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The **Birds** and the **Bees**, the **Flowers** and the **Trees**

BY LAURA WHEELER, RITA HAGEVIK, KATHY CABE TRUNDLE, MICHELLE PARSLow, AND KATHERINE VELA

*Let me tell ya 'bout the birds and the bees
And the flowers and the trees
And the moon up above
And a thing called 'Love'
"The Birds and The Bees" sung by Jewel Atkin*

I can still hear this familiar song from my youth playing in my head, and you have probably heard or sang the melody yourself. Although I appreciated the catchy tune, I certainly didn't comprehend the engaging scientific concepts the lyrics implied. What do birds and bees have to do with flowers and trees? How do pollinators connect to this thing

called "love"? This 3-D lesson distinguishes itself from classic flower dissection lessons in that we tell the flowering plant story from the perspective of pollen and coevolution. This lesson allows students to engage in sensemaking through the process of modeling; students develop initial models of the reproductive parts of plants and continue to revise their models as they predict, observe, and explain scientific phenomena.

We use a constructivist approach to learning by utilizing the BSCS 5E model: Engage, Explore, Explain, Elaborate, and Evaluate (Bybee et al. 2006) to engage students in three-dimensional learning as utilized in the *Next Generation Science Standards* (NGSS Lead States 2013). The activities presented here are the results of collaborations in Utah and in North Carolina.

Although angiosperms currently account for approximately 94% of vascular land plants (Crepet

and Niklas 2009), they did not always dominate the botanical world. Angiosperms entered Earth's evolutionary game of survival and reproduction about 150 million years ago (Crepet 2000). Since then, flowering plants' abilities to successfully reproduce have ensured their critical place in human history. Flowering plants owe their early successes to helpful DNA mutations that allowed for covered seeds and sexual reproduction.

Coevolution occurs when multiple species influence the evolution of each other. After 150 million years, angiosperms owe their successful survival and dominance to coevolution with pollinators (Armbruster 2014). The birds and the bees, and any organism that assists in transferring pollen to the flower's stigma, make pollination and subsequent fertilization possible. Birds play a part in seed dispersal and plant growth, ensuring that seeds spread to fertile places. Adaptations by angiosperms (80–96%) that entice pollinators to land and sip nectar facilitate sexual reproduction, while also providing high protein pollen for pollinators to eat (Armbruster 2014). Many pollinators have species-specific adaptations and behaviors (Crepet and Niklas 2009) that allow them to access the nectar and transport the pollen, which benefits the growth of the plant and/or its fruit (e.g., bumblebees, strawberries, and buzz pollination).

Engage (10 minutes)

First, we introduce the students to the plethora of flowering plants (angiosperms currently account for approximately 94% of vascular land plants) on our planet and engage them in playful

thought by making sense of why flowering plants (angiosperms) dominate Earth. For example, we ask, "Why is giving flowers used as an expression of the heart or love?" We engage students by having them connect to their personal experiences both emotionally and affectively. We ask students to imagine themselves as a bee with their only food source being high protein pollen. "How will you know where the pollen is located? How will you access it? How can you make sure you can eat the pollen before other bees?" Students consider these questions as they watch the video.

Students watch the National Geographic video "*Time-lapse: Watch Flowers Bloom Before Your Eyes*" from the viewpoint of the bee (see Online Resources), then share their ideas with a neighbor before reporting out to the class. We ask the students to shift their thinking and imagine they are now the plant: "How will you attract the bee to your pollen? How will you make sure your pollen can be carried to other flowers?" Typical student responses include "we attract bees with our scent and flowers" and "pollen is small and sticky so we will stick to pollinators." Finally, we ask students to predict why flowering plants dominate Earth. We encourage students to share their predictions with a neighbor and the class. The students share a few of their predictions by writing them on the board, and they record predictions in their science journals. Students' responses include that "flowering plants dominate the earth because of pollinators" and "flowering plants dominate the earth because flowers have pollen."

CONTENT AREA

Biology

GRADE LEVEL

7-9

BIG IDEA/UNIT

Sexual reproduction

ESSENTIAL PRE-EXISTING KNOWLEDGE

Plants, pollinators

TIME REQUIRED

120 minutes

COST

\$15

SAFETY

Plastic knives for dissection

Explore (1 session, 40–50 minutes)

After a discussion of the phenomenon (multitude of flowering plants, angiosperms account for approximately 94% of vascular land plants), direct students to develop their initial models of the reproductive parts of angiosperms by drawing and labeling the parts of a flower. Students attempt to draw flower parts from memory as a type of preassessment to measure current conceptions of flower parts. The students revise their initial models when they explore by dissecting the sexual reproductive organs of *Alstroemeria pelegrinaor*, a lily, and identifying the flower's structures and functions. *Alstroemeria pelegrinaor* is an inexpensive lily that can be obtained from a local florist or grocer; we recommend asking the florist to donate any lily leftovers. Lilies have little to no airborne pollen, and students who are aware of pollen allergies may wear goggles and a face mask to protect from pollen as needed. We use the dissection guide student handout to create an enlarged template. Students can recreate the dissection guide found in author handouts (see Supplemental Materials) on butcher paper. Students then use a serrated plastic knife (go over class rules on handling sharp tools) to separate the different parts of a plant and place them into the corresponding labeled box on the butcher paper. Students are not initially provided information on plant parts. They discuss and attempt to reason on their own first. Dissecting the flower on the butcher paper makes cleaning up easier and allows students to draw the flower parts in their notebook or student handout. Although the petals are not a reproductive structure, encourage students to explain the function of the petals: "What connection do petals have to pollen?" By encouraging students to make observations of the petals using their senses, students begin to understand that every part of the flower has a role to play in the overall reproductive success of the plant. Petals attract insects to the flower and may offer protection to the reproductive organs. We travel from group to group and ask questions such as, "How are you determining whether the part is male or female?" and "Does every part of the plant have a function?" Students attempt to reason before the teacher explanation.

Once students have all the plant parts placed on the butcher paper and have shared their ini-

tial ideas about plant part function, we display an image of plant parts and discuss each. Following explicit, direct instruction, we allow students to make changes to the function and the location of the parts on the butcher paper. We now instruct the class to draw the plant parts in the handout. Having made observations, received instruction on plant part names and functions, and drawn the plant parts, students revise their initial model of the flower by drawing and labeling all the parts of the flower (see Figure 1).

Regarding technology, encourage students to view the microscopic world using wireless digital microscopes with 250–1000× magnification (see *Best Reviews Guide* in Online Resources). These devices allow students to capture images or videos of pollinators and flowers when on a nature walk or during the dissection. Up-close observations may lead to student-initiated inquiries such as "Why do these petals have lines on them?"

Explain (10 minutes)

Following the plant dissection, we lead students in a class discussion by asking them to share and explain their observations—for example, "Where is the pollen located?" We introduce students to the processes of pollination and fertilization or the transfer of pollen to the stigma and release of the sperm down the style to the ovary and ask, "What are some possible ways the pollen will move from the anther to the stigma? What would happen if there were no pollinators?" We encourage students to write their explanations or draw a concept map (for students needing accommodation) and evaluate how their initial conceptual models of the phenomenon have changed after reasoning the processes of sexual reproduction in angiosperms from the viewpoint of pollen. Instruct students to once again draw a model of the flower, but this time include the processes of pollination and fertilization. We direct students to include a pollinator and arrows to show the path of the pollen. We give students an opportunity to observe how their initial models and explanations of flowering plant abundance have evolved throughout the lesson.

FIGURE 1: Students labeling flower parts.

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Regarding art, we ask students to draw the process of pollination and fertilization (including the pollinator and flower) as part of scientific modeling. Allow students to go outside and draw a flower and the pollinator it attracted or design a flower with unique adaptations and the pollinator it will attract. Students can make pollen slides of different flowers, draw them, and even possibly digitize and 3D print them! Free 3D printing files of pollen grains are readily available (see the *3D Pollen Project* in Online Resources).

Elaborate (10 minutes)

The next part of the lesson elaborates on a related phenomenon, and students gain more evidence supporting angiosperm success by the introduction of species-specific coevolution of buzzing bees and another enclosed pollen. Students watch a coevolution video (*"This Vibrating Bumblebee Unlocks a Flower's Hidden Treasure"*; see Online Resources) that describes buzzing bees landing on a specific flower that has an anther adapted to enclose the pollen. When the bee uses its wings to vibrate at a high frequency, the anther releases the pollen. The vibrating bee species now have a source of pollen to eat, and the flower now has a pollinator that will disperse the

pollen to a flower of the same species. We love telling students the story of the large tropical jackfruit and the Durian flower, both found in Southeast Asia, that we first encountered when traveling through India and Indonesia. This unique fruit smells like rotting meat and the flower smells like sour milk. We pose the question to the students such as "Why would a fruit and flower, which is usually sweet and delicious, smell like a rotting carcass and sour milk?" Students begin to dialogue about the smell of a fruit and flower and the angiosperms desire to attract an organism that will ensure the reproductive success of the tree. Student comments range from "flies and insects love to land on dead animals" and "scavenger birds like to eat meat too." We ask, "Do you know of any plants that smell like meat that grow close to you?" Skunk cabbages, which grow locally and smell like rotting meat, provide an example that allows students to make global to local connections.

Evaluate (1 session, 40–50 minutes)

We evaluate by playing an interactive native bee game as a formative assessment (see author handouts in Supplemental Materials). Hang up equally spaced pictures (10) of flowering plants around the classroom before beginning the native

bee game. Review students' models of pollination and plant reproduction. Ask the students to identify important flower attributes, from the pollinator perspective, for when they search for the right food source from the buffet of flowers available to them. Refer back to the jackfruit and durian flower story of Southeast Asia. For example, students may say things like smell, color, size, shape of flower, or length of flower. Place students in 10 groups and give them one pollinator card per group. Ask each group to read their card out loud to the class. "What do you notice about the types

of pollinators on the cards (bees, flies, butterflies, moths, beetles, birds)?" Now ask each group to discuss the favorite flower description on the pollinator card and then take the two small tags and tape them onto the flower on the wall that best matches the description on the card of that pollinator's favorite flower (there can be more than one possibility). Ask several groups to use evidence from the pollination card to justify their selection or claim. Allow the class to discuss the choices and adjust as needed. Summarize overall observations at the end of the native bee game by

FIGURE 2: Chart showing students' claim, evidence from the lesson and graph, and their reasoning based on evidence that supports their argument.

Question: What would happen if HALF the flowering plants no longer existed on Earth? Data: Use this graph and all the information in your handout to present your argument.																					
<p>Massive Insect Decline Threatens Collapse Of Nature Percentage decline in selected global insect populations over the past decade</p> <table border="1"> <caption>Percentage decline in selected global insect populations over the past decade</caption> <thead> <tr> <th>Insect Type</th> <th>Percentage Decline</th> </tr> </thead> <tbody> <tr> <td>Caddisflies</td> <td>68%</td> </tr> <tr> <td>Butterflies</td> <td>53%</td> </tr> <tr> <td>Beetles</td> <td>49%</td> </tr> <tr> <td>Bees</td> <td>46%</td> </tr> <tr> <td>Mayflies</td> <td>37%</td> </tr> <tr> <td>Dragonflies</td> <td>37%</td> </tr> <tr> <td>Stoneflies</td> <td>35%</td> </tr> <tr> <td>Flies</td> <td>25%</td> </tr> <tr> <td>Total global insect population decline over the past decade</td> <td>41%</td> </tr> </tbody> </table> <p>Source: Sánchez-Bayo & Wyckhuys, Biological Conservation, 2019</p>		Insect Type	Percentage Decline	Caddisflies	68%	Butterflies	53%	Beetles	49%	Bees	46%	Mayflies	37%	Dragonflies	37%	Stoneflies	35%	Flies	25%	Total global insect population decline over the past decade	41%
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Claim: (answer the question)	There would be a collapse in the number of flowering plants.																				
Evidence: Use at least 3 The data shows... The evidence I use to support... is... Based on ... I think...	<ul style="list-style-type: none"> Based on the graph insects are declining and many of them are pollinators. Based on the dissection pollen has to travel from the Anther to the stigma. Insects like Butterflies would help pollinate flowers, some for specific flowers. 																				
Reasoning: Based on the evidence, I conclude (restate claim) because (your analysis) ... The most logical conclusion we can draw from the evidence is that... because...	<ul style="list-style-type: none"> Based on the Evidence there will be a collapse in flowering plants. Because the evidence shows butterflies are declining and pollinators are needed to pollinate. 																				

asking, “Which pollinators are generalists? Which are specialists? Which pollinators prefer one flower? Which pollinators prefer groups of small flowers? Which flowers are more likely to attract different types of pollinators than others? Why?”

Going farther

Next, students connect personally and emotionally to a new scenario. We return to the anchoring phenomenon and watch the video of all the flowering plants again. We ask the students, “What would happen if half the flowering plants no longer existed on Earth?” We show students current scientific evidence and graphs on the decline of insects including pollinators worldwide (Dicks et al. 2021). As a summative assessment, we ask students to make a claim, provide at least three lines of evidence from the lesson and the graph, and explain their reasoning based on the three lines of evidence that support their argument around what might have happened if there were fewer flowering plants (see Figure 2). We provide a rubric to assess students’ understanding of plant reproduction and the coevolution of pollinators (see author handouts in Supplemental Materials). To differentiate learning, the argument can be constructed individually or in groups.

Conclusion

The pollen connection to birds and bees is responsible for a planet filled with the beauty of flowers. Students play a part in this connection every time they plant a flower. Considering plant reproduction from the perspective of the pollen allows students to think globally and make sense of flowering plants locally. The 5E learning model

gives students the opportunity to apply their new conceptions of why angiosperms (the flowers and trees) rule the world because of the coevolution of birds and the bees and a thing called love (sexual reproduction).

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- Crepet, W.L., and K.J. Niklas. 2009. Darwin’s second “abominable mystery”: Why are there so many angiosperm species? *American Journal of Botany* 96 [1]: 366–381.
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ONLINE RESOURCES

- 3D Pollen Project—<https://bit.ly/3ESHQda>
- Best Reviews Guide. *Digital USB Microscopes of December 2022*—<https://bit.ly/3XQW9Y2>
- “This Vibrating Bumblebee Unlocks a Flower’s Hidden Treasure” [YouTube video]—<https://bit.ly/3VNHlqZ>
- “Time-lapse: Watch Flowers Bloom Before Your Eyes” [National Geographic YouTube video]—<https://bit.ly/3H2D5Ar>

SUPPLEMENTAL MATERIALS

- Author handouts—<https://bit.ly/3FvaG3q>

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