonates with my students?

- Connect science learning to my students' identities, and illuminate possible academic and career pathways for them to pursue?

Meet the Lab offers media resources and activities that we hope will serve you as you dig into these challenges. Each lab starts with a context-setting video that describes real-world problems that are relevant to student lives. We follow that with a second video and two activities that introduce students to multiple real-life scientists (as well as real lab content and practices), with a goal for students to relate to the scientists personally and to consider the possibilities of STEAM in their future.

A student's STEAM identity ("Who do I think I am, who can I be, where do I belong, and how do others see me?" in context of Science, Technology, Engineering, Arts, and Math) starts to develop very early on. Middle school is a critical time for students to actively construct their identities, and identify directions and possibilities for their lives. The science classroom is one place for students to develop an internal drive for science, and to see science and career pathways in science as relevant and accessible.

Meet the Lab features lab teams (rather than only featuring individual scientists), showing how diverse groups of people work together across disciplines to pursue answers to questions about our world. We hope this will support a parallel vision for student groups in your science classroom to work together as they enact scientific practices to answer relevant scientific questions.

Learning Goals

By using *Meet the Lab* resources, students will:

Learning Goal	**Project Component**
Make connections between lab research and why it matters in real life.	*Why Research Matters*
Identify scientific practices researchers use and apply these same practices to classroom experiments.	*Science Practices*
Identify strengths in science, and relate to people in science careers.	*Meet the Scientists*

Meet *This* Lab: Optical Microscopy in Medicine Lab

This set of education resources introduces students to the researchers at the Optical Microscopy in Medicine Lab (founded by Melissa Skala) at the Morgridge Institute for Research, and helps students uncover some of the patterns researchers use to find new treatments for cancer. Researchers at the lab use photonics-based technologies to develop personalized treatment plans for cancer patients (including breast, pancreatic, colorectal, neuroendocrine, oral, and other cancers). They work with oncologists to collect fresh patient biopsies that are maintained in 3D culture, which are then used to screen responses to multiple treatment options for each patient.

Before using these resources: Students should have prior knowledge that the body is made of cells. They should also have a basic familiarity with the structure and function of cell parts, especially the nucleus and cytoplasm.

Founder and Principal Investigator: Melissa Skala

Melissa's Education:

- Selah Middle School and Selah High School (Selah, WA)
- BS, Physics, Washington State University (Pullman, WA)
- MS, Biomedical Engineering, University of Wisconsin-Madison (Madison, WI)
- PhD, Biomedical Engineering, Duke University (Durham, NC)

Melissa says, "I founded this lab because I enjoy building new things and working with light (lasers, lenses, microscopes) while addressing needs in healthcare. I also find fulfillment in mentoring scientists and love the freedom to follow my curiosity.

Activating the *Why Research Matters* Content

This video features one young person's story of how cancer impacted her life and what she did to get involved in helping others as a result. The story is meant to elicit discussion about students' experience with cancer, as well as their prior knowledge and questions about research.

Watch the video as a class or in small teams of students and discuss answers to the questions provided below.

1. Kat saw a problem in the world and took clear steps to make a difference. What problems do you see in the world? What steps could you take to start getting involved?
2. Kat wanted to learn as much as she could about cancer. What do you already know about cells and about cancer? What do you want to know about cancer?

Activating the *Science Practices* Content

This video focuses on the tools researchers at the lab use, the practices used to conduct investigations, and the cross-cutting concept of finding patterns. In the video, researchers from the Optical Microscopy in Medicine Lab answer questions posed by middle school students.

The accompanying slide deck activity allows students to closely examine the images that Amani, one of the researchers, has taken to find treatments for cancer. The slide show steps students through a process of identifying key parts of cells and describing similarities and differences between different cell types. They then identify how cancer cells look different from healthy ones. Next, they examine images taken with the laser microscope seen in the video that identify how cells are metabolizing energy differently in healthy vs cancerous cells. Students examine five different treatment options the lab is investigating to determine which show the most promise for slowing down the growth of cancer. All of the images students will use come from the lab and are involved in real research projects.

On the companion data sheet, students can record their answers to questions posed by Amani, before they move on to the next slide, where she reveals her answers. Encourage students, especially in the treatment section of the activity, to defend their own interpretation of the images and use evidence they see in the image patterns to decide on a treatment. There is room for subtle differences in the interpretations of these images that might lead to productive disagreements and discussions over which treatments look most promising.

The focus is for students to participate with Amani as she identifies ways she uses patterns in her research. This is an NGSS cross-cutting concept that should be made explicit as students are participating in the activity, they are engaging in the same practice of identifying and classifying patterns that a scientist does.

Treatment Names and Descriptions (Optional)
Treatment B: 2-Deoxy-glucose - a sugar that prevents cells from making energy
Treatment C: Iodoacetic Acid - an acid that prevents cells from making energy
Treatment D: Etomoxir - prevents proper functioning of the mitochondria
Treatment E: Rotenone - prevents proper functioning of the mitochondria and causes cell death
Treatment F: Malonate - Causes the mitochondria to produce toxic substances that cause cell death

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Q&A with a *Meet the Lab* Scientist

What's different about the imaging technology you use, compared to simple microscopes?
Amani: This imaging technique gives us more in-depth information about the cells. You are not able to image metabolism with simple microscopes without the addition of external dyes.

Would it be more difficult to test treatments without this imaging technology? Why?
Amani: You would be able to get some of the same information (do the cells die, or live), but it is much harder to detect whether the cells are alive but sick or damaged without the added contrast that we get from the metabolic imaging. You could add dyes and get some similar information, but dyes have been shown to mess up the cells on their own so they are not always reliable.

If you didn't have this imaging technology, is there another way to collect data and make claims about cells and treatments? Why is this other way not as effective? (maybe time, money, difficulty?)
Amani: It is possible to collect similar data, the other methods that are used to collect data about metabolism are much more time consuming and challenging to get the samples right, you have to prepare the samples very carefully for the data to be trusted. You also don't have the ability to look at changes on the single cell level, the other methods are all population level measurements. So you lose the ability to detect whether the treatment works on some or all of the cells.

What are some common words and phrases that Amani the scientist uses?

- **Cancer:** A disease in which abnormal cells divide uncontrollably and destroy body tissue
- **Pancreas:** An organ located very close to your stomach that helps with digestion
- **Pancreatic duct cells:** Special cells lining the pancreas that allow it to function
- **Light microscope:** Uses visible light and lenses to magnify small objects
- **Laser microscope:** Hits samples with very specific colors of light, prompting the sample to emit light that is collected by the microscope
- **Control cells:** Cells that provide a baseline to compare all other variables (treatments) against

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Activating the *Meet the Scientists* Cards

The researcher trading cards are meant to foster students' own STEAM identity by making a connection between themselves and a featured researcher.

Encourage students to review the trading cards from the scientists from the lab, keeping in mind the question "Who do you relate to the most and why?" and then have them discuss what they learned and their own answers to the question in small groups or as a class.

To extend the activity, share the list of superpowers (below) with your class, and ask students to identify which superpower(s) they have. Do they share a superpower with any of the scientists?

Sample superpowers:

Ambition
Compassion
Creativity and Originality
Deep Investigation
Dependability and Follow Through
Endurance and Perseverance
Enthusiasm
Flexibility
Heart and Passion
Imagination and Curiosity
Inclusive Communication
Organization and Order
Outgoing Optimism
Planning and Strategy
Precision and Attention to Detail
Sensitivity and Intuition
Spontaneity and Risk-taking
Super Helper Skills
Terrific Troubleshooting
Vision and Leadership

As an additional extension to the activity, invite students to create their own trading card using the downloadable PDF on the website.

To use the fillable PDF in the browser: Select “View” to open the PDF, fill in the text boxes, and use the “print” function to save as a new PDF (or to make a physical copy). To annotate the PDF in the browser you will need an extension (like Kami for Google Chrome), or you can download and print a physical copy to write on directly.

To use the fillable PDF in an application like Adobe Acrobat: Select the “Download” option. Open the file in your preferred program, fill in the text boxes, and use the “Save As…” function to save as a new PDF.

To use the PDF as a physical worksheet: Just download and print!

Curricular Connections

Are you teaching about DNA, cell division, and/or cancer? Consider having students create a model of what they think causes cancer. Use the resources in this guide (on page 10) to get ideas.

- Students can start by drawing what they think might be happening, write down their ideas and make connections between them.

- Once students have drawn and written their own ideas, they can share ideas in small groups to make a team model.

- Each team should share their ideas with the class. As a class, see where one model addresses questions another model raises. What do we want to know as a class? What information do we need to improve our models? Create a list of questions the class has.

- If students watch the *Science Practices* video and/or complete the activity, return to these models after to add to and revise them. Use the class question list to see what students are learning to answer those questions. Add more questions as necessary.

Standards Supported

Next Generation Science Standards (NGSS)

Disciplinary Core Ideas (DCI):

LS1.A: Structure and Function: All living things are made up of cells, which is the smallest unit that can be said to be alive. An organism may consist of one single cell (unicellular) or many different numbers and types of cells (multicellular). (MS-LS1-1) Within cells, special structures are responsible for particular functions, and the cell membrane forms the boundary that controls what enters and leaves the cell. (MS-LS1-2) In multicellular organisms, the body is a system of multiple interacting subsystems. These subsystems are groups of cells that work together to form tissues and organs

that are specialized for particular body functions. (MS-LS1-3)

Extended version: PS3.D: Energy in Chemical Processes and Everyday Life
Cellular respiration in plants and animals involve chemical reactions with oxygen that release stored energy. In these processes, complex molecules containing carbon react with oxygen to produce carbon dioxide and other materials. (secondary to MS-LS1-7)

NGSS Practice Standards

SCI.ETS1: Students use science and engineering practices, crosscutting concepts, and an understanding of engineering design to make sense of phenomena and solve problems.

SCI.ETS3: Students use science and engineering practices, crosscutting concepts, and an understanding of the nature of science and engineering to make sense of phenomena and solve problems.

Wisconsin Science Standards (WSS)

Disciplinary Core Ideas (DCI) — Life Science:

Learning Priority SCI.LS1.A.m: Structure and Function All living things are made up of cells. In organisms, cells work together to form tissues and organs that are specialized for particular body functions.

a. Example Three-Dimensional Performance Indicators: Conduct an investigation to provide evidence that living things are made of cells, either one cell or many different numbers and types of cells. (MS-LS1-1) Develop and use a model to describe the function of a cell as a whole and ways parts of cells contribute to the function. (MS-LS1-2) Use argument supported by evidence for how the body is a system of interacting subsystems composed of groups of cells. (MS-LS1-3)

Extended version: Learning Priority SCI.PS3.D.m: Energy in Chemical Processes and Everyday Life
Sunlight is captured by plants and used in a chemical reaction to produce sugar molecules for storing this energy. This stored energy can be released by respiration or combustion, which can be reversed by burning those molecules to release energy.

Disciplinary Core Ideas (DCI) — Engineering, Technology, and the Application of Science:

Standard SCI.ETS1: Students use science and engineering practices, crosscutting concepts, and an understanding of engineering design to make sense of phenomena and solve problems.

Standard SCI.ETS3: Students use science and engineering practices, crosscutting concepts, and an understanding of the nature of science and engineering to make sense of phenomena and solve problems.

Meet the Lab resources will work with a Claims Evidence Reasoning and/or Conceptual Modeling approach to teaching. Support for implementing these frameworks can be found through the National Science Teaching Association.

Resources for More Information

On Modeling and Cancer Biology:
For information on the practice of modeling, go to the Wisconsin Department of Public Instruction website and search for “Science and Engineering Practices.”
Link: https://dpi.wi.gov/science/standards/practices#model

For information on cancer biology, go to PBS LearningMedia and search for the “History and Science of Cancer” collection.

For information about the challenges of curing cancer, go to PBS LearningMedia and search for “Kent Hunter” to find and listen to the Earth and Sky Podcast episode about this topic.

On Exploring What Causes Cancer:
The National Institutes of Health (NIH) have several resources for helping educators and students understand the basic biology of cancer on their “Cell Biology and Cancer” education page.

The “Curing Cancer” activity page of the *Teach Engineering* website has resources for helping educators and students understand cancer as well as connections between cancer, math, and engineering.

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Meet the Lab is a collaboration between PBS Wisconsin Education, Morgridge Institute for Research, Wisconsin Alumni Research Foundation, and Wisconsin Institute for Discovery.