U.S. DEPARTMENT OF ENERGY | Office of NUCLEAR ENERGY

SINGLE LENS—MULTIPLE PERSPECTIVES:

VIEWING NUCLEAR ENERGY IN A NEW LIGHT

Essential Question: How can we view things in our world in a different way?

Overview: This activity will enable students to explore their world more closely using an innovative technology, the Smartphone Microscope. The microscope employs a unique design and construction and was invented at the Department of Energy's Pacific Northwest National Laboratory. Students will review the historical context of microscopes and their function, utilize the STEM/STEAM integration of the device which encourages the collection of data (images) from objects that are culturally-relevant to them, and be introduced to 3D printing, advanced manufacturing, and new nuclear technologies.

Invention Backstory: At the heart of innovation, creativity and critical thinking lead to solutions. How did two of our engineers at the Department of Energy's Pacific Northwest National Laboratory come up with their design for a Smartphone Microscope? Well—they were trying to solve a problem! Rebecca Erikson and Janine Hutchison describe in their own words how they took a problem and created a technology to solve it.

"We interviewed a lot of first responders, public health labs and civil support teams. They told us when confronted with a suspicious white powder, the first thing they do is send a sample to the lab where it is put under a microscope. An inexpensive yet powerful microscope in the field could be used to quickly determine whether the material is a threat or a hoax. Listening to their needs we were quickly reminded of a very early microscope—the Leeuwenhoek Microscope, which used a single glass sphere to provide magnification. Taking his lead, we used an inexpensive glass sphere and put it into a housing or clip that we designed and printed on a 3D Printer. Combining this microscope with the great cameras found on cell phones and tablets, we were able to create a very inexpensive microscope that has applications beyond first responders." You can use this link to learn more about Rebecca's work at PNNL and see her laboratory and 3D-printer. And don't miss this video explaining how Rebecca is working in additive manufacturing to keep America safe.

A Bit of History: In the mid 1600's, van Leeuwenhoek (pictured at left) used his imagination and

curiosity to construct a single lens microscope. Most microscopes we use now are called compound microscopes which mean they use more than one lens to magnify an image. Van Leeuwenhoek ground a bead of glass very small to be used for the lens. He was actually able to see things much clearer than scientists that used the compound microscopes at that time. When light hits an object, it can be reflected, which means the light exits the source at an angle directly back or it can be refracted which means that the light exits the substance at an angle that looks offset. Light moves differently when it passes through different substances. When light changes course, it "bends" as it moves through a glass bead and produces a point where all of the light converges. This focal point and its distance from the lens determines the magnification of an object. The smaller the lens, the shorter the focal length and the result is a higher magnification. The bead you will be using in your microscope magnifies 100X and there are also beads that magnify 350X. The open source 3D printing directions for the clips to hold these beads as well as a source to buy the beads are available at this link.

STEM/STEAM Integration: The microscope illustrates for students integrated science, technology, engineering, and math (STEM). For the "S" in STEM or Science, you can study biology (such as plant and animal structure/function), chemistry(material structure), and physics (optics/lenses/light energy). The "T" stands for Technology, the microscope is an innovative technology because you use the camera on a phone or digital device to convert the camera to a 100X microscope. The "E" stands for Engineering, so the device can raise student awareness of how the microscope was designed so that it could be used on multiple devices in a stable manner with the opportunity to capture images. The "M" stands for Math, students can capture images and compare patterns and shapes, introducing students to the importance of these for computer science and algorithms. Actually, because the microscope can be 3D-printed, it is an application of computer science. The "A" for Arts that is a part of the STEAM acronym can be explored by studying the images of different samples and using those images to explore the visual arts.

How the Smartphone Microscope Works: What is a microscope? What does it help us do? These questions will help students think about how and why they might use the microscope.

Students can brainstorm and discuss (if in a group setting) what they might want to look at more closely with the microscope. This is the perfect opportunity for students to think creatively about objects that might be culturally-relevant for them to study. There are Indigenous plants, Indigenous animal's fur, and other things such as natural fibers that can be viewed with the microscope. One thing to keep in mind, light needs to be able to travel through the sample to the glass bead and the lens of the camera. The microscope can be used on the front camera or back camera, but remember that there is a difference in resolution of those two cameras.

Below are some steps that can be used to guide the exploration with the microscope.

1. The microscope lens can be aligned to the front or back camera--it is easier to demonstrate on the front camera, if someone uses it on the back they need to turn the flash ON and place the lens directly on the object. No extra App needed, just the camera App that is already on the phone, tablet, or computer.

2. Place the lens on the front of the camera and align the glass lens of the microscope on top of the camera. Make sure you have a good light source above the phone or tablet. It also helps if the brightness is turned to high on the device. (This is a great opportunity to talk about light as a form of energy--especially with younger students who may want to place a solid, opaque object over the lens.) You want to align the lens so there is a white circle that appears on your screen.

3. Place the object to be viewed DIRECTLY on the glass lens. Students can take pictures, videos, and it can also be used with APPS that employ a camera such as Snapchat, WhatsApp and others.

4. It is sometimes easiest to start with something simple such as salt on a piece of tape because that is something that is familiar with most populations. Students also like to look at money, hair, skin cells(they can take a piece of tape and press on their arm for skin cells), and anything that is important or interesting to them. Here are a few examples of other things you can look at through your microscope:
   a. Any type of leaf, flower, or grass
   b. Crystals of different substances (salt, sugar, baking soda, different spices such as pepper, cinnamon, turmeric, or other types that you use when cooking)-- use a

clear piece of adhesive tape to attach crystals, then make sure you place the crystal side of the tape directly on the microscope. If you use tape, what else do you see? (You can see the adhesive that is used on tape to make things stick.)

   c. Paper money
   d. Strands of thread, hair, dust particles, lint

5. If students would like to send some cool images to #microSTEM and @GovNuclear that would be great!

How This Device Relates to Nuclear Energy: So you might be thinking, how does all of this relate to nuclear energy?

In the same way that scientists and engineers, like Rebecca, use their creativity and STEM skills to solve real-world problems, they are also solving the real-world challenge of providing clean and reliant energy to people around the globe. Innovations in nuclear technology are happening now and they are using some things like 3D printing or additive manufacturing to construct parts for new nuclear technologies like small modular reactors (SMRs).

Here are two examples of how 3D printing, the same process that printed the smartphone microscope, is being used, albeit on a grander scale to contribute to advanced nuclear technologies.

Kairos Power

The Department of Energy (DOE) Oak Ridge National Laboratory (ORNL) successfully 3D printed a salt pump impeller for Kairos Power's new advanced reactor prototype. Additive manufacturing, also known as 3D printing, allows developers to make complex, three dimensional shapes from a computer design file. Traditional manufacturing methods would have required Kairos to mold, cast, finish, and machine the impeller before testing it. By incorporating 3D printing techniques with real-time data characterization, Kairos was able to cut months off of the design process and save thousands of dollars. Follow this link to read more about the 3D printed key component.

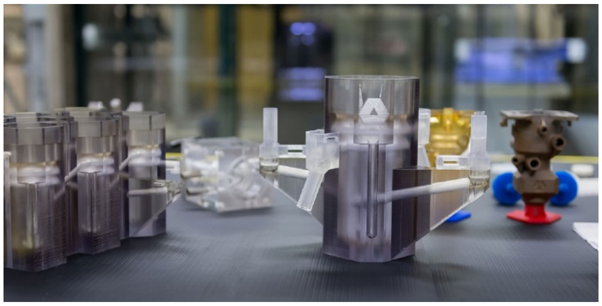

Photo courtesy Argonne National Laboratory

Another DOE National Laboratory, Argonne National Laboratory, is utilizing the flexibility of 3D printing, or additive manufacturing, as a pathway to recycle up to 97% of used fuel produced by nuclear reactors. This new approach could drastically reduce the amount of used fuel stored and the time it remains hazardous. Follow this link to learn more about 3D printing and nuclear fuel.

For Educator Use-- Next Generation Science Standards(NGSS):

4-PS3 Energy
Students who demonstrate understanding can:
4-PS3-1.Use evidence to construct an explanation relating the speed of an object to the energy of that object.
Science and Engineering Practices:

Ask questions that can be investigated and predict reasonable outcomes based on patterns such as cause and effect relationships. (4-PS3-3)

Use evidence (e.g., measurements, observations, patterns) to construct an explanation. (4-PS3-1)

Disciplinary Core Ideas:

Energy can be moved from place to place by moving objects or through sound, light, or electric currents. (4-PS3-2), (4-PS3-3)

Light also transfers energy from place to place. (4-PS3-2)

Cross-cutting Concepts:

Energy can be transferred in various ways and between objects. (4-PS3-1), (4-PS3-2), (4-PS3-3), (4-PS3-4)

Science affects everyday life. (4-PS3-4)

4-PS4 Waves and Their Applications in Technologies for Information Transfer

PS4.B: Electromagnetic Radiation

Disciplinary Core Ideas:

An object can be seen when light reflected from its surface enters the eyes. (4-PS4-2)

Cross-cutting Concepts:

Similarities and differences in patterns can be used to sort, classify, and analyze simple rates of change for natural phenomena. (4-PS4-1)

MS-PS3 Energy

Cross-cutting Concepts:

Science knowledge is based upon logical and conceptual connections between evidence and explanations (MS-PS3-4), (MS-PS3-5)

MS-PS4 Waves and their Applications in Technologies for Information Transfer

MS-PS4-2. Develop and use a model to describe that waves are reflected, absorbed, or transmitted through various materials.

Science and Engineering Practices:

Develop and use a model to describe phenomena. (MS-PS4-2)

Integrate qualitative scientific and technical information in written text with that contained in media and visual displays to clarify claims and findings. (MS-PS4-3)

Science knowledge is based upon logical and conceptual connections between evidence and explanations. (MS-PS4-1)

Disciplinary Core Ideas:

When light shines on an object, it is reflected, absorbed, or transmitted through the object, depending on the object's material and the frequency (color) of the light. (MS-PS4-2)

The path that light travels can be traced as straight lines, except at surfaces between different transparent materials (e.g., air and water, air and glass) where the light path bends. (MS-PS4-2)

Cross-cutting Concepts:

Technologies extend the measurement, exploration, modeling, and computational capacity of scientific investigations. (MS-PS4-3)