PLANTING SEEDS

THE ART & SCIENCE OF POLLINATION

TEACHER'S MANUAL GRADES 9-12

Rose-Lynn Fisher, *Sabine 15x*, photograph

Artmobile

Covering the County • Uncovering the Arts

Traveling throughout Bucks County **September 2017 – June 2019**

ARTMOBILE is a traveling museum dedicated to providing the students and adults of Bucks County access to fine, original works of art and innovative art education programs through its visits to schools and public sites. Artmobile is a vital component of Bucks County Community College which provides significant cultural outreach programs in accordance with its mission.

Since 1976, Artmobile has been committed to fostering an understanding of art, art making, and the value of art in our lives and communities by exhibiting and interpreting works of art.

This manual was developed to help teachers incorporate the Artmobile experience into their curricula by providing background information and classroom activities related to the exhibition. It is intended to serve as a resource both in conjunction with and apart from the exhibition.

For more information about Artmobile and its programs, call 215-968-8435, email artmobile@bucks.edu or visit www.bucks.edu/artmobile.

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Bucks County Community College
275 Swamp Road | Newtown, PA 18940

ACKNOWLEDGMENTS

THIS EXHIBITION had the gestation period of an elephant. It began as a twinkle in my eye (as things sometimes do) and a conversation with Provost Lisa Angelo, then Dean of Science, Technology, Engineering and Math (STEM) at Bucks County Community College. I was looking for a way that Artmobile could collaborate with the College's STEM Department to bring a STEAM (STEM + Art) exhibition to Bucks County K-12 schools. Lisa shared about several fascinating projects underway, but a faculty-student collaboration with Tyler State Park seemed like the perfect match for Artmobile. The rest, as they say, is history.

I offer my heartfelt thanks to all who helped to make this exhibition a success, especially:

- Liz K. Sheehan for her curatorial skill, unflagging energy and consummate professionalism;
- The artists who graciously loaned their work:

  The Beehive Collective
  Anda Dubinskis
  Cara Enteles
  Marissa Farra
  Rose-Lynn Fisher
  Linden Gledhill
  Dennis Hlynsky
  Ellie Irons & Anne Percoco
  Kim Kurki
  Julia Oldham
  Eric Schultz
  Judy Simon
  Moritz Stefaner & *Scientific American*

- Lisa Buffardi, Carly Noella Nájera and Lisa M. Waibel for curriculum development;
- Ron Dorfman, for the design of the exhibition logo and this manual;
- The Bucks STEM Department, for sharing their considerable expertise, especially Interim Dean Debra Geoghan, faculty Michael Bernarsky, Joann Corn, Kathi Knight, Caryn Babaian and Lee Ann Lippincott, and Biology Lab Supervisor Rochelle Vollmerding; and
- Provost Lisa Angelo, Dean John Mathews and all of my Bucks colleagues.

Finally, I offer my deepest gratitude to my talented, resourceful and dedicated staff—my dream team:

Cayla Belser, Artmobile Assistant;
Jennifer Garey, Exhibitions Assistant;
Cassandra Stancil Gunkel, Ph.D., Artmobile Coordinator;
Melody Hunt, Art Handler;
Eileen Streeter, Exhibit Designer; and
Artmobile Educators Carole Cunliffe, Michelle Kinney and Rachelle Moes

Together, their expertise and enthusiasm will bring *Planting Seeds* to life for more than 35,000 visitors over the course of its two-year tour.

Fran Orlando
Director, Exhibitions and Artmobile
Bucks County Community College

OPTIMIZING YOUR ARTMOBILE EXPERIENCE

OPPORTUNITIES FOR TEACHERS

Our Artmobile Coordinator provides in-service training at schools prior to Artmobile's visit to help you incorporate the lessons we provide into your curriculum. To schedule in-service training at your school, call 215-968-8435.

Earn Act 48 hours at our Teacher Workshops led by exhibition artists at the art studios at Bucks County Community College.
See www.bucks.edu/ArtmobileWorkshops for a complete listing. Visit often, as we update our professional development opportunities throughout the tour.

PREPARE YOUR STUDENTS

Introduce your students to some of the concepts our educator will address by presenting the Pre-Visit Lesson in this manual.

THE ARTMOBILE EXPERIENCE

Your students will encounter a variety of artworks during their visit to Artmobile. Our educator will engage students in discussion and encourage them to make connections between what they see and what they know. By listening and speaking about the artwork, your students will develop the vocabulary and ideas that they will use later in your classroom.

After the presentation, students will have an opportunity to look at the artwork on their own. They will explore the many interactive displays that reinforce the concepts presented by our educator.

FOLLOW-UP

Post-Visit Classroom Lessons found in this manual will enable your students to synthesize what they have learned in Artmobile with your curriculum. Encourage students to visit the Artmobile website to review the artworks and videos displayed in Artmobile.

EVALUATE

Complete a written evaluation to help us continue to improve and better understand your needs. Download the survey at the bottom of this link: www.bucks.edu/ArtmobileVisit.

THIS MANUAL and the online resources for *Planting Seeds* found at www.bucks.edu/Artmobile or www.bucks.edu/ArtmobilePlantingSeeds provide all you need to incorporate Artmobile into your curriculum with stimulating and effective lessons that directly correlate to Pennsylvania State Academic Standards.

ABOUT THE EXHIBITION

THE IMPORTANCE of pollinators in our environment cannot be overstated. With so much information about the decline in bee and monarch butterfly populations in the news in the last decade, artists have begun to join scientists in the effort to help raise awareness of their endangerment as well as to find solutions to their habitat loss.

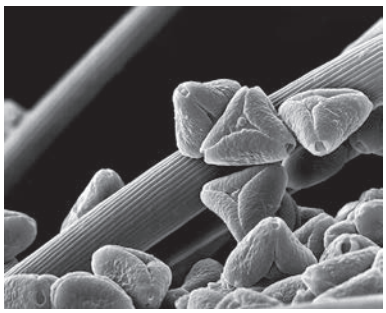
Planting Seeds: The Art & Science of Pollination was inspired by an ecological restoration project currently underway in several meadows at Tyler State Park. With a grant from PECO, faculty and students from the Department of Science, Technology, Engineering and Mathematics (STEM) at Bucks County Community College (BCCC) are removing invasive plant species and seeding native ones, in part to improve the park's function as a habitat for a broad number of insect and animal species. The Artmobile exhibition will track the progress of this long-term project through photography and other documentary means, as a companion to work by a group of 14 artists and scientists on the theme of pollination.

Geared toward a K-12 audience, *Planting Seeds* is based on STEAM principles, which prove that Art & Design can drive innovation in Science, Technology, Engineering, and Math, and that interdisciplinary approaches are necessary to solve our most pressing environmental problems. Special attention was therefore given in this exhibition to artists who partner with scientists or conduct research as part of their studio practice. Through this exhibition, students will learn about the important roles of a variety of pollinators and about the plant species that sustain them, as well as what they as citizens can do to minimize the human threat to habitat loss.

The structure of the exhibition is as important as the content. With a wide range of methods and media, *Planting Seeds* is designed to introduce students to how and why artists and scientists come together to solve problems and to communicate information. Video, digital, and other time-based media reveal patterns in pollinator movement, make visible the mechanics of pollination, and examine the behavior of different species. Botanical illustrators create drawings at the service of science, using technical accuracy and observational skill to communicate both fact and form. Microphotography reveals how bee and butterfly anatomy is specifically designed to trap and carry pollen. Data visualizations translate complex amounts of research. Other artists employ pattern and expressive style to convey the functional beauty of pollinators and plants.

ABOUT THE ARTISTS

Photographer **Rose-Lynn Fisher** was prompted to study bees when she found that the structure of a bee's eye matched the hexagonal shape of their honeycomb, and wondered if it was by coincidence or design. Using a camera attached to a powerful microscope, Fisher produces highly detailed topographic images that move between wonder and fact. "As though revealing a secret, the scanning electron microscope presents a realm of structure, design and pattern at a level of intricacy we are oblivious to in our daily experience. In this bizarre frontier our sense of scale is confused, and connections between the micro and macro world become clearer and more tangible. In the myriad forms that constitute one little bee at higher and higher magnifications is a hint of the unending complexity of nature, the worlds within worlds comprising our reality."[1] Fisher's photographs reveal that a bee's anatomy is designed for function, particularly specific to collecting and transporting pollen. *Leg Pollen x1100* shows the bee's leg magnified 1100 times, with pollen grains lodged



in the "pollen basket" and anchored by the leg hairs. As she explains, "Using her forelegs and mandibles to loosen pollen from a flower, a foraging bee is dusted in pollen. She cleans her head and mouthparts with foreleg brushes, her forelegs with middle leg brushes, and then, grasping a middle leg with both hind legs, she draws it forward, transferring the pollen through to her hind leg brushes. She rubs her hind legs together scraping pollen from brushes on one leg with the *rastellum* (rake) of the other, on to the *auricle* (ledge) of the pollen press. With a pumping action, she pushes the pollen into the *corbicula* (pollen basket), and through this repeated motion it collects into a pellet. This is all done while hovering in the air."[2]

This complex series of actions, too fast to be seen with the naked eye, is highlighted in the work of video artist **Dennis Hylnsky.** *A little bumblebee lands on a flower*, 2015, is a one-minute slow-motion video that shows the "the story of a little dance slowed down enough to let our mind understand the complexity of this everyday event in the garden."[3] In other pieces such as *Flight of a Small Northern Cloudyspot,* we learn as much about the expressive possibilities of the video medium as we do about the flight pattern of the small butterfly. In this work, a flat background shifts color from gray to blue behind a group of Echinacea flowers rendered in grayscale; this simplified landscape puts the focus on the action, which is both slowed down and endlessly repeated in what Hylnsky variously refers to as "extruded time," "echoes," or "time trails." These studies of flight patterns, which Hylnsky sees as both data and drawings, have had significant impact on the understanding of inter-species communication. As one interviewer recently noted, "… while he's perfectly content in his role as artist, he does hope that projects like his will inspire scientists to look at problems in new ways."[4]

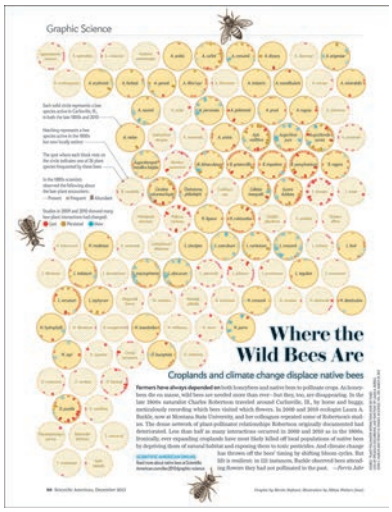
Artist **Julia Oldham** also adds to our understanding of insect behavior, by using her body to mimic the different actions that bees perform. For *Rotations 1–3,* Oldham recorded her performance and then edited the charming and humorous footage to create "humanly impossible" movements that approximate pollination and the "waggle dance"—the name given to the particular body language that bees use to communicate the location of pollen to the rest of the hive. Like many of the artists in *Planting Seeds,* Oldham merges expressive vision with scientific observation to create hybrid work that exists between disciplines. Although inspired and influenced by the expertise of entomologists, botanists, horticulturalists, physicists and other specialists, the work is not exactly scientific. As Oldham writes, "I examine the place where science and art must part ways; and I force them back together again."[5]

Activism on behalf of these vital insects is a recurring theme throughout *Planting Seeds.* In the last decade it has been widely reported that pollinators are partly responsible for nearly 30% of the food that we consume in the U.S. One of the biggest threats to bee populations is pesticide use, both by homeowners and by the agriculture industry. Educating people about these threats has become one focus of the **Beehive Design Collective,** headquartered in Machias, Maine, a group of activist-artists that use the idea of pollination as a metaphor for the spread of ideas. Like bees in a hive, they work anonymously and collectively to design and fabricate large-scale posters, or "graphic campaigns," that help educate the public about global environmental concerns, including pesticide-based agricultural practices and fossil fuel extraction. The series of prints in the Artmobile exhibition are details from some of their posters in which a variety of insect and animal species are shown working together to combat human intervention into their natural habitats. *Paper Wasp Co-Op* imagines a hive as a kind of apartment building where the insects are busy printing posters, washing dishes, and doing other tasks to benefit

[1] Fisher, Rose-Lynn, *Bee.* New York: Princeton Architectural Press, 2010, page 13.

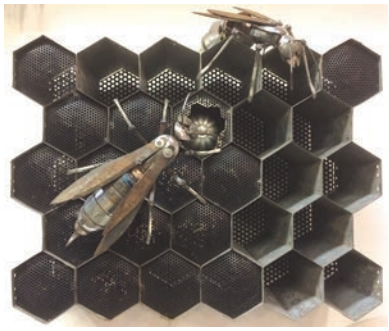
[2] Ibid, page 71.

[3] Artist statement, accessed at vimeo.com



the group. The overall message is that collaboration, communication and adaptation will prevail. Unlike the industrious insects in the Beehive Collective's graphics, however, our ecosystem is powerless. It is up to us to change our ways.

Designer **Moritz Stefaner** creates information graphics to uncover the "truth and beauty"[6] hiding in data. In "Where the Wild Bees Are," commissioned by *Scientific American* magazine, Stefaner translated a report on the declining number of plant-pollinator interactions observed over 120 years, in Illinois. After determining the key finding of the report—that half of the bee species present in the 19th century are no longer observed today—he chose a honeycomb-like design that people would immediately associate with bees, then mapped the pollinator-plant interactions onto the hive in a variety of colors and symbols. Another artist contributed the vintage-style illustrations of bees to convey the passage of time in the original study. In the context of this exhibition, this data visualization is an example of the ways in which artists can help scientists communicate complex research to the public.



Eric Schultz uses found metals to create recycled sculptures that promote environmentalism while creating a sense of playful wonder. The disconnect when we see organic, living creatures rendered in metal makes us stop and think: Schultz's goal is to "open people's minds to the diverse function and meaning of the everyday objects we create, by exploring the programmed response and emotional attachment people have to their things."[7]

There are many artists going beyond inspiration to find real solutions to the disappearance of pollinator habitats and food sources. *The Next Epoch Seed Library* aims to help spread the word about the value of plants often considered weeds, like milkweed and Asiatic dayflower, that are nevertheless beneficial to pollinators. Formed by artists **Ellie Irons** and **Anne Percoco,** the seed library is both an information resource and a conceptual art project that aims to teach others to identify, harvest, and collect seeds from urban areas or marginalized spaces, such as parking lots, where only the hardiest species survive. As part of this project the artists used a scanning electron microscope to make highly detailed enlargements of the seeds of several plants, to better understand how seed structure aids in dispersal and germination. Irons and Percoco developed icons, a poster, brochures and booklets to guide people through the process of collecting and cataloguing seeds; teachers and students might use these tools to contribute to the seed library or to explore school grounds looking for similar plants. "We're trying to help validate and help people engage with these wild plants that are often called weeds," says Irons. "And to think about them as habitat, think about them as these really valuable parts of green infrastructure…that would also be beneficial for a whole suite of nonhumans, including bees." [8]

Plants are a focus of illustrator **Kim Kurki,** who has spent her career depicting the natural world in colorful drawings that both educate and delight. *Planting Seeds* includes a series of the many layouts she created for *Your Big Backyard* magazine, each one focusing on a specific plant species and its attendant pollinators. Kurki works from photographs, detailing the plant's anatomy and habitat, the bird and insect populations that feed upon it, and any human use, whether medicinal or edible. *Butter and Eggs,* for example, shows a drawing of this roadside wildflower with bees landing on the bright orange flowers, and explains that only large bees can open the flower petals to access the nectar deep inside. Kurki also writes the short poems that accompany each illustration, using rhyme to teach young readers about each species.

[4] https://www.wired.com/2014/03/birds-like-youve-never-seen/

[5] Artist statement, accessed at http://legacy.drawingcenter.org/viewingprogram/portfolio.cfm?pf=914

[6] Artist statement, accessed at http://truth-and-beauty.net/about

[7] Artist statement, accessed at http://www.eric-schultz.com/

[8] http://nextepochseedlibrary.tumblr.com/

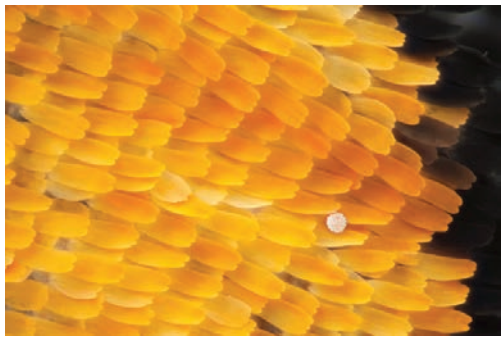
Judy Simon is a botanical illustrator, trained to reproduce specific elements of plant anatomy with scientific accuracy. Her drawing of a rare *Cypripedium acaule,* or lady's slipper orchid, conveys the form and color of the plant with near-photographic detail. Simon notes that the successful pollination rate of this orchid is only ten percent, due to the flower's complicated internal structure; despite a design that encourages insects to follow a specific path through the flower, only those of a particular size will pick up pollen on their journey.[9]

Flowers have evolved to attract specific pollinator species through their color, scent, and form. Work by two artists in the exhibition serve as analogies to the functional beauty of plants and flowers. Philadelphia artist **Anda Dubinskis** combines abstract botanical patterns found in historic textiles with realistic depictions of insects. The flat, decorative, and often symmetrical backgrounds, rendered in graphite and gouache, serve as an organic field on which bees, butterflies, caterpillars, and other species seem to alight. The naturalistic color and three-dimensionality of the bugs, which derive from the artist's observations in nature, are a stark contrast to the flat designs. By comparing this work to Kim Kurki's or Judy Simon's, students will gain an understanding of the wide range of realism that encompasses the field of illustration.

Cara Enteles is an expressive painter whose work is inspired by long hours in her rural Pennsylvania garden. Several years ago, she noticed a decline in the number of bees in her yard and began to research Colony Collapse Disorder and other reasons for the population shift. With this information, she turned to her studio to create "Pollinators," a series of paintings that feature insects, bats, and birds along with abundant flowers. Like Anda Dubinskis, Enteles shifts between the decorative and the realistic, the flat and the dimensional, in layered compositions that create a dream-like effect. (See cover image.) Ultimately, Enteles hopes her work will raise awareness of the importance of pollinators: "they are the bellwether of the health of our environment." [10]

Conservation photographer **Marissa Farra** has the same hopes for her nature photographs. As an environmental educator for Bucks County Audubon Society, she teaches visitors about local ecology and what we as citizens can do to protect it. As an artist, she works in several modes, including documentary work that captures fleeting moments in the landscape, and composite images that merge animal species with images of their habitats. "The goal of my work is to create a desire to protect the environment by building visual connections between people and nature. All of my wildlife and nature photos tell a story and strengthen bonds that we, as humans, have with our surrounding world."[11] Farra is also working in Tyler State Park with BCCC STEM faculty to document their meadow restoration project—both the changing landscape and the student activity within it—throughout the two-year run of the Artmobile exhibition.

Where Farra works to contextualize species in the landscape, biochemist and photographer **Linden Gledhill** uses macrophotography to present details of butterfly and moth wings in extreme close-ups that have been compared to "prismatic quilts" or kaleidoscopes of pattern. In *Swallowtail Wing with Pollen Grain,* we see the tiny scales of the butterfly's wing arranged like rows of flower petals, with a tiny speck of pollen lodged in between. Gledhill uses equipment similar to Rose-Lynn Fisher, but he works at such a close range that we lose sight of the subject entirely. Without an overt environmental agenda, these images instead convey the wonder and beauty of these insects, and—as is the aim of this exhibition—will inspire us to understand, appreciate, and take care of these species and their habitats.



Liz K. Sheehan, *Guest Curator*

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[9] Email exchange with the artist, January 2017.

[10] http://hamptonsarthub.com/2011/11/03/bees-and-trees-and-plexiglas/

[11] Email exchange with the artist, February 2017.

9-12 CURRICULUM INTEGRATION & LESSON PLANS

ALL OF THESE ACTIVITIES are designed to be multidisciplinary, incorporating science, art, math, literature, and technology, among other fields. The lesson plans are organized by topic and include extensions for further projects and research. We suggest that all classes complete "Learning to Look/Learning to See" before visiting Artmobile, and then choose any one or a number of post-visit activities to use in conjunction with the journal they will have made.

PRE-VISIT: All students

MUSEUM MANNERS

Take a moment to review proper museum behavior with your students. Leave food, drinks and bags in the classroom. Do not to touch the artwork or any of the Plexiglas protecting it. Walk, use quiet voices, and respect the Artmobile Educator.

LEARNING TO LOOK/LOOKING TO SEE *(pages 11–12)*

This lesson focuses on the process of observation. How do we take in the information around us using all of our senses? How do we process, record and express this information for ourselves, and for others? Students can make a journal out of recycled materials (or use one they have already) and record their observations, both in Artmobile and in the classroom, through a variety of means—whether drawings, charts, infographics, or descriptive writing practices.

Eric Schultz, *Wasp Nest (detail)*, found objects, metal

POST-VISIT: Choose one or more

POLLINATION: COLLABORATION AND COMMUNICATION *(pages 13–14)*

Bees are an inherently collaborative species, working and communicating to benefit the hive rather than the individual. Several of the works in Artmobile are similarly collaborative. These lessons will provide an overview of the process of pollination and the symbiotic relationship of plants and insects. Students can discuss what this means and why partnership would be an advantage to problem solving, then embark upon shared projects.

ANATOMY AND AESTHETICS *(pages 15–16)*

The purpose of a flower is to attract a pollinator to reproduce its plant. Plants have evolved in structure and in form to attract particular insect species, and seeds have specific shapes and textures to aid in their dispersal. Likewise, pollinators are anatomically designed to efficiently collect and distribute pollen from plant to plant. In these lessons, students will investigate the function of beauty in the environment—the role of color, design, smell, form, and structure—and learn the art and value of persuasion.

RESPONSIBILITY AND STEWARDSHIP *(pages 17–21)*

What does it mean to be a good citizen? These lessons focus on our relationship to the environment and why it is important to protect it. Recent studies have shown that nearly a third of the food we eat comes from pollinated plants. What can we do to maintain healthy gardens, yards, and schools? Who are our role models in conservation?

MANY WAYS OF THINKING *(pages 22–26)*

Interdisciplinary approaches and creative thinking is needed to solve some of our most pressing global issues. *Planting Seeds* includes artists and scientists working together to bring different perspectives to the crucial problem of declining bee populations. For example, an infographic distills a complex amount of scientific data into a design that is visually compelling and easy to read. In these lessons, students will consider methods of observation, analysis, data collection, and information delivery, whether technical or expressive.

PRE-VISIT LESSON

LEARNING TO LOOK, LOOKING TO SEE

Adapted from *Project Wild K-12 Activity Guide,* Gaithersburg, MD, 1992
www.projectwild.org

This is a good introductory activity to model best practices for observing nature AND experiencing art in the Artmobile collection. It is easily adapted for all ages and abilities.

GRADES 9–12

Language Arts, Science, Art

Key vocabulary:
observe, see, appreciate, sense

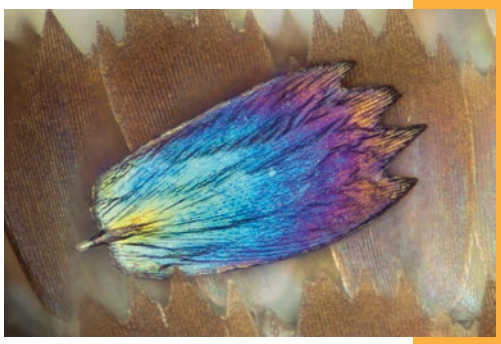
PA Standards:
ELA 1.4, 1.5
Environment and Ecology 4.1F, 4.3C
Art 9.1.12G, 9.1.12G, 9.2.12L, 9.3.12C, 9.4.12C

Objectives
Students will describe differences seen in an environment as the result of casual and detailed observation. Students will give reasons for the importance of looking closely at any environment.

Method
Students list what they remember seeing in a familiar environment, check their accuracy and discuss the results, and then apply their experiences and new skills to an unfamiliar outdoor setting.

Background
Looking and seeing can be entirely different things depending on who we are, where we are, what we are concerned about and our purposes for looking. We look at our classrooms every school day, but if questioned about simple details we may find that we are totally unaware of the existence of certain objects, colors, sounds and textures. As we walk through our neighborhoods, we have probably learned to notice only those things that are necessary to aid us in getting to our destination. We may not see a soaring hawk although we may be looking at the sky. We may not see a community of flowers even though we drive by them every day on the bus ride to school. During a walk in the woods, we may leave the trail to see a tree better and then not see the wildflower we step on, even though we are looking at the forest floor as we walk.

Each of us can educate ourselves to see. It takes at least three elements: 1) to learn to be a careful observer, even if we do not have sight through our eyes; 2) to be aware of our surroundings; and 3) to recognize any part of our environment as being part of a larger whole. As we enter a natural ecosystem (like the one at Tyler Park as seen in the pictures in Artmobile) we are part of that community, just as we are a part of our school community or neighborhood community. At some level, we are members of any community we enter. As a result, we have an opportunity and an obligation to see our neighbors and to be responsible members of each community we enter.



Linden Gledhill, *Tiger Swallowtail with Detached Scale,* digital macrophotography

Materials
Notebook, notepad or a student-made journal.
(See Creating a Field Journal, *page 25 for complete instructions.)*
Pencils Pens

Procedure
1. Let's practice seeing things. Cover a desk, bulletin board, other wall display, or table with a large sheet before students come to class. Ask the students to write down all the things they thought they saw there before the area was covered. When their lists are completed, ask them to turn over their papers. Remove the sheet. On the backside of their first lists, have the students make a new list of what they see. What kinds of things did they remember? What kinds of things were most often missed? Let them come up with reasons why they think this happened.

Kim Kurki, *Cones,* ink and watercolor

Anda Dubinskis, *Adelphia Summer,* gouache on paper

2. Have students go outdoors and pick one spot near a tree, a fence, a brook, a field (or pictures of these if they are not nearby). Each student should find a spot alone, at least some distance from the closest human neighbor. If you are outside, the students should look in a broad sense of the word—seeing, touching, listening and smelling. They should record everything they see. Allow 15 minutes for this for an initial spurt of observations, a plateau, and then another spurt as they begin to realize how much they missed the first time around. Use an agreed upon signal to indicate when it is time to return to the group.

3. Bring students together for a discussion, centering on the process they went through as well as their list of sightings. Did they focus on any one area for a long time? Did they continue to shift their gaze? How did they focus their hearing and smelling? Cupping hands around their ears to simulate animal hearing has a dramatic effect on abilities to hear. Blindfolding seems to cause a compensation toward better hearing as well. Moistening the undersurface of the nose and the entire upper lip area increases smelling ability (think of dogs' cold wet noses). *NOTE: Our role as teachers is a difficult one in that we are most effective when we teach our students* ***how*** *to look and see without telling them* ***what*** *to see.*

4. Talk with the students about the joy and importance of seeing as fully as we can—as a way of appreciating, respecting and learning about more about the world in which we live. Discuss the importance of careful observation of our environments beginning with the basis of our fundamental life-support systems—air, water, soil, plants, animals.

5. Talk about the process of continuing to develop our senses as being a lifelong process for each of us. We are always learning and can learn even more. Sensing more in our surroundings can help us detect changes in our environment, cause us to become curious and ask questions, and help us to become better, more aware and informed decision-makers.

Extensions

1. Blur your eyes. What patterns and shapes do you see?

2. What else did you see? Any living things? What were they? Were they plant or animal?

3. Categorize what was observed as living or non-living—and/or as animal, plant or mineral.

4. Play the game "Animal, Vegetable, Mineral" or "What Am I?"

5. Distinguish between qualitative and quantitative observations. Describe the difference between inferences and observations.

Evaluation

1. Think of three of your friends. Without looking at them, write down the color of their eyes, and a description of what they were wearing last time you were together. Check to see if you were right.

2. Find and observe an insect or plant. Pretend that you are making a report about what you observed to an entomologist (insect biologist). Include detailed observations. Explain the potential value of such detailed observations for two audiences: scientists and the public.

POST-VISIT LESSONS

POLLINATION: COLLABORATION AND COMMUNICATION

POLLINATOR NEEDS / WHO NEEDS POLLINATORS?

Objective

Students will understand that habitats satisfy plant and animal needs. People and animals (specifically pollinators) have similar basic needs, including: shelter, food, water and warmth. Students will explore the garden to see how it is meeting the habitat needs of pollinators.

Materials

Large dry erase board/ poster paper with markers
Access to a building with roof, door, windows, water, kitchen
One option, because all high schoolers love food, have them contribute snacks that depend on pollination (fresh fruits, granola bars, chocolate, etc.)

Procedure

1. Discuss needs.

• Ask, what are things that people need to survive? (Hint: direct students to go beyond "I want a video game.") Start a list on the board. Another good way to start is to ask your students this survival question, "If you get lost outside in a wilderness of any type what do you need to obtain first in order to survive?" Shelter, because you can freeze or die of exposure before you die from dehydration or lack of food. Have them google how long they can last without the food and water before giving the answer. Things people NEED to live should fit into these categories:

Shelter/protection—a place to live, doors, clothes-to protect us from weather
Food *Water* *Warmth, sunshine and light*
Write these and students' ideas on the board.

• How about animals? What do they NEED to survive? Probably some of the same things that people need!

Be sure to emphasize **Shelter, Food, Water and Warmth.** *A good habitat provides for all of these NEEDS for its inhabitants.* What animals live in the garden? Introduce/ review the idea that many animals here are pollinators.

2. Explore the garden. Students should search for specific ways in which the garden satisfies the needs of pollinators. Students should be given a list of questions to explore/answer in the garden. Think about the needs of pollinators. How does this garden meet those needs? Do you see any pollinators? If not, where do you think they are? Is there water nearby? Where could pollinators hide? Is it safe here? What would make it safer for pollinators? What can they eat here? How does the garden provide for warmth? Is there sun? Students may sketch what they find, or take notes.

3. Bring ideas back to the group. Discuss. Compare findings and ideas. Emphasize that pollinators are important to the garden so we must be sure to create a habitat that serves the needs of these creatures, so that they will continue to help the garden to flourish.

4. Tie pollinators into people's needs. Pollinators are important to people because they help us meet our need of food. We need pollinators in order to pollinate flowers and grow foods like chocolate, oranges, bananas, apples and nuts. Have a pollinator-inspired snack (fruit, peanut butter, nuts, juice, etc). The garden provides not only the pollinators with a good habitat, but helps people as well!

GRADES 9–12

Language Arts, Science, Art

PA Standards:
ELA Core 1.2, 1.4, 1.5
Science and Technology
3.1A, 3.1B, 3.1C
Environment and Ecology
4.1A, 4.1D, 4.1F, 4.3A–C, 4.4A–C
Art 9.1.3C, 9.2.3F, 9.2.3J

Marissa Farra, *Pollination by Proboscis,* photograph (detail)

Julia Oldham, *Rotations 3,* video

Extensions

1. *Language Arts.* Have students come up with ideas of how to better serve the needs of pollinators. How could they attract more pollinators to the garden? What could they provide? Change? Draw or write about their ideas.

2. Science. Students visit another habitat and explore to find out how IT satisfies the needs of its inhabitants. How is this different from the school garden? What different inhabitants does it attract? Different pollinators?

BEEHIVE COLLECTIVE MURAL

GRADES 9–12

Language Arts, Science, Art

PA Standards:
ELA Core 1.5
Science and Technology 3.1.C
Art 9.1.3, 5, 8,12 A–D & J

The Beehive Collective, *Biotechnology is Pollution*, silkscreen on fabric

The Beehive Collective, *Pollinator Petitioners*, silkscreen on fabric

Objective
Students will collaborate to create one large mural.

Method
Students will create a small piece of a whole mural. Students will then bring all of their individual pieces together to create a large work of art.

Materials
Source image *(Use a print-out of a work of art from the Beehive Collective or another interesting photograph from nature. Cut picture into equal pieces, enough for each student in your class.)*
Paper cut to scale *(For example, if you want your mural to be 5X larger than the source image, scale up this paper to be 5X larger than the source image. Size will vary depending on class size and mural size.)*
Pencils Erasers Sharpies Colored pencils, markers, crayons

Background
Examine the work of the Beehive Collective displayed in Artmobile. You may also refer to the pieces in the slide show on our exhibition website www.bucks.edu/ArtmobilePlantingSeeds. In their own words, the Collective is "a wildly-motivated, all volunteer, activist-art collective dedicated to cross-pollinating the grassroots by creating collaborative, anti-copyright images for use as educational and organizing tools." They work similarly to bees—each individual, no matter how small the contribution, makes the whole work.

Procedure
1. Randomly distribute a small piece of the divided mural to each student with a larger-scaled piece of paper

2. Ask the student to take a close look at the details from the source image, noticing texture and the scale of everything.

3. Ask students to draw exactly what they see from their source image onto their larger paper. They should work to the edges of the paper. Remind students that it should look exactly like the source image, just larger.

4. After everyone has completed their portion of the mural, show students the original work of art.

5. Have students walk around and put the "puzzle" together to create one large mural.

6. After seeing it all together, give students time to discuss the successes and failures and allow them to go back and edit their original large drawings so that lines and images line up appropriately to make a cohesive mural.

7. After editing, allow students to color their "tile" portion of the mural.

8. Hang the mural all together as one large piece of art.

ANATOMY AND AESTHETICS

ENGINEERING A POLLINATOR

Adapted from the National Park Service's "Biodiversity Bee Week Curriculum," written by Mary Klass, Geological Society of America, Geocorps America Program, Retired Poudre School District, Fort Collins, Colorado, Science Teacher; and Sally Plumb, National Park Service, Natural Resources Stewardship and Science, May 1, 2015. Accessed September 11, 2017 via https://www.nps.gov/subjects/pollinators/upload/FINALBee-Week.pdf

GRADES 9–12

Science, Art

Key Vocabulary: engineer, pollinate, macrorobotics, prototype

PA Standards:
Science and Technology
3.4.10.C2, 3.4.12.C2-3, 3.4.12.D2, 3.4.10.E7
Environment and Ecology
4.1.12.E, 4.4.10.D-E
Art 9.2.12A,F; 9.3.12A,B

Objective
Students will design and build a prototype of a macrorobotic pollinator that would have the potential to pollinate our crops in the event of native species extinction.

Method
Students will analyze how the anatomy of pollinators allows them to operate efficiently; design and create a robotic insect or other species that would be able to accomplish pollination; and describe different structures and functions of their designs.

Materials
Drawing supplies
Found objects and/or sculpture materials such as wire, pipe cleaners, small nuts and bolts, foil OR 3D printing capability

Background
As the exhibition *Planting Seeds* discussed, artist and scientists are trying to combat the decline in pollinator populations in a variety of ways. Robert Wood is an electrical engineer and professor of macrobiotics at Harvard who developed a robotic bee to pollinate crops in the event of species extinction. (Optional: This video lecture (13:01) by Wood discusses how robotics development originates with the study of nature, starting with the flight of a carpenter bee. http://video.nationalgeographic.com/video/ng-live/wood-robotics-lecture-nglive)

Reflect on the work you have seen in *Planting Seeds* that deals with pollinator and plant anatomy: Judy Simon, Rose-Lynn Fisher; and the behavior of pollinators: Julia Oldham, Dennis Hlynsky. Also consider the found object sculpture of Eric Schultz. With these artists in mind, students will design and build a pollinator using different building materials—pipe cleaners, toothpicks, wire, etc., or 3D printing if available—and discuss the adaptations pollinators have that allow for efficient collection and transfer of pollen.

When thinking about engineering a bee (or other pollinator), consider the phrase "form follows function." What adaptations (form) do bees have to move from plant to plant gathering nectar, and in the process, pollinating plants (function)? In order to pollinate plants, bees need (1) a power source to provide energy for movement, (2) the ability to move from plant to plant (wings, legs, etc…), (3) ability to see a flower in ultraviolet light to see the flowers, (4) ability to land on that flower, and (5) the ability to collect the pollen to carry from plant to plant for pollination.

Procedure
1. Sketch out how an engineered bee will look and label all the parts they will need to accomplish the functions listed above.

2. After sketching, use the materials you have gathered to build your robotic pollinator prototype.

3. Discuss your creation with the class or in small groups. What plant species is your pollinator designed to pollinate? What does your engineered pollinator need

Judy Simon, *Cypripedium Acoule with Bee Entering,* ink and colored pencil

to be effective? What are two problems with releasing engineered species into nature? What is one way to solve a problem that may result from releasing engineered species into nature?

Extension Discussion—*Robotics*

View the images, watch the short videos (less than 2 minutes) and read the synopsis of the "robobees" invented by a team at Harvard University. https://wyss.harvard.edu/technology/autonomous-flying-microrobots-robobees/

Compare them to the pollinator drone design developed by scientists at Japan's National Institute of Advanced Industrial Science and Technology. https://www.newscientist.com/article/2120832-robotic-bee-could-help-pollinate-crops-as-real-bees-decline/

What model and method do you think would be more effective? Are these robotic solutions legitimate answers to the problem of declining pollinator populations? Watch the response from Greenpeace: https://vimeo.com/93239025 - what is their message?

Resources

Singh, Timon. "Scientists Develop Flying Robobees to Pollinate Flowers as Bee Populations Decline." Inhabitat Sustainable Design Innovation Eco Architecture Green Building Scientists Develop Flying Robobees to Pollinate Flowers as Bee Populations Decline Comments. *Inhabitat.com,* 11 Mar. 2013. Web. 26 Feb. 2015. http://inhabitat.com/scientists-develop-flying-robobees-to-pollinate-flowers-as-beepopulations-decline.

Spector, Dina. "Tiny Flying Robots Are Being Built To Pollinate Crops Instead Of Real Bees." *Business Insider.* Business Insider, Inc, 07 July 2014. Web. 26 Feb. 2015. http://www.businessinsider.com/harvard-robobees-closer-to-pollinating-crops-2014-6

Dennis Hlynsky, *A Little Bumblebee Lands on a Flower,* digital video

RESPONSIBILITY AND STEWARDSHIP

RACHEL CARSON, "A FABLE FOR TOMORROW"

Adapted from Rachel Carson: Sounding an Environmental Alarm, *produced by Earth Day Network in association with American Experience http://www.weta.org/files/1RachelCarson_LessonPlanw_chapters.pdf*

GRADES 9–12

Language Arts, Science, Art

Key vocabulary:
pesticide, stewardship, responsibility

PA Standards:
Core ELA 1.3, 1.5
Environment and Ecology 4.3, 4.4, 4.5
Art 9.2.12A, F; 9.3.12A, B

Duration
One or two class sessions, depending on the level of your students.

Objective
Students will discover who Rachel Carson was and how her book, *Silent Spring,* changed the way we view and use pesticides and became the foundation of the environmental movement in the United States.

Method
Students will read and analyze "A Fable for Tomorrow," the first chapter of Carson's book. They will discuss how her choice of words and use of pictures combine to create a strong impact on the reader, then draw their own images based on Carson's descriptive language.

Procedure
Warm Up: What Compels You?

1. Begin this lesson by asking students the following question: What do you feel so strongly about that you would want to fully dedicate yourself to it, even if this risked your professional reputation and how others thought of you? Allow students to briefly share responses.

2. Explain that Rachel Carson was a biologist in the 1950s–60s who was compelled to share her concern about pesticides, even at the risk of her professional reputation. This lesson will introduce you to Rachel Carson, her concern, her actions, and the impact on her life and broader society.

3. Introduce students to Rachel Carson by showing the video clip https://whyy.pbslearningmedia.org/resource/amex29rc-soc-pesticide/american-experience-rachel-carson-pesticide-early-warnings/#.WUlCJdyQypo

ACTIVITY 1: "A FABLE FOR TOMORROW" WORKSHEET *(Appendix page 27)*

Part 1: Reading & Discussion

1. Have students read "A Fable for Tomorrow," either to themselves or out loud as a class. This four-page, first chapter of Rachel Carson's book *Silent Spring* can be found at your local library or online here: https://wilderness.nps.gov/idea61.cfm

2. Once they are finished reading, discuss the different descriptions of the town and the corresponding change in language that began around the mention of the "strange blight."

3. Have students record these descriptors on the chart in Part 1 of the Worksheet, then move on to Part 2.

Part 2: Drawing Two Towns

Students will use the descriptive language from Carson's fable to visually illustrate how the town changed.

1. Read the directions for Drawing Two Towns on the worksheet, explaining to them that they will be drawing two pictures, and that the pictures should correspond to the phrases and words they wrote down in the table. For example, their

"Town" picture might include drawings of different birds nesting in trees, while their "Silent Spring Town" picture might depict fewer birds and other animals.

2. Ask students to think about how the artists and scientists in Artmobile made their drawings—what kind of information did they include?

3. Allow enough time for students to complete their drawings.

4. Ask them to share their pictures, either with the whole class or in groups.

5. Encourage students to discuss why they selected certain descriptions, if the mood changed in their picture, and their thoughts for both pictures.

6. Optional: If you have a copy of *Silent Spring*, look at some of the drawings together as a class and discuss why Rachel Carson included them in the book. What kind of impact do they have on the reader?

ACTIVITY 2: LEARNING ABOUT DDT *(Appendix pages 28–29)*

Students will discover why the town changed, learn about DDT, and connect descriptions in the fable to information on DDT.

1. After their drawings, ask students to look at the heading on top of the picture "Silent Spring Town: After Blight." Note that the blight was of utmost concern for Rachel Carson and one of the main reasons she wrote her book.

2. Ask students if they know what the "blight" might have been.

a. Ask if anyone knows what pesticides are. (It is a chemical agent used to destroy pests, such as insects, that ruin crop or plant growth or spread disease.)

b. Where are they? (Practically everywhere. According to Duke University's Chemical Studies website, they are in places such as pools, food, wool clothing, wood, and other areas.)

c. Why are they used? (For food, they can increase harvest and productivity. For wood and wool, they can prevent the breakdown of these materials from insects—moths leaving holes in wool clothing or termites chewing up wood in houses, etc).

d. Why is Carson focusing on the negative aspects of pesticide use? (At the time, she witnessed the largest increase in pesticide use in U.S. history. She saw firsthand the dangerous ramifications of such wide usage, and she was compelled to share her findings.)

3. Hand out the two-page Learning About DDT Worksheet. Introduce the word "DDT" to students and refer them to Part 1, "What is DDT?" Let them know that around the time Carson wrote her book, DDT was a hot topic in the news. Then allot enough time for students to read the information on DDT. Go over questions they may have.

4. Refer students to Part 2 on the Worksheet Connecting DDT to Rachel Carson's "A Fable for Tomorrow." Have them answer the questions while connecting phrases and sentences in "A Fable for Tomorrow" to what they have learned about DDT.

Extensions

1. Look at the work of artist Alexis Rockman (American, born 1962), one of the first contemporary artists to build his career around exploring environmental issues. http://americanart.si.edu/exhibitions/online/rockman/
In 2010 there was a major retrospective (an exhibition looking back at an artist's career) of his work called *A Fable for Tomorrow.* Discuss the imagery, mood, and content of his paintings. How do they reflect the warnings of Rachel Carson?

2. Birds of Prey Make a Comeback: Graph the Data Since the use of DDT was banned in the United States in 1972, the populations of the birds of prey (eagles and osprey) most seriously affected have made a significant comeback. For

example, each state tracked the number of pairs of nesting bald eagles from 1990 to 2006. To see the results of this research, go to the U.S. Fish and Wildlife Service website: https://www.fws.gov/midwest/eagle/population/nos_state_tbl.html

a. Ask students to graph the data by using your preferred graphing program or by hand. (Line graphs would be particularly useful for this data set.) You can select data to graph in a variety of ways. For example, one could analyze the results for states in your region of the country; results for a variety of states representing various regions of the country; the ten with the highest eagle populations, or graph all of the results!

b. Questions for students:

What was the overall trend of bald eagle populations during this time period? Were there any exceptions?

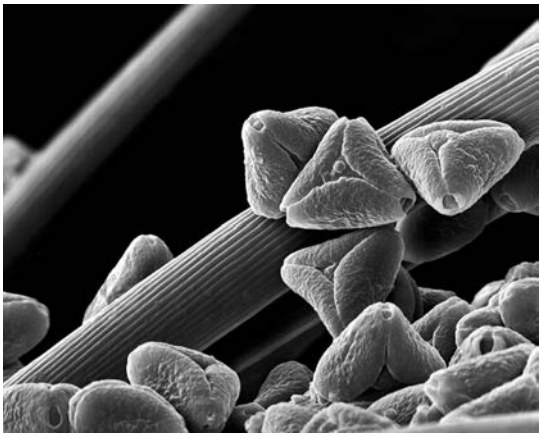
In 2000, what three states had the highest number of nesting pairs? How many?

What was the average increase in population for the states you reviewed?

What percentage increase does this represent?

Was the change in population steady, or were there particular years in which it changed more dramatically?

Why do you think the bald eagle population numbers have changed?



Rose-Lynn Fisher, *Leg Pollen* 1100x, photograph

Marissa Farra, *Pollination by Slime*, photograph

LENAPE HORTICULTURE

GRADES 9–12

Language Arts, Science, Social Studies, Art

Key vocabulary:
horticulture, agriculture, Lenape, sustainability, organic, monoculture

PA Standards:
ELA Core 5.1
Environment and Ecology 4.1B, 4.1D, 4.4A, 4.4B, 4.4C, 4.4E, 4.5A
Social Studies 8.3
Art 9.3.8C, 9.3.8F, 9.4.8C

Duration
45–90 minutes depending on the age/level of your students. Research and preparation of slides can take one class for high school students with presentations on the second day.

Purpose
The development of plant cultivation known as horticulture was developed five to seven thousand years ago. Gardening provided a more stable food supply as well as more established, sedentary communities. Native Americans practiced sustainable and organic farming practices that are still used today and are much more beneficial to ecosystems than monoculture commercial farming.

Objectives
Students will learn:
- How the introduction of gardening made it possible to settle in semi-permanent villages;
- The introduction of gardening provided at least three crops to the Lenape (Legend of the Three Sisters);
- The wild plants that the Lenape foraged to supplement their horticulturally derived crops;
- How the Lenape used sustainable planting and harvesting techniques that are still used today by organic farmers. The Lenape never wasted anything and always gave something back to nature every time they took something.
- How the Lenape protected their gardens and made their gardens attractive to pollinators and natural pest destroyers.

Materials
Computers with internet access. *(If you do not have internet access, then make copies for students of the "Background Information" found in the Appendix, pages 30–31.)*
White boards Dry erase markers Journals or paper Pen or pencil

Procedure
1. Allow students time to read "Background Information" *(Appendix, pages 30–31)* or research online, then answer the following questions.

What is horticulture?
What is agriculture?
What tools would be appropriate for digging, planting, harvesting and protecting crops? (at the time of the Lenape and now)
How did the Lenape water their garden and keep their crops moist?
What does sustainable mean?
What does organic mean?

Extension Questions
How are organic farms better in some aspects than the monoculture factory farms of today?
How are organic farming practices more in line with Lenape horticultural practices of 500–1000 years ago than modern factory farms?

2. Assign group of students to answer some or all of the questions and prepare a PowerPoint presentation, or just write answers on paper.

Cara Enteles, *Pollinating Pair,* oil and silkscreen on acrylic

References
Ewin, Gail, *Lenape Lore*

Kraft, Herbert C., *The Lenape: Archeology, History and Ethnography,* New Jersey Historical Society, 1987

Newcomb, Jr., William, *The Culture and Acculturation of the Delaware Indians*

Peterson, Lee Allen, *A Field Guide to Edible Wild Plants,* Peterson Field Guides, 2000

Tantaquidgeon, Gladys, *Folk Medicine of the Delaware and Related Algonkian Indians,* Pennsylvania Historical and Museum Commission, 1972

Helpful Websites

http://nextepochseedlibrary.com/ Next Epoch Seed Library videos and information on modern seed collecting.

http://www.almanac.com/content/three-sisters-corn-bean-and-squash *Farmers' Almanac* site specifically about the Three Sisters' crops.

https://soilsmatter.wordpress.com/2017/06/01/how-do-the-three-sister-plants-work-together/ Soil Science Society of America website on companion planting and nitrogen fixation.

Marissa Farra, *Pollination by Seed,* photograph

MANY WAYS OF THINKING

CREATING A FIELD JOURNAL

GRADES 9–12

Language Arts, Science, Art

PA Standards
Core ELA 1.4, 1.5
Environment and Ecology 4.1F, 4.3C
Art 9.1.12A, 9.1.12B, 9.2.12J, 9.3.12C, 9.4.12C

Objective
Students will understand the importance of documenting their experiences like artists and scientists.

Method
Students create field journals to record predictions and data, create observational drawings, journal and write reflections on their experiences in nature and in the Artmobile.

Materials
Two pieces of recycled heavy duty paper for your cover cut to size—4.25" x 5.5"
Ten pieces of paper cut to size—4.25" x 5.5"
Awl Washi, masking or duct tape Twine
Tapestry needles Binder clips

Background
This journal-making activity can be used effectively as a means to record data and personal observations in the Artmobile and in nature. With some activities, it may be important to differentiate between field notes and creative journal entries. Field notes are typically factual accounts of nature; journal entries allow for personal interpretation.

A naturalist is a person who studies nature, especially by direct observation of plants, animals and their environments. Naturalists often spend a lot of time in the outdoors, and they often record their observations in some form—from sketches, drawings, paintings, poetry and prose.

The major purpose of this activity is for students to learn to express and record their observations of nature in a variety of ways.

Procedure
Part 1: Making a Field Journal
1. Cut two rectangles of heavy duty paper for the cover

2. On the front cover only, measure 1" from the left edge and cut the strip off but reassemble using the tape of your choice (this allows for the front cover to easily open)

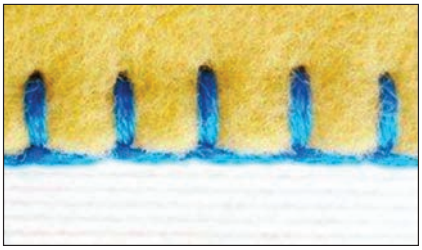
3. Cut the paper to size (you can just cut 8.5" x 11" printer paper in half)

4. Sandwich the paper in between the front and back cover and use binder clips to hold it together

5. Starting from .5" in from the left edge, measure and mark every .5" where the holes for sewing will go

6. Using the awl, punch holes through the entire book

7. Use a blanket stitch to bind the book together. View this You Tube video for instructions https://www.youtube.com/watch?v=S9zegUYdPmg.



http://www.holiday-crafts-and-creations.com/how-to-do-blanket-stitch.html

Part 2: Using a Field Journal

You can use your field journal in many ways. You can make predictions, record observations, take notes, and draw what you see. A field journal helps you organize your thoughts and evidence in whichever way makes meaning to you! Scientists and artists also refer to their field journals as references for other research or to revisit ideas.

Extension

Written reflection: compare and contrast the different methods that artists and scientists use to collect data/create a finished work of art. How are they similar? How are the different?

DRAWING ON NATURE

Adapted from Project Wild K-12 Activity Guide, Gaithersburg, MD, 1992
www.projectwild.org

GRADES 9–12

Language Arts, Science, Art

Key vocabulary:
observe, see, appreciate, sense

PA Standards:
ELA Core 1.5
Science 3.1
Art 9.1.12A, 9.1.12B, 9.2.12F, 9.3.12A

Duration

45 minutes depending on the age/level of your students

Objectives

Students will generalize that wildlife and other animals are important inspiration for art and science. The major purpose of this activity is for students to recognize the value of wildlife as an inspiration for art and science as well as to develop personal skills.

Method

Students use techniques of observation and visualization to record wildlife drawing.

Materials

Pencils Paper Erasers Colored pencils Felt pens

Background

Some significant breakthroughs have been made in recent years with respect to teaching drawing to young people and adults. Betty Edward's *Drawing on the Right Side of the Brain* and Robert McKim's *Experiences in Visual Thinking* are classics in this area, filled with actual instructional activities for use by oneself or with others.

Much of our understanding of science comes from interpreting visual images. The language of science is precise. The images that accompany scientific writing can enhance our knowledge of a subject and add more precision to our perception. Drawings that accompany scientific writing can enhance our knowledge of a subject and add more precision to our perception. Drawings that accompany field notes offer researchers several paths through which to interpret their experiences. The subject is the same, but the information is different. Incorporation drawing into research improves one's observation skills. Good science requires keen observation skills.

Wildlife has been an inspiration for artwork of varying kinds throughout human history. Skills for observation of wildfire are also important to the poet and scientist.

Anda Dubinskis, *Ghost Spiders,* gouache on paper

Procedure

1. This activity is best done in an outdoor setting and requires students to be able to observe a plant.

2. Tell students that they are going to be able to try their drawing skills. After the groans which may follow—since so many people are sure they can't draw at all—insist that you're serious. Encourage them not to worry about drawing but simply to enjoy this activity as a process of observing and recording plants.

3. Provide each student with drawing materials.

4. Take the students outside. If you can't find plants outside, then do the best you can—perhaps by going to a park or purchasing plants.

5. Give students their instructions

a. Find a plant. Observe the plan as closely as you can. Look at its color, form, and shape as if it were an outline against the sky.

b. Close your eyes and try to reconstruct the plant in your mind. See its color, form and shape again in your mind. Remember—this time your eyes are closed.

c. Now, try to draw just the shape of the plant. Draw the outline of the plant as you would see it if it were surrounded by sky. Draw the outline on sketch paper. Sometimes it helps to look at the plant—and not the paper—when you are drawing the plant.

d. Now that you've got the plant outlined, that's the hardest part! Now fill in some of the details.

e. After you've completed the drawing of the plant, start to add in the plant's surroundings—a bug on its leaf, the trees in the background, etc.

f. Now fill in as many details about the plant and background as possible. Think bout the textures and the colors. Complete with the materials of your choice.

Note to teacher: try to be supportive and encouraging of each of the students in this process, without being to evaluative and judgmental. A number of the students who have never been able to drawing anything with any feeling inadequate will experience success with this project. The goal is the focus on the process of close observation and documentation, not a masterpiece. All of the students should be able to come up with something on paper they can be proud of. Encouraging students to keep using this technique in their journals.

6. Once their work is completed, talk with the students about what happened while they were working on their projects - what they saw, how they felt, etc. Talk with them also about the importance of wildlife and all of nature as a source of inspiration for varying forms of art and science.

Judy Simon, *Cypripedium Acoule with Bee Leaving,* colored pencil on Duralar

Extension

A group of people were discussing endangered plants and animals, that is, those that are very close to becoming extinct. Some of the people felt that we should preserve and protect all kinds of plants and animals because we might learn that they could be very useful to us for chemicals, medicine, food and clothing, or that they are a necessary part of our ecosystem. Other people said that we did not need all those plants and animals and we should not worry about losing them. Suppose you are an artist in the group and you want to express your opinion about preserving plants and animals. What will you say?

THE DEVIL IS IN THE DETAILS

GRADES 9–12

Science, Art

PA Standards:
Science 3.1
Art 9.1.12A, 9.1.12B, 9.2.F12, 9.3.12A, 9.4.12C

Duration
Three 45-minute sessions depending on the level of your students.

Objective
Students will interpret the importance of nature as an inspiration for art while looking at the work of Linden Gledhill.

Method
Students research the work of Linden Gledhill and create digital photos of nature that mimic his aesthetic and attention to detail.

Materials
Digital camera or smartphone with camera

Background
Nature has served as inspiration for art throughout human history in the form of painting, sculpture, music, drama, dance literature and photography and other means of creative expression. With recent advances in technology, particularly the smartphone, everyone has access to quickly creating, editing and displaying digital photography.

The major purpose of this activity is for students to recognize the value of nature as inspiration for art, and to gain insight into historical and contemporary influence of technology on human culture and how we receive imagery.

Procedure
1. Students will look at the work of Linden Gledhill. Encourage students to notice all of the fine details in his work and recognize all of the elements and principles of design present in his work—line, shape, color, rhythm, pattern etc.

2. Explain to students that they will be recreating their own body of work using the same thought process and a similar technique. (Gledhill takes close-up, detailed pictures of nature to the point of abstraction.)

3. Encourage your students to pick something in nature that speaks to them—animals, insects, plant life, etc. Some students may even want to consider constructing a "photographer's blind" of some kind for use in observing wild animals outside without disturbing them. Other may find their wildlife in zoos. Remember that nature comes in all sizes - from large mammals to the tiniest seed. Be sure in any case that you remind students not to disturb whatever they are observing in nature.

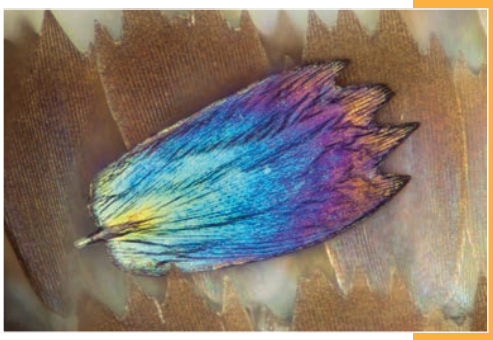
4. Students should aim for a series of five. For example, the wing of a housefly in five different compositions. Each photograph should be unique paying attention to the different angles, detail, layout and lighting.

5. Students should then take their digital images and edit them in an interesting way to create a series. Encourage students to now think of their images as works of art, and not just a documentation.

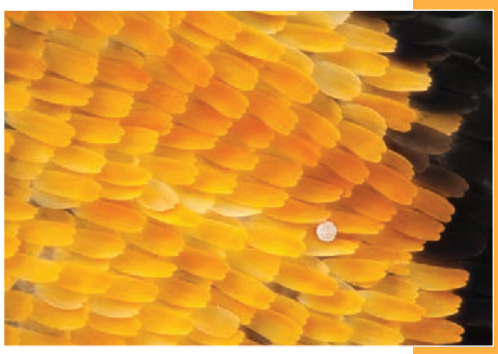
6. With their completed series, have students describe their techniques and experiences photographing nature, including their feelings of the importance of nature as an inspiration and how they feel technology has changed how we interact with nature.

7. Students should also mount and display their series with their essays for others to enjoy.

Extension
Identify and explain at least three major advances in technology that helps humans interact with nature. What are the advantages of using technology to document nature? What are the disadvantages?



Linden Gledhill, *Tiger Swallowtail with Detached Scale,* digital macrophotography



Linden Gledhill, *Swallowtail Wing with Pollen Grain,* digital macrophotography

9–12 APPENDIX

All of the worksheets and reproducibles are arranged by lesson.

RACHEL CARSON

"A Fable for Tomorrow" Worksheet

Part 1: Reading & Discussion

Directions: In the table below, write down key phrases or words from "A Fable for Tomorrow" that you think show the difference between the description of the town at the beginning of the story and how it changed by the end of the story. Place the first set of descriptions under the title "Town" and the second set under "Silent Spring Town."

Example:

Town	Silent Spring Town: *After the Blight*
• white clouds of bloom • great ferns and wildflowers delighted the traveler's eye	• a strange blight • browned and withered vegetation

Town	Silent Spring Town: *After the Blight*

Part 2: Drawing Two Towns

Directions: Using the adjectives, nouns, and key phrases you have written in your table, draw and color two separate pictures reflecting how the town changed. The pictures don't necessarily have to be of towns, but they should reflect Carson's writing.

RACHEL CARSON
Activity 2: Learning About DDT

Part 1: What is DDT?

Read the following and discuss the questions at the end.

DDT (dichloro diphenyl trichlo) is a synthetic pesticide.[1] Synthetics are artificially crafted, meaning that they are produced by humans and not found in nature. A pesticide is a chemical used to kill pests, such as insects. At first, DDT was widely used to eliminate mosquitoes that carry the harmful disease, malaria, but later it was used on farms and in industrial processes to control agricultural pests, such as various potato beetles, coddling moth, corn earworm, cotton bollworm, and tobacco budworms.[2] Its purpose was to increase the amount of food produced on farms by killing the pests that were destroying crops. Yet, as Rachel Carson demonstrates in her book, *Silent Spring*, there were dangerous and adverse effects to DDT.

DDT is insoluble in water. This means it cannot be dissolved in water, so it is difficult to remove from the environment or the tissues of living organisms. One group of animals most vulnerable to DDT is aquatic invertebrates. These include small insects and other creatures without backbones that live in water, such as clams and worms, which constitute a substantial portion of the food chain.

While DDT is insoluble in water, it is readily dissolvable in fats, including the fat tissues found in animals (and people.) Because of DDT's fat solubility, fats in animals can become storehouses for DDT accumulation. Therefore, DDT cannot be removed from water but is soaked up by fat. Its solubility and insolubility make DDT a persistent pollutant: a toxin that just won't go away.

> **"One of the reasons why we worry about DDT is because it doesn't break down in the environment or in organisms."**
>
> ~University of San Diego, Creators of *Cruising Chemistry*[3]

How much DDT is bad for you? The answer to this depends on the amount of DDT that you are exposed to, how much DDT you carry in your body, and your weight. Nevertheless, even a small amount as low as six to ten milligrams of DDT per kilogram, can cause nausea, diarrhea, irritation, and excitability. One of the more severe symptoms is losing control of your muscles, either through erratic movements or paralysis.[4] DDT also affects other animals. For example, it can disturb the reproductive processes of certain birds, such as the thinning of eggshells, or lead to imbalance of ions in cells that affects the nervous systems in some fish.[5]

DDT started being more widely used on farms for pest control in the 1940s. From 1947 to 1960, the use of pesticides went from 1.24 to 6.37 million pounds, growing fivefold over a 13 year span.[6] The dangerous effects of pesticides were not well known until Rachel Carson's book *Silent Spring*, in which "A Fable for Tomorrow" illustrated DDT's adverse effects. While DDT helped farmers to reduce crop damage and loss, Rachel Carson is known for conducting research and bringing attention to the damage it causes to other living systems. The book shocked and concerned so many Americans that then U.S. President John F. Kennedy ordered a scientific investigation on DDT. Later, the U.S. Environmental Protection Agency (EPA) decided that a process to remove its use in agriculture should begin immediately and a ban took place in the U.S. in 1972. Consequently, a worldwide ban was instituted in 2004 under the Stockholm Convention.[7] The Convention, however, was limited and still allowed for developing countries to use DDT to counteract malaria; a full ban is now being sought, as well as the broader implementation of safer alternatives.[8]

> **"Our aim should be to guide natural processes as cautiously as possible in the desired direction rather than to use brute force... Life is a miracle beyond our comprehension, and we should reverence it even when we have to struggle against it... Humbleness is in order; there is no excuse for scientific conceit here."**
>
> ~Rachel Carson in *Silent Spring*[9]

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[1] "Frequently asked questions on DDT use for disease vector control." World Health Organization. Retrieved 21 January 2010 from http://whqlibdoc.who.int/hq/2004/WHO_HTM_RBM_2004.54.pdf.

[2] "DDT: Physical and Chemical Properties." Duke University's Chemical Studies. Retrieved 19 January 2010 from http://www.chem.duke.edu/~jds/cruise_chem/pest/pest1.html.

[3] "DDT: Physical and Chemical Properties." Duke University's Chemical Studies. Retrieved 19 January 2010 from 2010http://www.chem.duke.edu/~jds/cruise_chem/pest/ddtchem.html

[4] "Effects on DDT." Duke University's Chemical Studies. Retrieved 19 January 2010 from http://www.chem.duke.edu/~jds/cruise_chem/pest/ddtchem.html.

[5] "Toxicological Profile For DDT, DDE, and DDD." U.S. Department of Health and Human Services. Retrieved 21 January 2010 from http://ntp.niehs.nih.gov/ntp/htdocs/Chem_Background/ExSumPdf/DDT.pdf.

[6] Guha, Ramachandra. Environmentalism A Global History. 2000. pg. 69-97.

[7] "DDT Ban Takes Effect." Environmental Protection Agency. Retrieved 21 January 2010 from http://www.epa.gov/history/topics/ddt/01.htm.

[8] "DDT Overview." Stockholm Convention on Persistent Organic Pollutants (POPs). Retrieved 21 January 2010 from http://chm.pops.int/Programmes/DDT/Overview/tabid/260/language/en-US/Default.aspx.

[9] Carson, Rachel. Silent Spring. Cambridge, MA: Houghton Mifflin Company, 1962.

Part 2: Connecting DDT to Rachel Carson's "A Fable for Tomorrow"

Directions: After reading the information about DDT, answer the following questions. You will be relating what you read in Rachel Carson's "A Fable for Tomorrow" to what you have just learned about DDT.

1. What is Carson warning us about?

2. Why do you think Carson titles it "A Fable for Tomorrow"?
Think about the choice of words in the title.

3. A question is asked in the fable: "What has already silenced the voices of spring in countless towns in America?" What is the answer?

Critical Thinking Questions:

1. After reading the short information on DDT, what side effect do you think Carson is describing when she says "They [the birds] trembled violently?"

2. "On the farms the hens brooded, but no chicks hatched" refers to what category of DDT's effects?

3. (**Open-ended Question**) Rachel Carson states that "humbleness" is required when we begin to work with nature. What do you think she means? How can we have humbleness toward nature?

LENAPE HORTICULTURE

Background Information

IT IS BELIEVED that gardening or horticulture was first introduced in the Lenape woodland community in the Philadelphia, Bucks County area in approximately 1000 A.D. Horticulture was a means of more stable control over the environment. Crops such as corn, squash and beans (known as "The Three Sisters") were planted, cultivated and harvested. Gardening marked a change in the social structure of the Lenape. A more stable food source decreased the nomadic lifestyle. Through adaptation and resourcefulness, the Lenape modified horticulture into an intricate part of the woodland community. Foraging and hunting remained a big part of the Lenape life since not all groups practiced horticulture as much as others did.

Planting of Seeds
A dibble stick was used to plant a particular seed into a rounded mound of dirt. The stick was made from a tree branch with a fire-hardened tip for planting (think of a used marshmallow roasting stick as a dibble stick). Seeds were NOT planted in a straight row.

Cultivation of Soil
Crude hoes fashioned from deer shoulder blades as well as clamshells and stone implements were used in breaking up soil.

Nurturing of Crops
Great time and energy went into maintaining the communal garden. Most gardens were situated close to a water supply where in times of drought, water could be carried in gourds. Proper placement of crops was accomplished through trial and error, adapting a particular technique for a more bountiful harvest.

Protection of Garden
The garden keeper was a basic structure or platform whereby a young child or elder of the village would sit in hopes of frightening birds and animals away that could destroy the crop. They also hung gourds to act as birdhouses to attract birds that feed on insects to the garden area.

PLANTS USED BY THE LENAPE AS FOOD

CULTIVATED PLANTS

Corn (Maize *Zea Mays)*
One of the "Three Sisters" Corn is the most valuable of all U.S crops and was introduced from Mexico and spread throughout the country. Corn arrived in the eastern U.S. woodlands (this area) about 1000 A.D. which was about a 1000 years after beans and squash. It took over 7,000 years for corn to go from teosinte to a cob as we know it.

Definition of *teosinte* (from *Merriam-Webster Dictionary)* any of several tall annual or perennial grasses (genus *Zea)* of Mexico and Central America that have small dark triangular seeds and include two species *(Z. mays parviglumis* and *Z. m. mexicana* synonym *Z. mexicana)* which are closely related to and often considered ancestral to corn.

The Lenape grew several types of corn: red, white and blue corn were used in the preparation of food. The majority of communal garden was planted with white flour corn. Green corn was boiled or roasted and used for corn bread. Ears were stripped of the husks and hung on poles to dry. Shelled kernels were stored in grass baskets and placed in storage pits. Husks were used to make rope (cordage), for making rugs and roofing material. Corn silk was boiled into tea and used for kidney ailments.

Beans
One of the "Three Sisters"
Many beans including green, snap, string, wax, navy and pinto beans, are members of the kidney bean family. Windsor beans were first brought by early settlers from Europe. Kidney and lima beans come from Central America and soybeans from China. Beans were planted near corn so that the stalks could be used as supports for the bean plants. Ripened beans were shelled and sun-dried for storage. Beans were boiled for eating as well as pounded and mixed with bear grease. Corn and beans cooked together was a favorite dish known as succotash. Beans were also used as game counters for the Lenape children and elders.

Squash
One of the "Three Sisters"
The Native Americans taught colonists how to grow and cultivate squash. Squash and pumpkins were planted between corn hills. This helped keep the soil moist and cut down on weeds. Squash and pumpkins were boiled and then added to bear grease. Squash and pumpkins could easily be dried and kept in food pits for future use. The seeds of the plant could also be dried providing good sources of protein and vitamins A and C. Gourds were first used as waterproof containers.

Sunflower
The giant sunflower head contains seeds. Once harvested, the seeds are dried and ground into oil for cooking. It was also used as a hairdressing for sheen.

Sun Chokes (Jerusalem Artichokes)
This plant is neither an artichoke nor from Jerusalem… it is related to the sunflower. Once harvested in the fall, the tubers (roots) of the plant are boiled and eaten, or could be stored. The leaves are dried and stored.

FORAGED PLANTS

Pokeweed
This perennial plant is edible in small of amounts of young shoots under one foot tall, however older plants are poisonous. Pokeweed sprouts similar to asparagus, while the leaves are more like spinach. Leaves were boiled twice as food preparation in soups and stews. The purple berries made dye for face paint and other uses. The root was used to treat rheumatism.

Cattail
This aquatic plant provided an abundance of food for the Lenape. The roots of the cattail were dug in the spring and fall. Once dried, the roots were made into flour for cooking. In summer, the flower heads were cooked and eaten similar to corn. Pollen from the plant was used as flour for breads. Young plants were boiled and eaten as celery. The plant leaves were also used to make mats. The fluffy seed down was used as the lining for baby diapers. The root was used as a remedy for kidney stones.

Stinging Nettle
Young plants and leaves were cooked as a green. Stinging qualities were removed with cooking.

Milkweed
Young shoots, leaf tips and flower buds were boiled and eaten as a cooked green. The root was used to treat epilepsy.

Mayapple
The small fruits were collected when slightly yellow and ripe and the outer pulp eaten. The seeds are poisonous.

Lambs Quarters
This annual spinach was first brought by early settlers, however other members of the goosefoot family were present here pre-contact. Once foraged, the wild spinach was either boiled or dried. Flour was prepared from the seeds of the plant. Plants called wormseed were given both to humans and animals to cure intestinal worms. Roots of the plant were grated and used in soups.

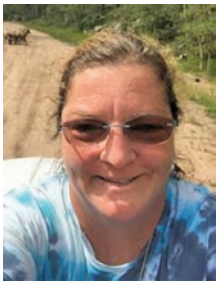
Arrowhead
This is an aquatic plant. The Lenape searched in shallow marshes and ponds by using their bare toes to find plant tubers. Once removed from the mud, the tubers floated to the top of the water for easy collection. Arrowhead was roasted much like a potato by being baked in a cooking fire. The plant was foraged in the spring, fall and winter.

Left to right: Jennifer Garey, Eileen Streeter, Cassandra Gunkel, Fran Orlando, Melody Hunt, Cayla Belser

OUR CREATIVE TEAM

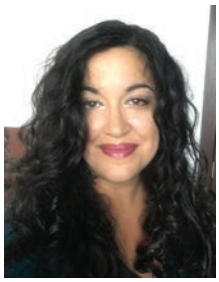
GUEST CURATOR

Liz K. Sheehan is an educator and independent curator of contemporary art with particular interests in public, interactive, and interdisciplinary projects. In 2016 she developed exhibitions for the Hunterdon Museum of Art in Clinton, NJ and the James A. Michener Museum in Doylestown, PA. She is currently working on a monograph and exhibition with photographer, Bruce Katsiff. Sheehan has degrees in Art History and Museum Studies from Bowdoin College and Tufts University.



CURRICULUM WRITERS

Lisa Buffardi, M.Ed, is Pennsylvania Certified in Biology, General Science, Environmental Science and K-12 Special Education, and teaches at Bensalem High School.



Carly Noella Najera has over 8 years' experience in education, teaching high school Art and Literacy classes from Philadelphia to Bucks County. She was the K-12 Art Curriculum Coordinator for Bensalem Township School District where she introduced AP Studio and AP Art History, and co-chair of the PSEA "Touch the Future" art show. She is member of the Bucks County Intermediate Unit Visual Art Advisory Council. Najera holds a B.F.A. from Tyler School of Art in Painting and Art Education and a M.Ed. in Reading from Cabrini University.

Lisa Waibel has taught in the Palisades School District for 21 years and is the elementary science department head for the district. She has her Bachelor's degree in Social Welfare from Temple University, her Master's in Curriculum, Instruction, and Supervision from Rider University, and her Doctorate of Education from Lehigh University.