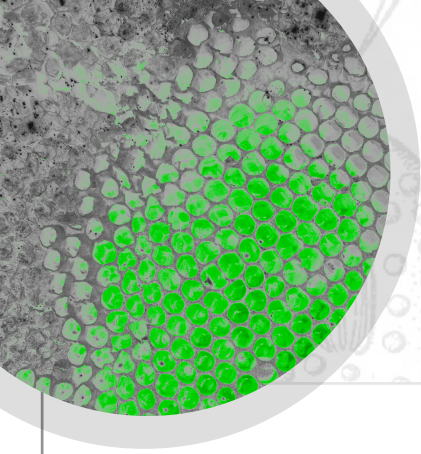
BIO-MACHINE:

Pollinator Inspired Design

TEACHER GUIDE

BioSTEAM: Pollinator Concentrator Project Unit



BIOSTEAM RESOURCE QUICK GUIDE

This quick guide highlights some of the resources used to develop the BioSTEAM curriculum tools. Explore these live linked resources and more on the BioSTEAM project pages and in the wiki located in the Design Tool.

The biomimicry curriculum methodology is derived from and in consultation with Ana MacArthur. The Pollinator Concentrator installation by Ana Macarthur inspired and informed the Pollinator Concentrator Project. Visit Ana MacArthur website to learn more.

The BioSTEAM Curriculum tool methodology is founded in the STEMarts Model and starts with creative inquiry into the concepts and themes found in the featured artist's work, interdisciplinary collaborations, and real world challenges. The tool is rooted in exploration; open-source research; STEM experimentation; creative design; and connecting to local youth, educators, artists, and place based cultural innovation through art, science and technology.

As a whole, the *BioSTEAM Curriculum Tool* aligns with core ideas from the Next Generation Science standards(NGSS), and the P21 Framework for 21st Century Learning. In addition, each *project* addresses specific science standards relating to that sci-art intervention. The *BioSTEAM Curriculum Tool* designs to the United Nations Sustainable Development Goals which address current global challenges. Through this partnership students know that they are working on meaningful solutions toward building a sustainable future for all.

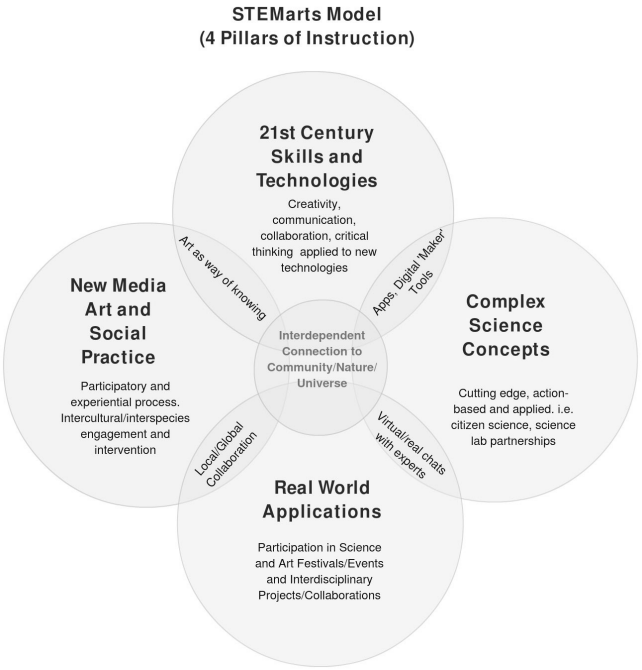
BIOSTEAM RESOURCE FAVORITES

Check out these links to some of our favorite resources found in the BioSTEAM Curriculum Tool.

Biodiversity Teacher Resources
Pollinator Concentrator
Interdisciplinary Knowing
Participate in Science
UNESCO Commitment to Biodiversity
Biomimicry Institute
Biomimicry Toolbox
Biomimicry Global Design Challenge
Ask Nature
Bat Conservation International Species Profiles
Arduino Project Hub
Adafruit Create & Learn

Archive

STEMarts Lab Archived Feedback & Activity Guides
STEMarts Archive Art-Sci Inspiration & Tools



BIOSTEAM WIKI FAVORITES

Check out these links to some of our favorite open-source resources found in the BioSTEAM Wiki in the Design Tool. The live links below are organized by design tool stages.

EXPLORE

Art + Ecology

Ana MacArthur
Creative Pollination
Rio Fernando Park

RESEARCH

Biodiversity

Why is Biodiversity so important?
Ecosystem Services
Introduction to Ecology
Soundscape Ecology
How Nature Can Protect Us From Pandemics
Pollinators Need You, You Need Pollinators
Citizen Science in Researching Biodiversity
Pollinators Under Pressure

Bioculture

Biocultural Crops and Traditional Farming
Biocultural Diversity Combats Climate Change

Biomimicry

Design Inspired by Nature
The World is Poorly Designed, but Copying Nature Helps
The Innovators Using Nature's Design Principles to Create Green Tech

Bio-machine

Biobots
DOLPi Polarimetric Camera
David Dunn's Bark Beetle Patent
Biomachine Wind Animals
PHOX Ears

Pollinator Inspiration

Bat-lovers unite!
Echolocation
Why Nature Loves Hexagons
Electric Bazaloo! How Bees See the Invisible
Bee-eye Camera: See like a bee
Secrets of the Hummingbirds Tongue
Desert Bees Have A Secret
Bio Strategies of Butterflies + Moths
Bio Strategies of Wasps
Bio Strategies of Bats
Bio Strategies of Bees
Bio Strategies of Hummingbirds

EXPERIMENT

Sensing the Invisible

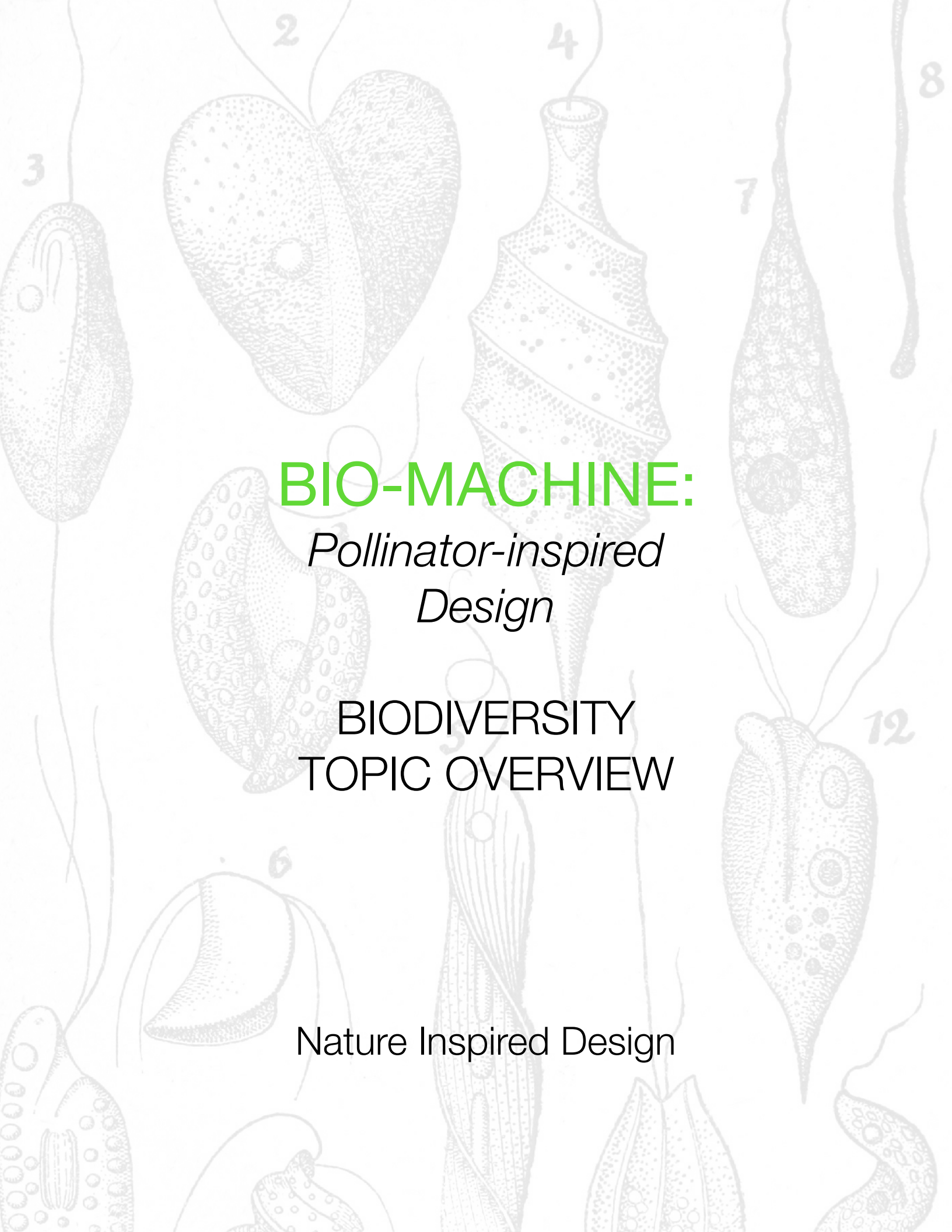
Polarization of the Sky
Only Some Humans Can See This Kind Of Light
Interactive Polarized Light Viewer
Industructables: Sensors
Echometer Touch 2
Linear Parabolic Reflectors: Practical Experiment for Students
Twisting Light
Polarized-Light Mosaic
How To Make Polarized Art With Household Items
Invisible Art: Mosaics. Polarized Light, and 3D Glasses
See Like A Bee

DESIGN

BIO-MACHINE Challenge
Bio-inspired drawing samples
Biomimicry Global Design Challenge Entries
Lesson Plan: How Mimimicing Nature Inspires New Inventions

CONNECT

Biosteam Partners
Youth Corps

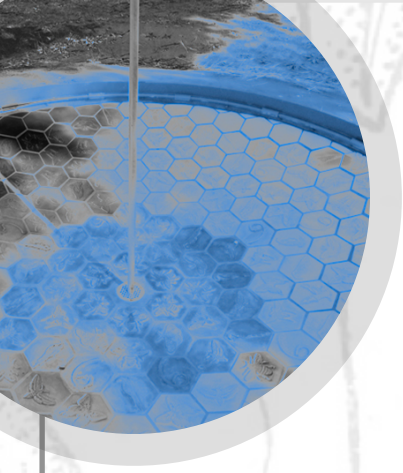


BIO-MACHINE:

Pollinator-inspired Design

BIODIVERSITY TOPIC OVERVIEW

Nature Inspired Design



BIOSTEAM TOPICS OVERVIEW

Explore the three main biodiversity topics for this project. Research what inspires you and the topics, or pollinator species that you will choose to inform your sci-art experiments and designs. Watch the INTERviews to see how people are using new models from multiple worldviews to protect biodiversity. Learn about how art, science, technology and culture are inspired by nature. Use the sketch pads to experiment and journal inspiration for your BIO-MACHINE design. Connect to the people working on the BioSTEAM project and see the art and ecology at Rio Fernando Park. Do something now to help scientists using tech tools to monitor and protect local biodiversity in citizen science projects online.

BIODIVERSITY LOSS + PANDEMIC DISEASES

Human activity has an immense effect on the life connections around us. How we seek knowledge, learn to do things, and the way we connect to people and place will define what impact humanity has on the future of our shared planet. Biodiversity loss is a poignant topic as the COVID-19 pandemic has direct ties to habitat encroachment, exploitation of resources and the spread of zoonoses.

FOOD SOVEREIGNTY + COMMUNITY

Biodiverse relationships can be observed at all scales and and from many perspectives. The effect of pollinator loss and species decline has a big impact on our environments ability to adapt to change. We'll need big ideas to envision and design a biodiverse future. These big ideas can be found at multiple scales and can be demonstrated in the relationships of community to place. One of humanities closet relationships with nature is through the food we eat. At the tiniest scale, atomic interactions aid the pollination that is happening to produce edible foods for animals at every level of the food web. At larger scales food is distributed globally, so that even the bat pollinating the chocolate in your candy bar has an impact on the system as a whole. Our industrialized food system is one of the major contributors to biodiversity loss because of the way we approach problems and enact solutions. The Food Sovereignty movement is another way people are enacting scaled solutions in place as a response to biodiversity loss and the food system. It approaches solutions from the perspective that it is the right of all people to healthy and ecologically safe consumption, production and distribution of food.

TECH TOOLS FOR ENVIRONMENTAL PROTECTION

TECH Tools are the tools and technologies developed and used by human culture to engage nature. Tech tools are the interfaces between humans and nature. Even with the best intentions some do good and some do harm. For example industrial agriculture uses pesticides to control pests that threaten mono-culture crops. The unintended consequence of this solution is that broad chemical treatment can have a detrimental impact on biodiversity such as the vital ecological relationships between soil, plants, pollinators and water systems. We will need to develop creative technological and cultural tools to address the difficult problems in our world like biodiversity loss and climate change.

BioSTEAM WIKI KEYWORDS

biodiversity
ecology
human impact
species in peril
nature inspired design
restoration
COVID 19
food sovereignty

QUESTIONING
Ways of Knowing + Ways of Doing

Creative problem solvers are looking to natural systems and creatures for inspiration on solve the complex problems we face in the world.

What are some of the challenges we face with biodiversity loss and pollinator decline?

How might we approach the problem of biodiversity loss and pollinator decline through different cultural lenses?

What interdisciplinary tools can we imagine to address the challenges?

How has nature approached design challenges in their environment?

OPEN-ENDED QUESTIONS

Open ended questions are meant to facilitate discussions that inspire creativity and dig deeper into topics than yes and no questions. The questions can be used with the Biodiversity Topics Map to dig deeper into the BioSTEAM project. Sketch out topic connections you find on the topics sketch pad. For further information on nature inspired design, the installation at Rio Fernando Park or the artist, search the bioSTEAM Wiki and explore the curriculum design tool.

Ana MacArthur's artwork, like Pollinator Concentrator, is inspired by the diversity and ingenuity of nature. Art, science, technology and culture often start in an act of questioning whether it is to test a hypothesis, experiment with new ideas or to look to nature for solutions to complex problems. Nature Inspired Design may not be new, but it is being applied to the ever changing challenges we face today in novel ways.

It leads with the deceptively easy question: *How has nature solved this?*

BioSTEAM
WIKI KEYWORDS

biodiversity
ecology
Rio Fernando Park
human impact
species in peril
nature inspired design
biomimicry
sensing the invisible
quantum biology
engineering

PEOPLE IN PLACE:
unique point of views interacting in a distinct place

How might a place or ecology inspire unique design solutions for survival?

How might art and science combined impact how solutions are developed locally and through time?

What can artists, scientists and cultural specialists learn from the successful strategies developed by animals and plants?

WAYS OF KNOWING:
the ways we gather, process + disseminate big ideas.

What invisible relationships do we depend on to survive? How do we know they are there?

How might human impact effect these relationships?

How might this change be observed by a bee? Or a giant? Why do these perspectives matter?

How might a worldview impact how big ideas are developed and communicated?

How can native science inform our design solutions to environmental challenges?

WAYS OF DOING:
the tools and technologies we create to put ideas into action.

How do we develop tools to test and actuate ideas?

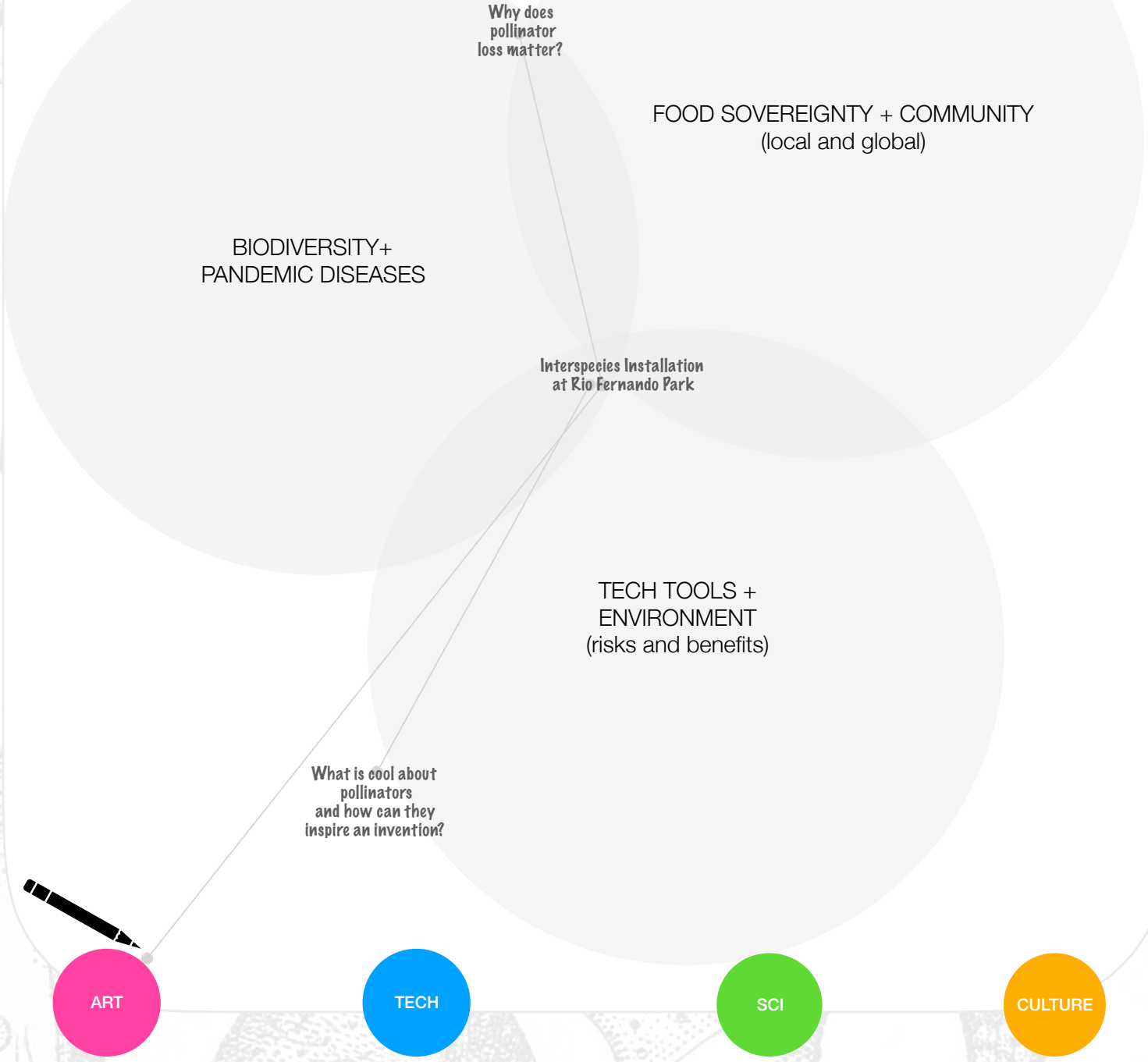
How might your worldview impact how tools are used or developed?

How might the worldview of an artist, scientist, engineer or entrepreneur affect the design of the tool? What can these disciplines learn for each other?

What tools and technologies can we design inspired by successful strategies working in nature?

The Biodiversity Topics Map below gives you a birds-eye view of the topic areas embedded in the Pollinator Concentrator project. See the interdisciplinary connections explored in the BioSteam Design Tool and throughout the project. Trace how the BioSTEAM concepts highlight the working relationships between art, culture, science, and technology. Search the BioSTEAM Wikis using the colored keywords to see the big picture.

TOPICS SKETCH PAD



Draw connections between big ideas found in Art, Science, Technology and Culture, and the topics of biodiversity loss, our food system and the tools of nature inspired design. A connection has been drawn to get you started. Write in topic words or questions on the diagram above to explore the connections *you* are making. Or create your own mind map! Discuss in small group or as a class.

What stands out?
Do any ideas or connections inspire you?

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.

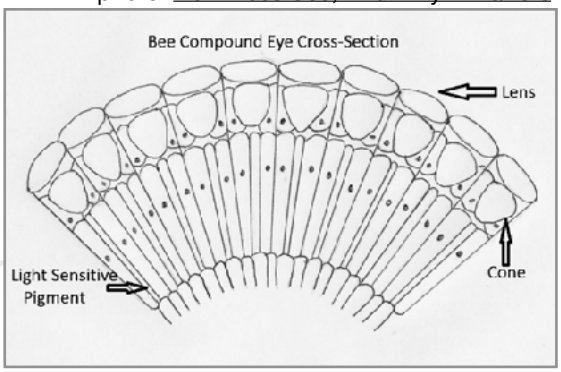
Pollinators have developed many biological adaptation strategies from specialized leg hair for buzz pollination, to complex eyes that perceive subtle environmental cues to locate resources essential to survival. An eye that can see polarized light is one feature shared by many animals that have influenced 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

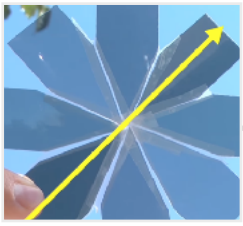
When daily sunlight hits Earth, the light scatters at a ninety degree angle as it encounters air molecules in our atmosphere. This phenomena creates predictable polarized patterns in the sky used by many animals, like pollinators, for orientation and navigation. Most light is unpolarized in that it is 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

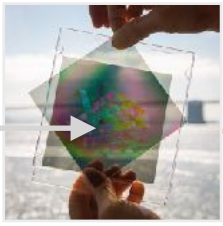
Design and build a creative polarized light device that incorporates multiple layers of polarizing film to visualize the qualities of polarized light in your environment. Make your own "mashup" device inspired by polarizers, the polariscope, sky compass and polarized mosaics using layered polarized filters 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.



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

Your Awesome Idea

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).

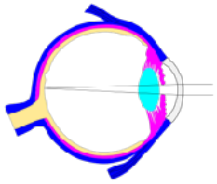
Get creative with your device. Experiment with the form to make something you wear like glasses; write a poem on the surface of your creation about pollinators or the challenges they face; use colors or patterns to communicate a metaphor; make an robotic polarizing all seeing eye or another unique idea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

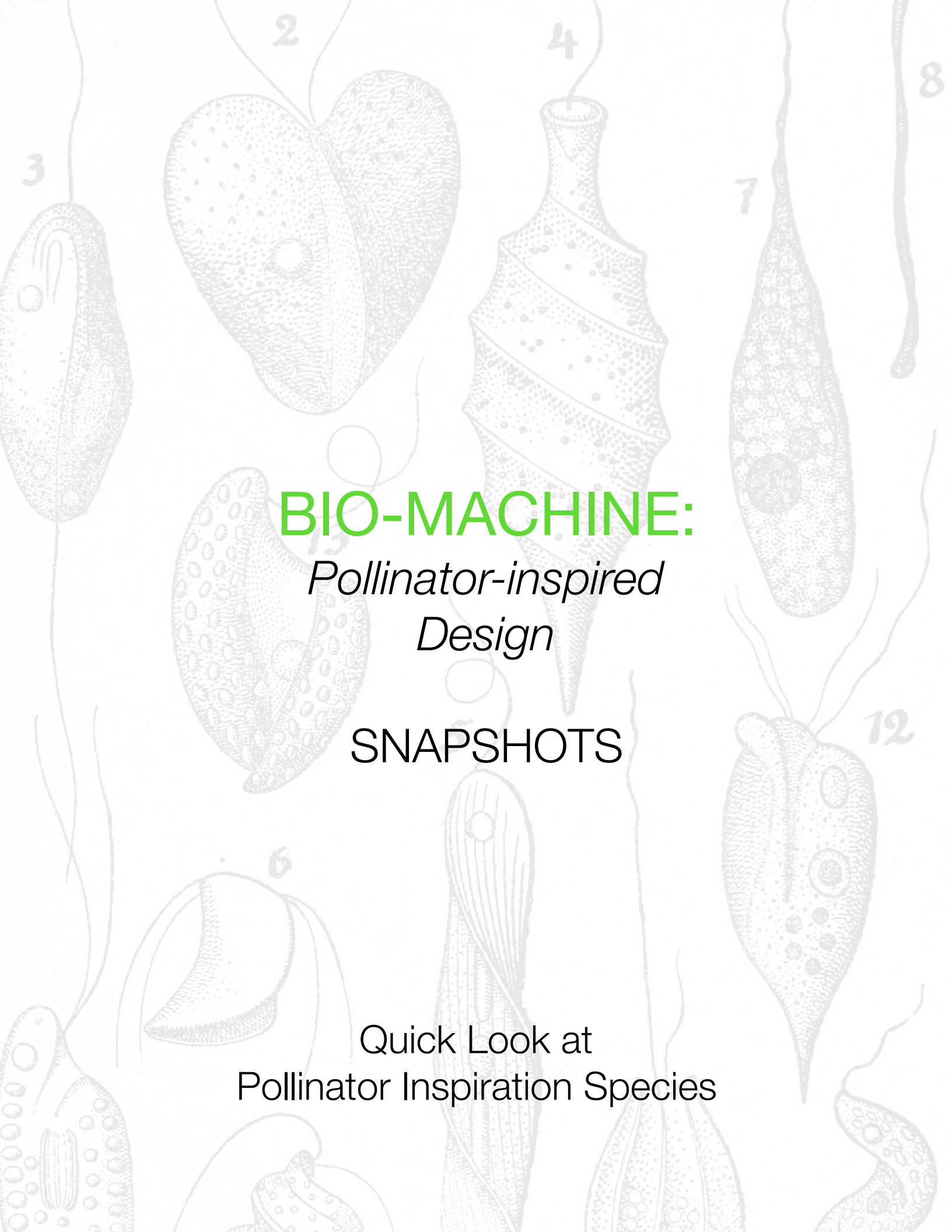
Field Study: BAT Echometer

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.

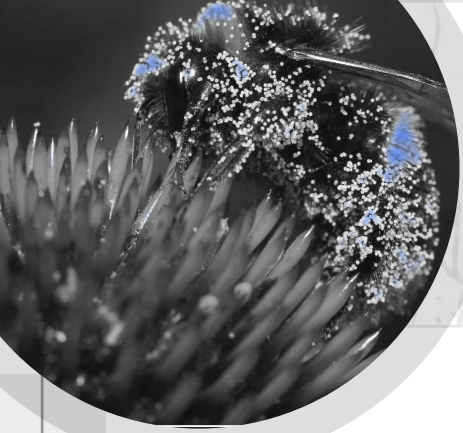


BIO-MACHINE:

Pollinator-inspired Design

SNAPSHOTS

Quick Look at
Pollinator Inspiration Species



POLLINATOR SNAPSHOT

The Pollinator Snapshot is intended to make connections between the Pollinator theme with biomimetics or nature inspired design. For further information on nature inspired design, biomimicry and pollinators role in biodiversity search the bioSTEAM Wiki.

The biomimicry curriculum methodology is derived from and in consultation with Ana MacArthur. The Pollinator Concentrator installation by Ana Macarthur inspired and informed the Pollinator Concentrator Project. Visit Ana MacArthur website to learn more.

BioSTEAM WIKI KEYWORDS

light
polarization
electromagnetic spectrum
optics
pollinators
bees
butterflies
bats
hummingbirds
solar navigation
ecoservices

Rio Fernando Park is a living ecology laboratory. The park has rich and diverse habitats that host a wealth of biodiversity, and demonstrates positive human impact through their land restoration work and community programing. Your backyard or school garden can also be a living laboratory for biodiversity.

The Pollinator Concentrator art installation by Ana Macarthur, uses technology or human tools to reveal hidden relationships between pollinators, local ecology and global interconnectedness. Tools like the sun dial and bat detectors are technologies that extend the human senses to “see invisible” relationships in the living world, like our relationship to the sun. UV sensors detect and respond to bats ultrasonic sound revealing the hidden relationships of nocturnal biodiversity. While unseen water catchment nourishes the pollinator garden extending hydration to native plants that feed pollinators. Pollinator Concentrator tiles highlight different species of pollinators including bees, butterflies, moths, wasps, hummingbirds and bats.

There are hundreds of thousands of pollinator species, with new ones discovered everyday by researchers and citizen scientists. Pollinators facilitate the reproduction of 90% of flowering species of plants and are important to our food supply. Human impact, climate change and biodiversity loss threatens the lives of pollinators and our interdependent relationship on their ecoservices.

Pollinators play an important role in our environment and have evolved amazing adaptations over time. Nature Inspired Design is a term for when we use the lessons all around us provided by nature to create innovative design processes and products. For example: Pollinators see the world in a unique way. They can see wavelengths and qualities of light the human eye can’t. In order to see the invisible relationships between ourselves and our environment humans have developed technological tools from sundials to polarizers to take in the information in our environment.

SENSING THE INVISIBLE:
land, space + time tools

What strategies might we learn from the pollinators highlighted in Pollinator Concentrator?

How might we use our human bodies as tools to collect data about our environment?

How do pollinators collect or process data in their environment?

What invisible pollinator relationships are we taking for granted or do not see?

What tools might we develop to help us see and show those relationships?

Pollinator Strategy/ Inspiration

Pollinators have developed unique adaptations to survive including:

Biomimetic Innovation

Pollinators have inspired the creation of cutting edge design including:

BEES

- hives and hexagons
- nest building
- social strategy
- electrostatic hair
- signal detection
- buzz pollination
- compound eye

Bee strategies have inspired numerous innovations in technology including building materials, swarm inspired technology like drones and software, and compound camera lenses.

BUTTERFLIES+ MOTHS

- multifunctional wing scales
- cocoon building
- thermoregulation
- structural color
- aerodynamics
- internal compass
- flight patterns

Butterfly and **moth** strategies have inspired transformations in fabrics, solar cells, acoustic camouflage, biophotonic implants and airplane wings.

WASPS

- nest building
- waterproof fiber
- parasitic relationships
- vortex lift
- solar pigments
- antifreeze blood

Wasp strategies have inspired composite building materials, novel solar cells, micro air vehicles, drones and steerable needles.

HUMMINGBIRDS

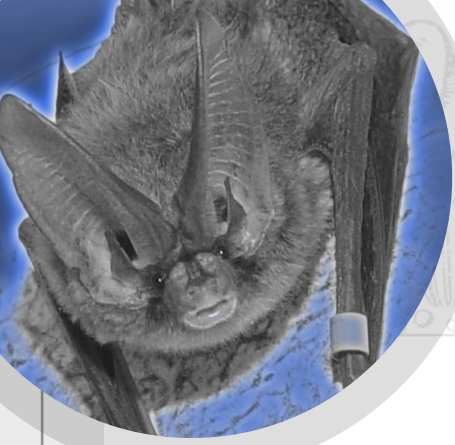
- hover mechanisms
- rotating joints
- torpor
- efficient tongue pump
- microstructure feathers
- electrostatic pollination

Hummingbird strategies have inspired innovation in drones, wind turbines, and AI robots.

BATS

- biosonar
- unique immunity
- social strategy
- thermoregulation
- internal magnetic compass
- flight maneuverability

Bat Strategies have inspired a sonar cane for the visual impaired, robots, drones, ultrasonic image reconstruction Radar, Lidar and other sonar based systems.



BAT SNAPSHOT

The Bat snapshot is intended to to make connections between the Pollinator theme with biomimetics or nature inspired design. For further information on nature inspired design, echolocation and the bats role in biodiversity search the bioSTEAM Wiki.

BioSTEAM WIKI KEYWORDS

sound
bioacoustics
echolocation
ultrasonic sound
waves
sensors
navigation
sensors
bats

Bats provide an important role in our ecosystems, providing ecosystem services like pest control and even night pollination of important crops like chocolate and agave. Nature Inspired Design uses the lessons all around us provided by nature to create innovative design processes and products. Bat species as a group represent interesting biological strategies that scientists, artists and engineers are mimicking to design new technologies to address the complex challenges we face.

21 species of (non-pollinating) bats have been identified at the Rio Fernando Park. Bats species can be found all over the world and in most climates. They are the only flying mammal and have unique biological adaptations that motivate nature inspired designers.

The most famous bat adaptation is echolocation which has inspired sonar systems like radar, lidar and other sound applications like a walking cane that uses echolocation to aid the visually impaired. Other adaptations like their wing structure inspire flexible flight maneuverability for drones and other robots.

Bats have a unique immunity that evolved over time. This immune response protects them from infection while the bat becomes a carrier for multiple disease called zoonoses- or disease that are passed between animals to humans. COVID-19 is one of these diseases. As biodiversity loss and habitat encroachment brings humans and bats closer together the risk of novel zoonotic disease spreading to humans is high. New solutions will need to be developed in conjunction with environmental protections to prevent devastating consequences of disease and to protect bats from ecological destruction.

SENSING THE INVISIBLE:
land, space + time tools

Bats use specialized sensing to navigate their environment. Their physical being and survival strategies express unique adaptations to place.

What is unique about bats? What inspiration can we draw from bats that might solve a current or future problem?

What can we learn about ecological communication and relationships from bats, or other local species?

How might we collect data on local ecologies? Why does it matter?

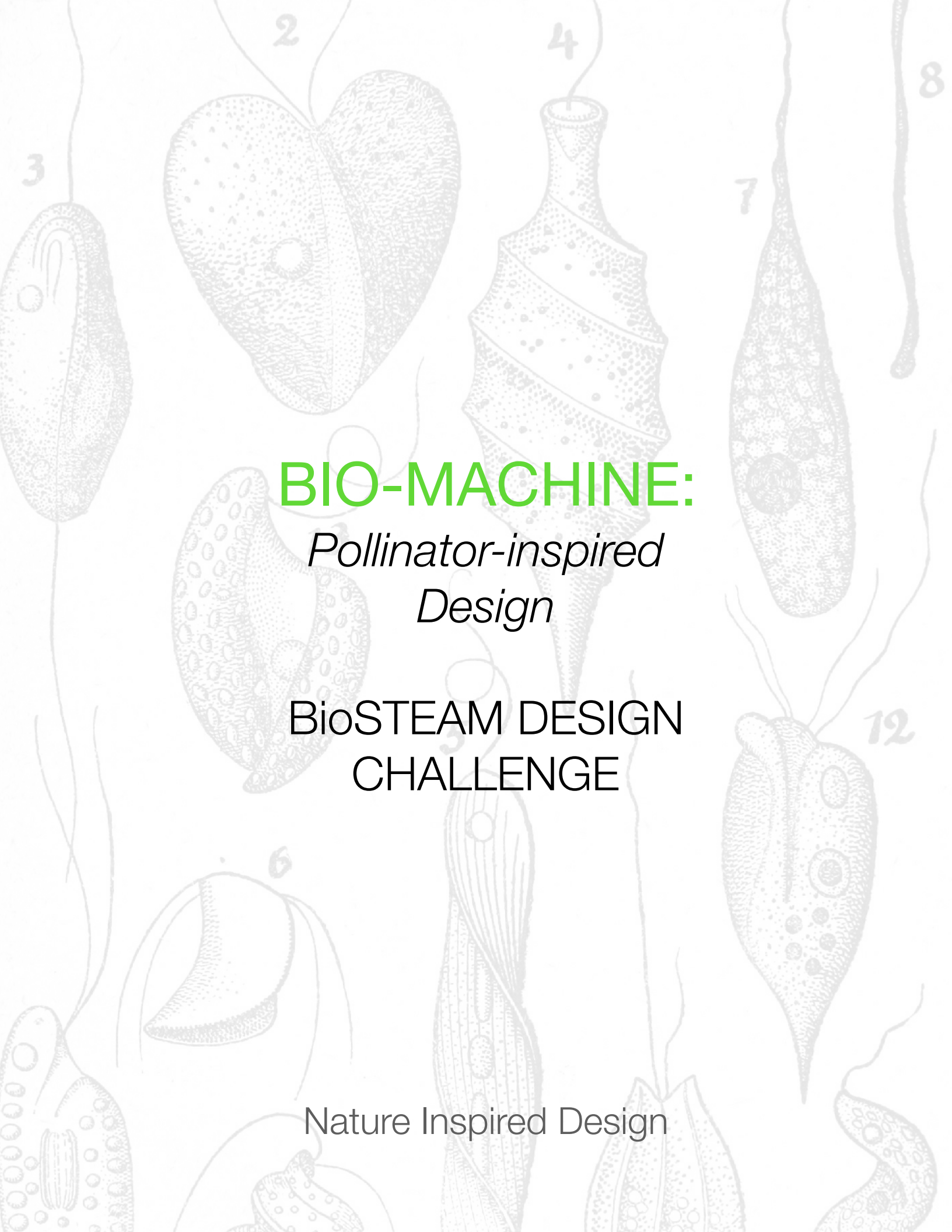
What strategies might we develop to help us see and show ecological relationships?

SKETCH
PAD

Design Journal/Notes:

Name:

School:

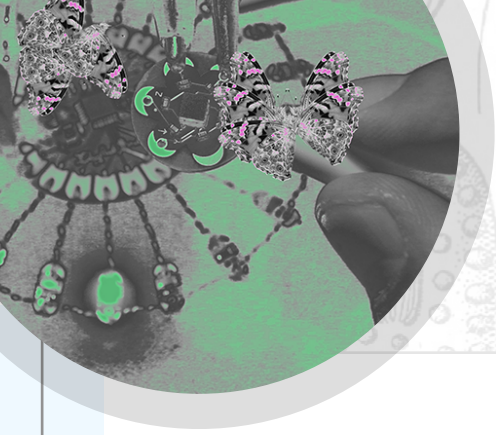


BIO-MACHINE:

Pollinator-inspired Design

BioSTEAM DESIGN CHALLENGE

Nature Inspired Design



BIO-MACHINE:
POLLINATOR INSPIRED DESIGN

Explore the Pollinator Concentrator project to learn about biodiversity loss and pollinator decline and let it inspire a design for a wildly imaginative BIO-MACHINE that helps us live in balance with nature and protect biodiversity locally and globally. See the SNAPSHOTS for a quick look at the pollinator and bat inspiration species. The biomimicry curriculum methodology is derived from and in consultation with Ana MacArthur. The Pollinator Concentrator installation by Ana Macarthur inspired and informed the Pollinator Concentrator Project. Visit Ana MacArthur website to learn more.

WHAT IS A BIO-MACHINE?

For the BioSTEAM Design Challenge we are using the term BIO-MACHINE to describe an invention that incorporates, synthesizes or is inspired by biological materials or systems in the design. The final design can be an object, a new system or an interface between species. It performs a task or combination of tasks to solve a problem.

WHAT ARE SOME EXAMPLES OF A BIO-MACHINE?

Invention can take many forms: A bio-machine interface for the human body inspired by bats with tiny dot pattern sensors that light up to detect and block airborne viruses; A bio-machine sensor inspired by earthworms that squirm in the dirt consuming all the unnatural chemicals in the soil; A swarm of drones that emit signals that ward off pests that contribute to crop devastation; A clay air conditioner inspired by compound eyes that collects and cools water; or a polarizing camera that reveals abandoned land mines. Use your imagination.

WHY POLLINATOR INSPIRED DESIGN?

Pollinator species diversity provides an incredible resource to learn from. The interspecies art installation, Pollinator Concentrator, highlights six species of pollinators local to Rio Fernando Park or in reference to global species in peril. Pollinator species as a group represent interesting biological strategies that scientists, artists and engineers are mimicking to design new technologies. The BioSTEAM Design Challenge is an opportunity to learn from nature and to cultivate the agency to innovate the art, culture and technologies for a resilient future.

IMAGINE FUTURE INNOVATION

Let your imaginations fly to create an original BIO-MACHINE that is an expression of what you have learned. BioSTEAM encourages creative, wildly impossible futuristic solutions, as well as innovative and practical designs.

The final pollinator inspired BIO-MACHINE should be an artistic expression, and clearly demonstrates that careful thought has been given to its sustainable materials, ecological impact, benefit to community and planet, and sensitivity to the biocultural diversity of the community it serves. Research and consider the benefits and risks of your BIO-MACHINE. Reflect on the ethical implications of your design to assure a do no harm ethos.

What pollinator inspired bio-machine can you invent that uses existing and future technologies in a way that is in balance with nature and can protect biodiversity?

What are the ecological impacts of the materials you have chosen? How does your machine get power? How does it process waste?

How can pollinator adaptations and processes inspire new tools and creative application to real world challenges?

BIO-MACHINE DESIGN CHALLENGE GUIDELINES

1. Go to the BioSTEAM Design Tool on the BioSTEAM website. Here you will have access to information about the topic of biodiversity loss and pollinator decline to inform and inspire your BIO-MACHINE design.

2. Choose one or more pollinators from the list of 6 pollinators to inform your design.

3. Decide on an idea for your BIO-MACHINE design. *What will be its purpose?* Choose from one or more of the Biodiversity topics that address challenges and opportunities. *How is your pollinator-inspired Bio-Machine helping us to live in balance with nature?*

4. Choose the science/technology that will support your design. The idea can be futuristic but it must be based in science. Use the sketch pad to try out ideas.

5. Choose the materials and processes that you imagine for your design.

6. Write a design statement that describes your BIO-MACHINE: How it works, how it addresses one or more of the Biodiversity topics, what is the research-based science/technology behind the work, what are the sustainable materials that would be used, how it helps people/community/planet, how you designed it sustainably for and with nature.

7. Create your final BIO-MACHINE design in whatever medium you like. The final should be a two dimensional image scanned into a high quality JPG.

8. Submit your design statement as a one page PDF and the final design as a JPG.

DESIGN Criteria	Criteria Explained
Creativity (2 pts)	The design is creative and uses futuristic ideas to address possible solutions to the problem.
Science & Technology (2 pts)	Innovative research based science and technology informed the design.
Nature-Inspired//Pollinator focus (2 pts)	Mimics pollinators/nature's adaptations as part of the design or demonstrates knowledge of the complexity of nature in the design.
Craftsmanship (2 pts)	Design reflects effort and attention to detail and professional presentation.
Community/Culture Connections (2 pts)	Reflects on the impact the design would have on the greater community and cultural traditions
Sustainable materials/practices (2)	Design demonstrates consideration of sustainable materials and practices; impact on biodiversity
Submission guidelines. (2)	Meets the submission guidelines
Total (out of 14 pts)	

SKETCH
PAD

***Design Journal/Notes**:*

Species: Bio-inspiration	Research: Science and technology	Purpose: Application in world

Name: School: