BIO-MACHINE:
NATURE INSPIRED EXPERIMENTS

BIODIVERSITY TOPIC BRIDGE

Experimenting is an important part of the creative process. Thinking creatively and critically are 21st Century skills that students will need to address future challenges and opportunities of our world. Nature Inspired Experiments explore the NGSS crosscutting concepts of patterns, structure and function.

Nature Inspired Design

NATURE INSPIRED EXPERIMENTS: SEEING THE INVISIBLE

Biodiversity loss threatens the invisible systems that connect us, like pollination. Pollinators are facing the threat of extinction, and with each species lost is a wealth of information and services that nature provides. Pollinators are good teachers because of their incredible diversity, and impact on local and global systems.

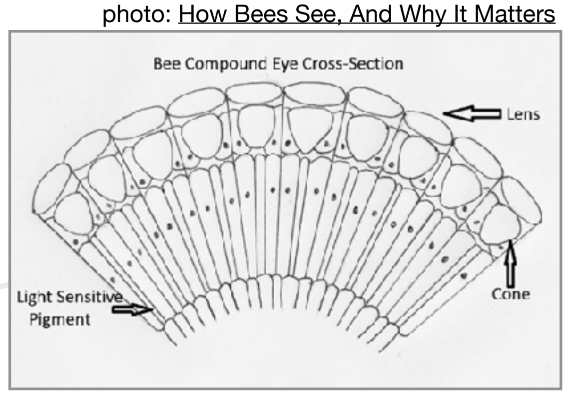
Pollinators have developed many biological adaptation strategies from specialized leg hair for buzz pollination, to complex eyes that perceive subtle environmental cues to locate resources essential to survival. An eye that can see polarized light is one feature shared by many animals that have influenced the development of innovative TECH tools like polarimetric cameras that can see better underwater, detect abandoned land mines, identify cancerous tissues, sense invisible pollutants and more.

Nature Inspired Design looks to nature for the adaptations and strategies that will help us design more efficient technologies and resilient systems that support biodiverse ecologies. Studying nature at multiple scales can influence breakthrough ideas. *What can we learn by modeling the design of nature's specialized adaptions to place?*

BioSTEAM WIKI KEYWORDS

electromagnetic spectrum
polarized light
optics
polarizer
sky compass
polariscope
sensing the invisible
solar navigation
quantum biology
bees
bats
butterflies
experiment

photo: How Bees See, And Why It Matters



Pollinator eyes are specialized to see wavelengths on the electromagnetic spectrum that we can't see like ultra violet light that helps them navigate to nectar rich flowers. Pollinators like bees, butterflies and bats can also see qualities of light that we can't see with our eyes alone like the light polarization that happens in our atmosphere, even during cloudy weather or at night by the milky way.

COPYING NATURE'S GOOD IDEAS

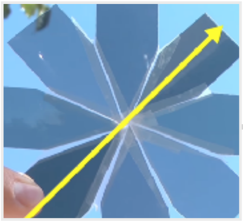
When daily sunlight hits Earth, the light scatters at a ninety degree angle as it encounters air molecules in our atmosphere. This phenomena creates predictable polarized patterns in the sky used by many animals, like pollinators, for orientation and navigation. Most light is unpolarized in that it is moving in multiple directions, polarized light on the other hand moves on a plane in one direction. Pollinators can perceive the optical effect of polarized light with specialized photoreceptors in their eyes. With some simple tools we can model this specific aspect of pollinator sight and visualize polarized light normally invisible to the human eye.

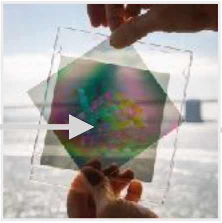
WHAT IS A POLARIZER?

Light can be polarized when passed through a polarizing filter or material. A polarizer is a device that helps scientists, or other people with human eyes to control or visualize the phenomena of polarized light. Some polarizing tools include sunglasses, 3D Glasses, a sky compass, polariscope or polarimeter, and polarized mosaics. These tools use single and multiple layers of polarized film to visualize atmospheric polarization, stress test materials or to see things invisible to the naked human eye. Polarizers like polarimeters are used in photoelasticity experiments to visualize the patterns and details that indicate stress or weakness in materials.

EXPERIMENTING

Design and build a creative polarized light device that incorporates multiple layers of polarizing film to visualize the qualities of polarized light in your environment. Make your own "mashup" device inspired by polarizers, the polariscope, sky compass and polarized mosaics using layered polarized filters and recycled materials. Observe nature and the objects around you with and without device. Record your observations. These devices come in many styles, materials and forms- research the differences. Use your creativity and be resourceful! Experiment using your device as a sky compass and a polariscope. Journal your observations and any new questions that stand out.





Your Awesome Idea

POLARIZED FILM SHEET ONE

Sheet one can detect polarized light by changing liner orientation in relationship to light waves. For example a used as a polarized sky compass.

Example

MIDDLE CLEAR PLASTIC SHEET/ OTHER

The middle sheet can demonstrate the different speeds polarized light travels across the long polymer molecules of transparent tape for example. Sandwich birefringent material to analyze (like cellophane tape mosaic, clear plastics, viking sunstone or piece of mica) between two rotating layers of polarized sheets. Observe the effects.

Example

POLARIZED FILM SHEET TWO/ LCD DISPLAY

Can be used with sheet one, birefringent middle, sheet two and a light source like a flashlight or bright window to observe the twisting of polarized light. The second polarized sheet is used as the third layer of the polarizer sandwich. Sheet two can be another polarized sheet or a LCD (Liquid Crystal Display) computer screen. For example used as a Polariscope.

Examples

BUILD IT!

Build a hand held frame or wearable device out of recycled or natural materials for one and two layers of polarized film that can be individually rotated or used separately- the goal here is to be able to use your polarized light device to demonstrate:

a) Atmospheric polarization of light and solar navigation
b) The use of polarized filters in seeing the invisible

BASIC PROJECT MATERIALS

Inspiring DIY projects and instructions can be found in the BioSTEAM wiki and online. The materials below are the basic materials needed to do the experiment. The exact form you create is up to you and may require other elements to express your design vision.

1. **Polarized Film sheets**: Can be purchased in sheets and slides; can be salvaged from recycled phones, computer monitors and other recycled LCD screens; old polarized sunglass or 3D glasses.

2. **Clear middle** sheet like glass, plexiglass, sheet protector, old CD cover or overhead acetate.

3. Cellophane tape like **clear packing tape**, or other plastic materials to test, minerals like mica and crystals, iridescent bugs, or experiment with items around school or home.

4. **Recycled Materials** like cardboard, card stock, sticks (for a frame), old sunglass frames, eye masks, plastic, homemade bioplastic or what ever you have. Be creative!

5. **Light source**: The sun, lamp or LCD screen (has the bonus of built in polarizing filter).

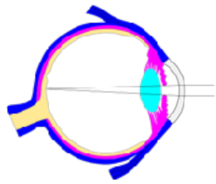
Get creative with your device. Experiment with the form to make something you wear like glasses; write a poem on the surface of your creation about pollinators or the challenges they face; use colors or patterns to communicate a metaphor; make an robotic polarizing all seeing eye or another unique idea that you come up with.

TEST IT!

Go outside! *What can you observe with one layer of your interactive polarized light visualizer (for example: using as a sun compass)? Does your sky compass work in all weather?* Try it out on a sunny or cloudy day. *What patterns do you observe at different times of the day or season? Does your design communicate what you want?*

Observe patterns in the structures of materials. *What details can you observe using both layers (for example: using as a polariscope)?* Materials to test in your polarized light viewer: Plastics (Polarizers are used to stress test materials in engineering!), minerals like mica and calcite crystals, iridescent bugs, cellophane tape mosaics or experiment with items around school or home. Journal any observations. Share your results. *If you had to share your device could another student understand how to use it? What can you add to your polarizer device to communicate something that you learned or want to say artistically about the patterns or details you observed?*

Discuss with class: How might you create model that more closely captures how bees see for example, that incorporates a compound eye shape that observes polarized light and ultraviolet light (UV)? What could we learn from this model?



OBSERVATIONS IN NATURE: PATTERNS + DETAILS

Artists, scientists and engineers make observations and visualize the patterns and details of the environment around us in order to build models to study and communicate ideas. Drawing is a creative and technical skill to prototype and work out solutions to the complex problems that come up in interdisciplinary work. Natural observation of processes, relationships, feedback mechanisms, patterns, shapes, diversity and scale can be expressed through diagrams, sketches, or technical drawings. Experiment with drawing and diagramming the environmental data around you. Share drawings with other students as a gallery collection or presentation to draw inspiration from each other, or as research for the BioMachine BioSTEAM Challenge.

Explore pollinators and biodiversity around us. *What human tools or technologies do we have to observe the world around us? What can we observe in our back yard? What can we observe together?*

How does body shape or structural adaptations influence the properties or functions of pollinator survival?

DRAWING PATTERNS
Observation of patterns, processes and relationships in nature
Get outside and explore the nature around you from different perspectives. Create a three section drawing that captures patterns and relationships in your local environment at different scales, for example: from the point of view of a grain of pollen, a bee, a field of flowers, or a giant. Pick three scales *you* find interesting (tiny to huge) to view the world from and draw the patterns you observe. Identify and discuss patterns as a group. *What relationships can you observe looking from different scales and perspectives?* Create a diagram individually or as a group that communicates shared patterns or relationships observed. Think about for example wind pollination and night pollinators: *what pollination relationships are we not seeing? Why?*

How can we communicate the visible relationships we observed as data? What invisible relationships can we communicate and with what tools?

DRAWING DETAILS
Observation of micro details: zooming in on natural structure and function
Do detail drawings of pollinator body or plant adaptations that can be examined under a microscope or with online microphotography. Human TECH tools like the DINOLITE or other handheld microscopes can see and share detail unseen by the human eye. Draw and analyze pollinator specimens. Examples could include the electromagnetic hairs on a bee, compound eyes, or other features of interest. Try sketching specimens at varying time intervals.

What features in nature inspired you? What shapes stood out? How might the time spent on a subject drawing impact the structural or functional detail you are analyzing? What might the structure of a pollinator reveal about patterns and relationships in nature? For example the connection of a pollinator's UV vision to flowers.

OBSERVATIONS IN NATURE: VISUALIZING DATA

A diverse population of bats has been identified at Rio Fernando Park. While these bats are not pollinators, they provide important ecoservices like eating mosquitos. Scientists at Rio Fernando Park are learning about the 21 species of bats identified, their habitat and relationships to the ecosystem. One way scientists study bats is by using bat detectors. The Echometer 2 is a bat detector that can be used with a cell phone to collect, analyze and visualize the bat sounds humans can't hear with spectrometer software. Most bats that echolocate have unique specializations in their body shapes that allow them to receive and communicate ultrasonically. These sounds are picked up by bat detectors and can reveal specific information about bat species or movements. Bioacoustics is one way scientists study animal sound to reveal hidden patterns or relationships in a biodiverse ecosystem. This data can be collected over time to generate a fuller picture of how biodiversity is impacted by human activity, and how habitat encroachment for example effects the spread of zoonotic diseases like COVID-19. Tools like bat detectors allow students, citizen scientists, artists and biologists to monitor, collect, and share data about the ecological health around us.

How can we use TECH tools to understand complex relationships in place? What future tools could we develop to see and show important relationships in biodiversity? Why does it matter?

Field Study: BAT Echometer

Learn about bats and bat habitats. Visit Rio Fernando Park, or other local habitat that is known for bats. Observe and record impressions about the habitat. *What habitat features do you think bats are attracted to? Why? What predictions can you make based on your observations?*

Return to the site near dark using the Echometer 2 to detect bat activity. *What do you notice about your environment?* Document time of day, location on site, and any other pertinent observations such as bug activity.

Monitor and record bat data with the Echometer 2 and document any observations not captured with the detector. *What quantitative and qualitative data can be collected about bats and their environment? What environmental patterns or relationships stand out during the time when bats are active?*

Share data collected and discuss. *Does the data collected support any predictions you made by observing bat habitats? Did anything surprise you?* Document any observations. Create a graphic representation of bat data. *How can we visualize our collective data to reveal patterns in bat activity? How might an artist look at this challenge? How might a scientist? How might a historian?* Sketch out an idea for a data art piece, or a piece of art that communicates data in a novel form. For example: An infinite 3D printed coil pot that vary in thickness according to bat activity throughout the year, or a musical instrument that plays notes constructed of bat frequency variations. Use your imagination. Think about how you might visualize (or sonify) scientific data in an artistic form to create data art.