

An Educational Experience Evaluation Highlighting Pollinating Insects



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Pollination is a phenomenon that is necessary for the germination of a seed. This process is made possible by pollinators, such as bees, butterflies, moths, flies, and bats, who carry pollen from one flowering plant to another. The largest contributors to pollination are insects. Habitat loss, pesticides, pathogens, and parasites are leading to decreases in pollinator populations. Being that there are environmental concerns surrounding pollinators, environmental education aims to make more people aware of their importance. In environmental education, connectedness, real-world application, and tactile learning have been shown to improve learning experiences for students. Being that pollinators face environmental challenges, pollinator education is essential in developing community awareness. To increase conservation efforts towards pollinators, pollinator education becomes essential. There are many techniques in pollinator education, but specimen-based learning has been shown to improve understanding of content and engage learners in a meaningful manner. In this research, a pollinator lesson, which includes hands-on experience with pollinator specimens, was taught to middle school students at libraries. A pre- and post-survey was used to evaluate its effectiveness. Participants were asked about their perceptions of pollinator species, along with willingness and understanding of conservation efforts. While there was no statistically significant change in learning due to the program, there were trends of improved answering and deeper understanding of content. If replicated during the appropriate season and including possible extensions to learning, this model would prove to deepen pollinator knowledge and equip participants with the tools they need to take conservation action.

Introduction

Pollination & Fertilization

Pollination occurs when pollen is moved from the anthers of a flowering plant to the stigma of the same (self-pollination) or another (cross-pollination) plant. This process allows for reproduction to occur, which is mediated by the development of a seed, which develops into another plant (Figure 1).

Pollen are round, sticky capsules that contain pollen grains which carry sperm cells (Figure 2).

The pollen, consisting of only two or three cells, is produced in the microsporangium, which are a smaller part of the larger anther. The anther, located at the end of the stamen, is part of the

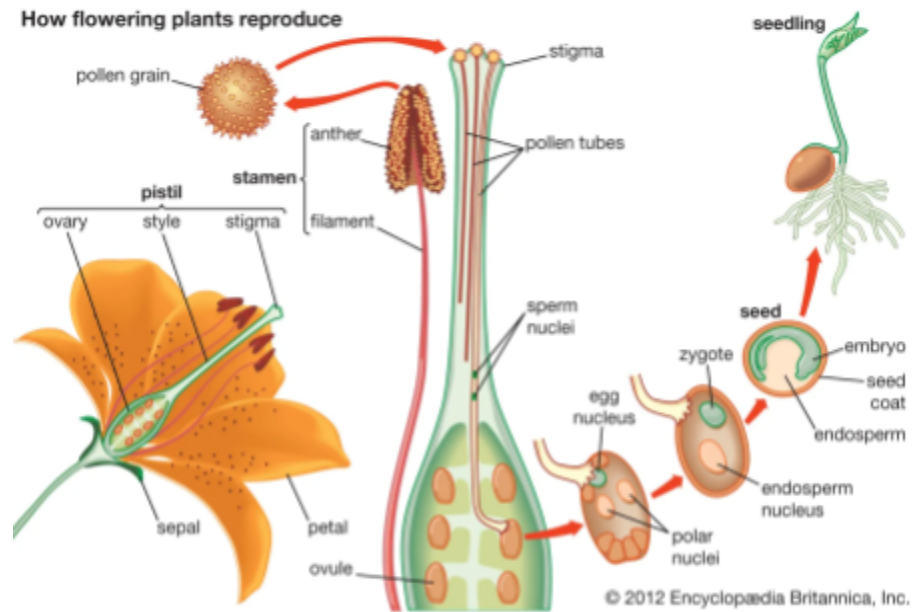


Figure 1. Sexual reproduction in a flowering plant. Source: Encyclopædia Britannica

whole male reproductive organ of a flowering plant, also known as the androecium (Bedinger, 1992; Clark, Choi, & Douglas, 2018; Lord & Russell, 2002). Once pollen is matured, it contains two parts: one generative cell and one pollen tube cell. The female part of the plant, the pistil, has a stigma, which is where pollen is caught. The pollen attaches to the stigma and creates a tube-like structure, the pollen tubes, from the single pollen tube cell. The pollen tubes travel down the style, to the ovary. The ovary contains ovules, which is where the generative cell releases sperm cells, which fuse to the egg cell nucleus. Once the sperm and egg cells fuse, fertilization is complete and a zygote forms. The zygote divides to form an embryo, which in combination with the ovule form the seed. The seed germinates until it is mature enough to be released by the plant into the surrounding environment (Clark, Choi, & Douglas, 2018; Lord & Russell, 2002).

Pollen is deposited in great numbers on the stigma. Hundreds of pollen grains land on the stigma, but only a few sperm cells ever make it to an ovule. This is called pollen population effect, or the mentor effect (Chen, Matsubayashi, & Sakagami, 2000; Lord & Russell, 2002). This process is density-dependent, which means that hundreds of pollen grains must travel from one plant to another for successful pollination to occur (Lord & Russell, 2002).

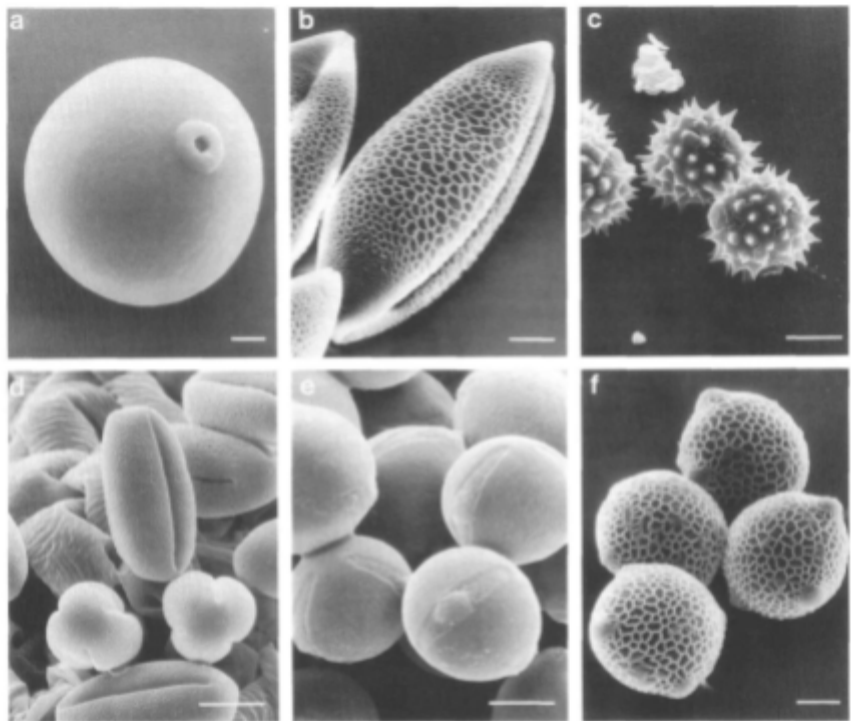


Figure 2. Scanning electron micrographs of pollen. a) Maize b) Amaryllis c) Liatris, a composite d) Redbud, a legume (with stigma), e) Tobacco f) Impatiens; Bars = 10 μ m. Source: *Bedinger (1992)*.

Pollinators

Pollination is essential for plant species to create genetic diversity in an environment (Regal, 1977). As plants are rooted into the ground, they are unable to disperse their pollen over long distances by themselves. In order for the dispersal of pollen to occur, pollinators are a key player. Pollen can be transported from an anther to a stigma in many ways. There are both abiotic methods of pollination and biotic methods of pollination.

Abiotic methods of pollination are performed by non-living factors in the environment (Faheem, Aslam, & Razaq, 2004). Wind and water are two abiotic methods of pollination (Koenig & Ashley, 2003). Wind can move pollen long distances, and many species of plants, for example, species of grasses, oaks, maples, and beeches are considered well-known for being wind pollinated (Koenig & Ashley, 2003). Wind pollinated species often release pollen in early spring before leaves emerge to limit the blocking of pollen as it travels through the air. Wind pollinated plants produce lightweight pollen that is located on small, often petalless flowers. These flowers are usually not colorful or offer little to no scent (Clark, Choi, & Douglas, 2018).

Water pollinated plants include sea grasses and pond weeds, which release their pollen to float in the water, which carries it to a nearby flower (Clark, Choi, & Douglas, 2018).

There are also biotic methods, such as birds, bats, and insects, which physically pick up pollen and transport it on their bodies from one flower to another. These factors are alive in the environment. Many birds, specifically hummingbirds, act as pollinators as they move from flower to flower in search of nectar, a food reward. As the bird extracts nectar from the flower, pollen sticks to the bird's body, where it may fall from while visiting the bird's next flower. Similarly, bats visit flowering plants, such as morning glories, during the night. Also looking for nectar, bats will become covered in pollen just the same as birds. In the same way, they will transfer that pollen onto the next flower they visit (Clark, Choi, & Douglas, 2018). Insects are the primary avenue by which pollen travels from plant to plant (Faheem, Aslam, & Razaq, 2004). Insects that feed on flowering plants include Collembola (springtails), Coleoptera (beetles), Diptera (flies), Lepidoptera (butterflies and moths), and Hymenoptera (bees, wasps, etc.) (Faheem, Aslam, & Razaq, 2004). As insects feed on nectar and pollen, their fuzzy, hairy bodies are covered in pollen, which is deposited on the next flower that is visited.

Factors that Influence Pollination

Pollination is influenced by both flowering plants' and pollinators' characteristics. Nectar and pollen are two food rewards that are incentives for insect pollinators. As the nutrients from nectar and pollen are why pollinating insects visit flowering plants, there are “food markers” that plants display to attract insect pollinators (Leppik, 1956). These markers can include shape, color, odor, nectar, and pollen (Faheem, Aslam, & Razaq, 2004; Kevan, 1983; Leppik, 1956). For instance, color can determine which species are more likely to visit a flower. Some pollinating butterflies prefer yellow-hued flowers, while some flies prefer white flowers (Faheem, Aslam, & Razaq, 2004). Bee-pollinated plants display more blues and violets. These colors are insect-type specific due to the length of the wavelength of each flower's color. As bees see only shorter wavelengths, blues and violets are visited most often (Clark, Choi, & Douglas, 2018). Similarly, butterflies and flies have eyes that only perceive specific lengths of wavelengths, so they only see certain colors. Thus, the type of insect and its ability to perceive color wavelengths dictates which plants that type of insect visits most frequently. At night, bright and light-colored plants are pollinated more by nocturnal pollinators, such as moths and bats

(Faheem, Aslam, & Razaq, 2004). This is because the bright or light colored plants contrast greatly with the dark background of the night (Clark, Choi, & Douglas, 2018; Faheem, Aslam, & Razaq, 2004). Like color, scent can dictate which pollinators visit a flowering plant. Flowers giving off strong fragrances tend to be pollinated by mainly insects. Insects, particularly bees, are very keen on detecting aromas. Insects have even been shown to associate different fragrances with food sources (Wright & Schiestl, 2009). Alternatively, flowers giving off little to no scent are more likely to be pollinated by mainly birds (Faheem, Aslam, & Razaq, 2004). This is due to the finding that most birds have a poor sense of smell (Cronk & Ojeda, 2008). Lastly, flower shape is essential in determining pollination. Shape can influence who gets to pollinate species of flowering plants and what pollinators are attracted to specific plant species. The azalea flower houses its nectar deep within a tubular structure, which attracts hummingbirds to visit and collect pollen from its outwardly positioned stigma and stamen (United States Department of Agriculture, n.d.). Similarly, purple coneflowers have wide open landing spots located on their flower, this allows for larger-bodied pollinators, such as bumblebees to land (United States Department of Agriculture, n.d.).

Some species of pollinators are generalist pollinators, these species can visit many types of plants and have a choice. Other species of pollinators are limited to only one, or a few, select species of plants. This phenomenon is termed constant pollination (Leppik, 1956). One example of this pollinator-plant relationship is the Yucca Moth (*Tegeticula yuccasella*) and Yucca (*Yucca filamentosa*). The moth-plant relationship is essential for the survival of both the moth and plant. The Yucca Moth uses the seeds from the Yucca plant for their larvae to develop. A female Yucca Moth lays her eggs in the ovary of the Yucca plant flower. Once the egg hatches, the larvae feed on the developing seed. Relying just as much on the Yucca Moth, the Yucca plant utilizes the moth as its sole pollinator species. The Yucca Moth has specialized appendages on their face that allow for the pollen from the uniquely shaped Yucca flower to be picked up and distributed to other Yucca plants (Pellmyr, 2003).

Another phenomenon that demonstrates selective pollination is steadfast pollination. Steadfastness to a particular plant species occurs in several species of bees, butterflies, and moths. While these species can visit a variety of flowers, they choose to visit one species of plant per flight (Leppik, 1953; Leppik, 1956). One species in particular that practices steadfastness is the European Honey Bee (*Apis mellifera*). Honeybees have a structure called a pollen basket,

which is located on the legs of the bees. Researchers have been able to determine through analysis of the pollen found in individual bees' pollen baskets that they only visit one type of plant during a flight (Leppik, 1956).

Pollinator Case Studies

Since pollinators are essential components to our global ecosystem, the two case studies showcased below are examples of pollinator species, which I will dive into deeper detail than I have been able to provide thus far. These case studies will serve as examples that I refer to heavily during presentations. Also, these will help illustrate the cause for concern of and need for conservation efforts directed towards pollinating species. Thus, giving reasoning to why this educational outreach is warranted.

*Pollinator Case Study I: European Honey Bee (*Apis mellifera*) and Concerns*

European honey bees, *Apis mellifera*, a species within the order Hymenoptera, is a pollinator globally (Figure 3). This species of insect is native to Europe, the Middle East, and Africa (Mortensen, Schmehl, & Ellis, 2017). European honey bees are a non-native bee species to Pennsylvania, but still play a large role in pollination. Globally, European honey bees are the largest pollinators, with their contribution being more than double that of a similar bee genus, Bumblebees (*Bombus*)



Figure 3. European Honey Bees (*Apis mellifera*). Source: K. Royal

(Hung, Kingston, Albrecht, Holway, & Kohn, 2018). This genus inhabits and acts as a pollinator on every continent, except for Antarctica (Mortensen, Schmehl, & Ellis, 2017).

In a colony, there are three types, or jobs, of honey bees. There is a queen, drones, and workers (Mortensen, Schmehl, & Ellis, 2017; Winston, 1991). The queen is the only female bee that reproduces in the hive (Figure 4). She is larger than the other two types of bees, and has a barbless stinger (Mortensen, Schmehl, & Ellis, 2017). The drones are the males of the hive. Drones are mid-size in comparison to the queen and worker bees. The only job of the drones is to

mate with the queen (Winston, 1991). The last of the types, the worker bees, are the smallest, but do the most jobs within and outside the hive. These are the bees that accomplish pollination while searching for and collecting food rewards for the hives (Mortensen, Schmehl, & Ellis, 2017; Winston, 1991).

European honey bees are kept by beekeepers across the United States to supplement pollination in agriculture which has declined naturally due to habitat fragmentation and pesticide use (Hung, Kingston, Albrecht, Holway, & Kohn, 2018; Steffan-Dewenter, 2002). Agricultural pollination by bees is estimated to be upwards of 30% of all crops (Mortensen, Schmehl, & Ellis, 2017). Along with pollination of crops, honey bees are domesticated for the collection of honey, beeswax, pollen, royal jelly, and propolis (Mortensen, Schmehl, & Ellis, 2017).

Unfortunately, parasites and pathogens, specifically parasitic mites, have been a culprit in both domestic and wild bee population decline (Ghazoul, 2005). *Varroa destructor*, commonly known as the Varroa mite, is a parasitic mite that has been known to target European honey bee populations and is considered the major threat to their populations across the world (Dahle, 2010; Mortensen, Schmehl, & Ellis, 2017). This small mite clings to the honey bee and uses the hive's resources for its own survival, sucking the life from the hive slowly. Once European honey bees were introduced to areas where Varroa mites were native, the mites began to target the European honey bees and cause havoc in their hives (Le Conte, Ellis, & Ritter, 2010).

Once infected with a parasite and attacked by synergistic factors, a phenomenon called colony collapse disorder can occur (Le Conte, Ellis, & Ritter, 2010; VanEngelsdorp et al., 2009; Watanabe, 2008). First investigated in November 2006 by a Penn State entomologist, colony collapse disorder has reduced the bee population across the United States (Watanabe, 2008). The symptoms of this disorder include the dying off of the majority of the adult worker bees in a hive. The hive is left with an abundance of premature offspring. The hive cannot sustain itself



Figure 4. A queen bee (indicated with the yellow tag) crawling on a frame of a domesticated bee hive.
Source: K. Royal

without the roles of the adult worker bees being performed, so the colony subsequently dies due to the loss of the workers (VanEngelsdorp et al., 2009).

Pollinator Case Study II: Luna Moth (Actias luna) and Concerns

The Luna Moth, (*Actias luna*), residing in the order Lepidoptera, is a type of giant silk moth (Figure 5). As one of the largest moths in North America, this species inhabits forested areas (Kavalerskaia, Kazachkova, Nikolić-Lukovska, & Marinović, 2023). Its range includes parts of southern Canada and the eastern half of the United States (Hall, 2019). As adult Luna Moths do not have mouth parts, they use their larval stage to store up enough food to survive for about 7-10 days after metamorphosing into an adult. As an adult, the sole purpose of male Luna Moths is to find a mate. Likewise, females are to find a mate and lay their eggs, the next generation of Luna Moths (Kavalerskaia, Kazachkova, Nikolić-Lukovska, & Marinović, 2023).

As a nocturnal species, this pollinator serves a special purpose. Some species of flowering plants only bloom during the night. Nocturnal plants have strong scents, as coloration is not as valuable as a pollination indicator in the dark (Faheem, Aslam, & Razaq, 2004). While they do not have mouthparts to collect nectar, the moth's wings and body pick up pollen as the moth passes by the flowers on plants and lands on the site of the plant where eggs will be laid (Anderson, 2014). While this action makes the Luna Moth a pollinator, their effectiveness in pollination is much lower compared to nectar-seeking insects.



Figure 5. Luna Moth (Actias luna). Source: Kavalerskaia, et al. (2023).

Major threats concerning Luna Moths are pesticide and herbicide use, along with habitat degradation (Kavalerskaia, Kazachkova, Nikolić-Lukovska, & Marinović, 2023). Alongside these human-influenced factors, light pollution can serve as an issue for Luna Moths as it can disrupt mating. These moths are attracted to UV light, which can lead to distractions from their purpose as adults, reproduction (Boyes, Evans, Fox, Parsons, & Pocock, 2020; Hall, 2019).

While it is clear that behaviors change due to artificial light pollution, it is yet to be determined if any population changes are directly linked to this factor (Boyes, Evans, Fox, Parsons, & Pocock, 2020).

Environmental Education

Environmental issues, such as climate change and biodiversity loss, require awareness spread to community members to create awareness and encourage environmental action. This includes the issue itself, why it is occurring, and how individuals can lessen its effects. Young people, children, are often the audience for environmental topics. Children are an excellent group to educate, since it is known that lessons learned from outdoor activities that children take part in during their childhood often are brought into adulthood (Basile, 2000; Kruse & Card, 2004). Children who had positive experiences in nature at an early age are more likely to have a positive outlook on nature in their adult years (Broom, 2017). Thus, by influencing the minds of young people, you build the next generation of outdoor recreators. Enjoying the outdoors through recreational activities is important, but taking environmental action is equally as important to instill in people. Taking action towards conservation is more likely to happen when people have taken to spending time enjoying nature and contributing to conservation efforts in their childhood (Kruse & Card, 2004). For instance, children who visited the zoo in childhood are more likely to donate to zoos in adulthood (Marshdoyle, Bowman, & Mullins, 1982).

When planning an educational lesson, it is important to identify techniques highlighted in pedagogical literature that will contribute to a successful learning experience and outcome. Connection to the outdoors has been observed as a pillar of environmental education (Barrable, 2019; Frantz & Mayer, 2014). In order to establish this connection, compassion, acknowledging beauty, and mindfulness are essential aspects to stimulate in an educational experience (Barbaro & Pickett, 2016; Barrable, 2019; Lumber, Richardson, & Sheffield, 2017; Wang et al., 2016). Compassion encourages people to care about the environment. People feel a need for protection and justice to be established (Wang et al., 2016). Beauty in nature develops an appreciation, which leads the learner to desire that “good thing” (Richardson, Hallam, & Lumber, 2015). Mindfulness encourages creativity and problem-solving, which stimulates the learner to think critically and engage in thought around environmental topics (Wang et al., 2016). By thinking

critically and being more aware of the environment surrounding a learner, environmentally friendly practices are more likely to be implemented (Barbaro & Pickett, 2016).

Along with looping in themes of connectedness, making the lesson applicable to the students' life and including current world implications of the topic is essential. This strategy has proved to be more effective in student information retainment compared to traditional textbook methods (Foley & McPhee, 2008; Stanisavljević, Mijakovac, Sumatokhin, & Stanisavljević, 2022). When students have the ability to put their own lives into their work, they are more likely to be deeply involved. One student in a case study examining this topic expressed, “One thing that I was impressed by was that there was a clear difference about “obligation” between being told to do something and doing something independently,” and another revealed they “‘feel motivated to further improve learning’ and/or ‘don’t feel they are being forced to do something’ when they become a main player” (Tamura & Uesugi, 2020). Students who act as “pedagogical consultants” gain more confidence in their learning and take more ownership and responsibility for the material and depth of which they learn in the curriculum (Cook-Sather, 2011). Current problems that students and their communities face being included in lessons and curriculum lead to more engagement and greater understanding, particularly in the STEM (science, technology, engineering, and mathematics) fields (Birney & McNamara, 2017; Foley & McPhee, 2008).

Pollinator-Based Education

Since bees, a stinging insect, are often talked about when teaching about pollination, educational experiences around bees and other pollinators need to overcome the fear of being stung. Biophobia, a term describing those who fear nature, can often be the outlook of many young people. However, through environmental education, there can be a transition from biophobia to biophilia, a term describing an appreciation or love for nature (Cho & Lee, 2018). Stinging pollinators, like bees, are feared due to their ability to sting and cause harm, but they also serve a vital role in our society as pollinators. Insect-based environmental education can be implemented in the classroom to create a biophilia towards bees and encourage students to undertake conservation efforts (Cho & Lee, 2018).

Lessons that incorporate specimens, in the case of this research bee, moth, butterfly, and fly specimens, are more effective in capturing student attention and creating a lesson that is “more interesting, valuable, and important over the course of the year” based on student

evaluations (Weeks & Oseto, 2018). Insect-based education can take many forms; this can range from graduate and undergraduate research to lessons conducted in K-12 classrooms. One group, Advancing the Integration of Museums into Undergraduate Programs (AIM-UP!) uses insect specimens that are housed at museums to be used in undergraduate projects. Having tangible and “place-based” specimens gives resources to individuals who do not have the capability to collect or house such a collection (Cook et al., 2016). Another group used capturing and pinning bumblebees as an educational tool that was part of a larger citizen science project, *Bumble Boosters*. The citizen science project included curating specimens, but also included an interdisciplinary aspect where industrial art and biology classes worked together to build artificial domiciles. Teachers related to researchers that their students experienced excitement and continued conversations about pollinators beyond their graduation (Golick & Ellis, 2003).

Another example, *Frass in the Class* is a learning model that focuses on increasing interest in the natural world in K-12 classrooms (Markee et al., 2021). The techniques used to meet this learning outcome are to introduce students to insect diversity, look at insect specimen collections, and rear insects in the classroom. First, the students were given background information pertaining to the activities that would follow. Second, the students explored and examined the specimens to see their adaptations and characteristics. The final component of the unit was to rear insects in the classroom. In the *Frass in the Class* lesson, a butterfly species, *Vanessa cardui*, was chosen for students to rear (Markee et al., 2021). While this learning model is a multi-week experience, components can be extracted and adapted to a shorter lesson while still keeping the main learning objectives for this research.

Statement of Research and Hypothesis

The purpose of this research is to establish a transferable lesson plan to educate middle school students about pollinating insects. In this lesson, I establish how native and domestic pollinators are not species to fear, but rather critical for our local ecosystem. The main objective for my lesson is to educate on the basics of pollination, examine insect specimens, and instill a mindset of conservation in my audience. The audience of my educational experience is middle school students, grades 6th-8th, of Northwestern Pennsylvania. The final portion of my lesson explores ways that students can be bee-friendly. I hypothesize that by participating in the

educational experience, students will show improvements in knowledge and conservational efforts in their post-evaluation when compared to their pre-evaluation surveys.

Methods

Educational Experience

The audience for this educational experience were groups of middle school students (6th-8th grade) attending the pollinating insect program at their local library. When creating this lesson (Attachment 1), I geared my activities to best fit this age group. The libraries that I worked with are set in northwestern Pennsylvania. I contacted the libraries' head of programs to discuss and approve the lesson to be taught prior to its time of implementation. The libraries that I contacted to seek approval were Meadville Public Library, Margaret Shontz Memorial Library (Conneaut Lake), Linesville Community Public Library, Saegertown Area Library, and Cambridge Springs Public Library. For statistical purposes, I aimed to conduct my program at five libraries at least. Each library provided me with a letter of approval for me to conduct my research at their library (Attachment 2). Informed consent forms (Attachment 3) were provided to participants and their guardians to receive permission to use their responses in this research.

The lesson was less than a two-hour experience. First, I presented briefly on the basics of pollination, pollinating insects, and why they are important. This information was presented via a powerpoint presentation that was interactive for the participants (Attachment 4). After the short lecture, I led an activity where participants viewed preserved species of bees, moths, and butterflies, all of which I collected myself and supplemented with Allegheny College's specimens. Students viewed these species under hand-held magnifying glasses and learned about how scientists use insect specimens. They recorded their observations and determined one adaptation they observed that would make the species a good pollinator. Doing so encouraged scientific observation and created a record of the group's research.

Before the start of the program, students tasted and smelled honey, a European honey bee product. Honey sticks were purchased prior to the start of lessons with funding from the Class of 1939 at Allegheny College. Having honey as part of the lesson illuminated the economic factor that bees provide to humans, and in particular, our local community. To conclude the lesson, "Bee The Change" Pollinator Wildflower mix seed packets were distributed. These were also purchased through the Class of 1939 funding. This was the final send off where students have how they can be "bee friendly" in their hands. To make this lesson desirable for teachers to implement, I have connected the materials to learning standards for Pennsylvania.

Assessment

To evaluate the effectiveness of my lesson, I performed pre- and post-evaluations (Attachment 5) that cover the core themes that the lesson offers. The evaluations consist of the same questions, so there is evidence for growth if students improve their score after attending the lesson. The basis of the questions are based on questionnaires used in other similar pre- and post-surveys for pollinator education (Stanisavljević, Mijakovac, Sumatokhin, & Stanisavljević, 2022). The questions for this particular lesson were generated based on what specific information was to be presented. The learning objectives were reflected in the nature of the questions, so that it is clear if they were met. An example of a question on the assessments is how participants rank their fear of bees. Their response is to select a number between 1 (no fear) and 5 (extremely afraid) (Figure 6). This system of ranking is easy to compare between the pre- and post-evaluations (Marques et al., 2017). Other questions included multiple choice and short answers. For the short answer question, I reviewed the answers to the question and accepted or declined it based on my knowledge on this topic. If the answer is not a pollinator friendly practice or a local pollinating species, I did not award a point for that question.

On a scale of 1-5, how scared are you of bees?

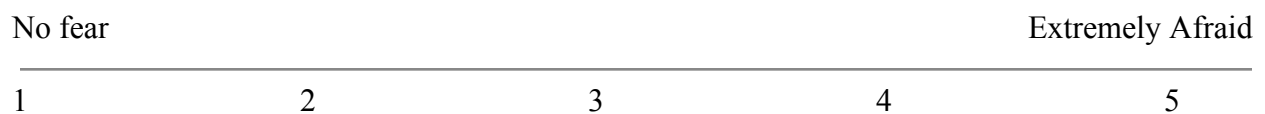


Figure 6. Example of assessment question to evaluate students' fear of bees.

To compare the before and after, I compiled overall scores for both surveys from each participant. In grading each survey, I awarded a point for each correct answer for questions four through eight on the before survey and one through five on the after survey. In regards to short answer questions, I only awarded one point for the question even if there was more than one correct answer listed. For the question that addresses fear of bees, more points were awarded for lower levels of fear. For instance, if a participant rated their fear as a one (no fear), then I would award five points. The question about protecting pollinators is rating excitement. I awarded more points for higher levels of excitement. For example, a participant rating their excitement as a four would have four points awarded.

The research is Institutional Review Board (IRB) approved (Attachment 6); I was certified in the Collaborative Institutional Training Initiative (CITI) before it was implemented. Additionally, I have my PA Child Abuse Clearances and Federal Fingerprinting completed.

Data Analysis

I uploaded the results of the pre/post-evaluation on a google form, which populated a google spreadsheet. To compare the results of the pre-evaluation to the results of the post-evaluation, I ran a paired t-test. From this, I determined if my lesson significantly increased the students' knowledge of pollinators and their desired conservation efforts.

Results

During the duration of the pollinator presentations, I was able to host a total of 56 individuals across the 5 libraries that hosted my program. Of those 56 participants, there were a total of 12 6th-8th graders, only eight of which were able to complete the consent forms and take both the pre- and post-survey. The four that were unable to participate did not have parental consent before the start of the lesson. Each of the eight participants completed both surveys and stayed for the entirety of the lesson. Their tests were graded and scored on correctness and levels of fear and excitement (Table 1).

Table 1

Participants' Overall Scores Before and After Program Intervention

Students	Before	After	Mean
1	10	13	11.5
2	5	12	8.5
3	12	13	12.5
4	13	13	13
5	12	13	12.5
6	11	12	11.5
7	12	12	12
8	11	12	11.5
		Average	11.625

*Test was graded on correctness and level of fear/excitement. The score is out of 19 possible points.

By grading the surveys on correctness and level of fear/excitement, I was able to determine that there is not a significant difference in the overall survey score before and after the program ($Df=7$, $t=2.1385$, $p=0.0698$, Average Mean=11.625). Because of the low power of the test due to small sample size, there are limitations to this study's statistical analysis. This can be attributed to a few factors, but participants' attendance without a parent/guardian was a major contributor. Overall, there were no surveys that saw a decrease in score after attending the program.

Since there were no losses in learning due to the program, highlighting the improvements and learning in the lesson is valuable. First, when asked to "List an example of a local

pollinator,” participants answered with only two categories, bees (87.5%) and hummingbirds (12.5%) (Figure 7a). After the program, participants listed 5 categories of pollinators: moths (25%), bees (37.5%), hummingbirds (12.5%), bats (12.5%), and wind (12.5%) (Figure 7b).

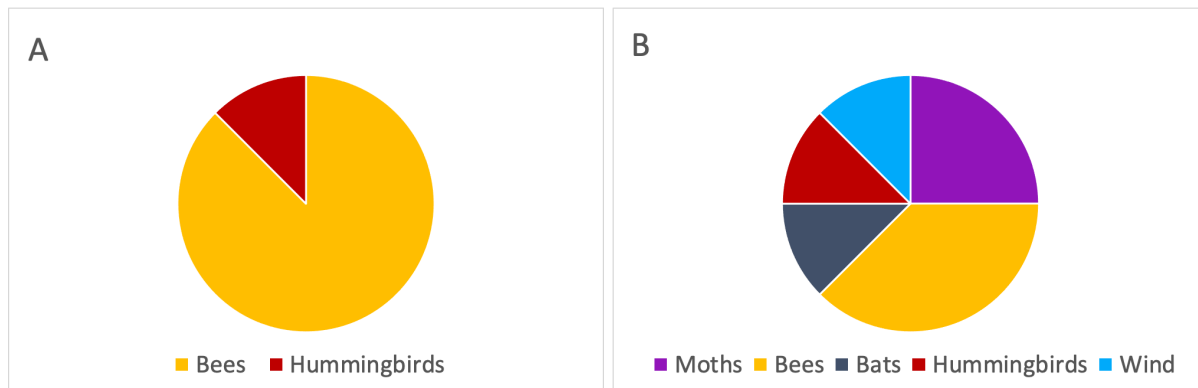


Figure 7. Pollinator examples provided on surveys. (A) Before program intervention. (B) After program intervention.

When asked, “What actions can YOU take to protect pollinators?” There were two groups of answers before the program, but after the program, there were three groups of answers (Figure 8). The majority of which were to stop using pesticides (75%) (Figure 8b).



Figure 8. Pollinator actions that could be taken by participants to conserve pollinators. (A) Before program intervention. (B) After program intervention.

At the end of the survey, the participants were asked to first rate their fear of bees, and second, rate their excitement towards pollinator conservation. While the change in fear decreased and the excitement increased, it was only -0.018% and +0.196%, respectively (Figure 9).

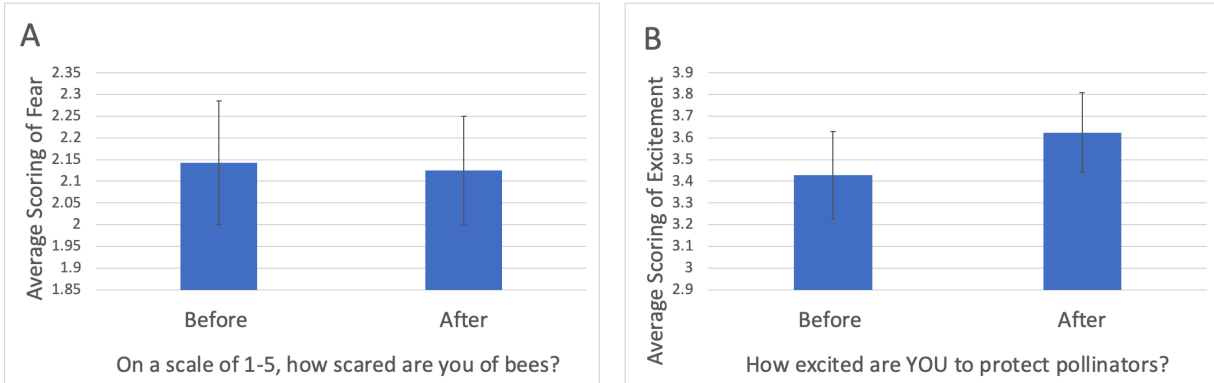


Figure 9. Participant attitudes change towards pollinators, showing standard error. (A) Student rating of their fear towards bees. (B) Student rating of their excitement towards protecting pollinators.

On each survey, there were questions included that served as background information on the participants' experience. The first question was, "How much time do you spend outdoors during a week?" All participants answered with either less than one hour (12.5%), one to two hours (50%), or three plus hours (37.5%). There is no correlation between the time spent outside and the overall score that each participant earned.

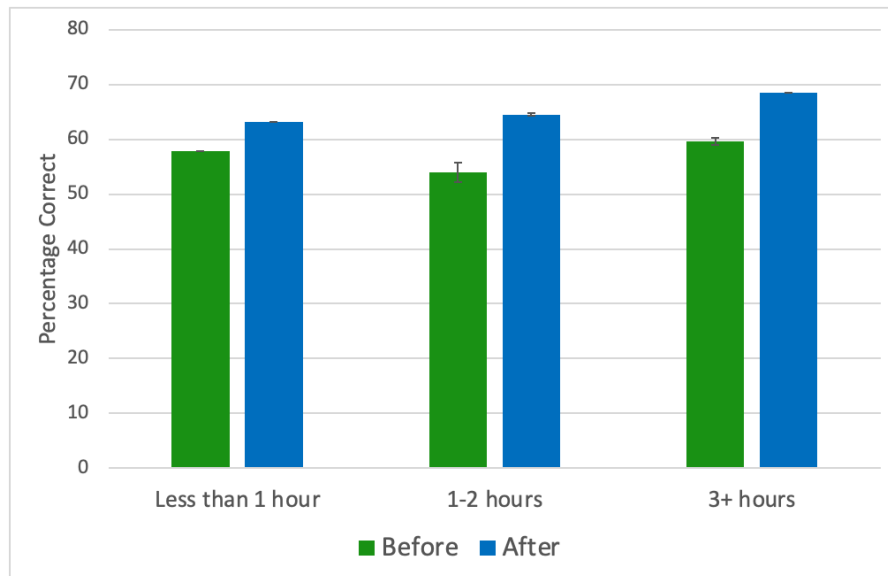


Figure 10. Time spent outdoors by participants on a weekly basis and its effect on the overall percentage correct that participants received on their surveys before and after the program, showing standard error.

Similarly, when participants were asked about the frequency of their camping habits, there was no correlation between camping frequency and overall score earned. All participants answered either never (12.5%), once a year (37.5%), or more than once a year (50%).

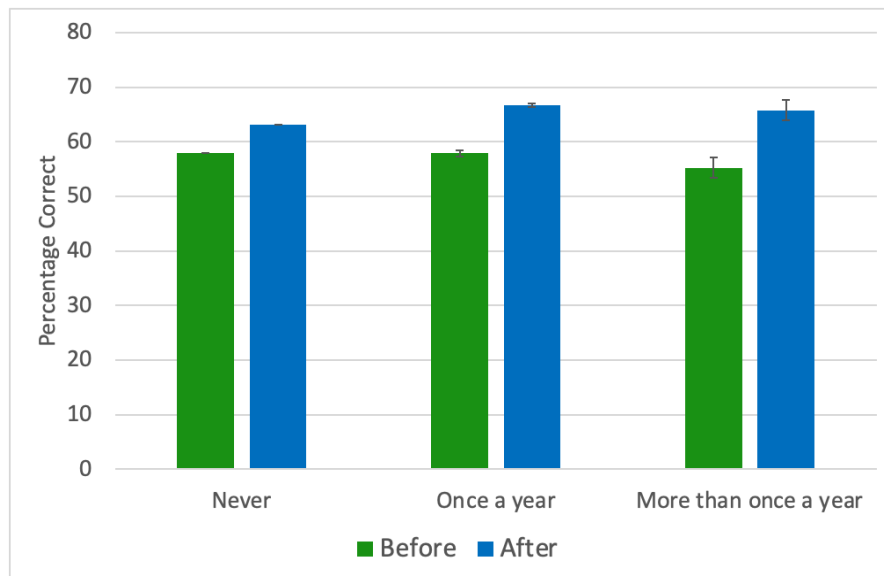


Figure 11. Frequency of camping by participants and its effect on the overall percentage correct that participants received on their surveys before and after the program, showing standard error.

The final question looked to understand participants' background by asking whether or not they had a garden, flower beds, both, or neither at their home. All participants answered with either having no garden or flowers planted outside their home (12.5%) or having both a garden and flowers planted outside their home (87.5%). While there was no difference between scores of each group, the participants with both a garden and flower beds outside their house grew in their knowledge more than those who had neither.

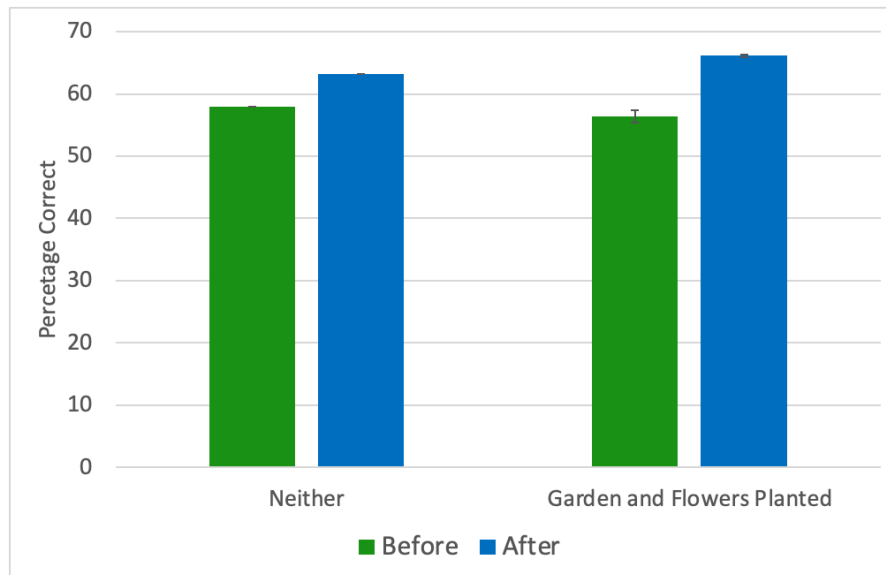


Figure 12. Absence or presence of gardens and flower beds and its effect on the overall percentage correct that participants received on their surveys before and after the program, showing standard error.

Discussion

In response to the survey's statistical analysis, this pollinator lesson did not contribute to statistically significant levels of meeting learning objectives. Even so, there are instances of growth and more thoughtful answering that was provided in their surveys. To this, as participants completed their after surveys, there was more diversity in their responses. For instance, on the question asking participants to list a pollinator, they went from only listing one of two options to one of five options. Thus, the program can see an effectiveness in introducing new pollinators to the participants. Similarly, participants showed improvement when asked, "What actions can YOU take to protect pollinators?" Participants answered only with not killing flowers and/or pollinators or planting flowers. After the program, there were still answers about not killing flowers and planting flowers, but the majority of participants answered with not using pesticides, a topic covered in the program as a conservation effort that individuals could do in their own yards.

Before the program, participants identified as more fearful of bees on average. After the program, participants rated their fears slightly less on average. This decrease in fear may be due to the activity done towards the end of the lesson. Students were able to get close to preserved specimens of bees, which allowed them to see the bees' bodies and make up close observations. Better understanding and being able to view the bees up close may have eased some participants' fears. In the same sense, after the program, there was a slight increase in excitement to conserve pollinator species. This also may be due to a deeper understanding of pollinators and participants' ability to see pollinators in-person. A deeper understanding of the topic may lead to compassion to be developed towards pollinators. As compassion encourages people to care about the environment, participants will feel a need for protection or conservation to be implemented (Wang et al., 2016). Additionally, participants remarked several times about the beauty of the pinned specimens during the program during informal conversations (K. Royal, Personal Observation). As discussed previously, appreciation of beauty in nature leads the participants to desire that "good thing" (Richardson, Hallam, & Lumber, 2015).

Neither camping or time spent outdoors contributed to overall scores. In the same sense, having a flower bed or garden at one's home did not increase overall scores, although, there was a larger increase in knowledge in participants that did have flower beds and gardens. One possible explanation to this trend is that having a real life example of how pollinators interact

with plants helps comprehension of new knowledge. In other learning models, students have been seen to make connections to their local environment with the knowledge that is highlighted in the classrooms. When students can make connections with their surroundings through outdoor learning experiences, the knowledge they learn is more meaningful (Zimmerman & Weible, 2017).

There is only so much that can be interpreted from formal assessment. To this, many observations of what participants showed and said during the programs is valuable. At the beginning of the lesson, I asked participants to draw what they thought a pollinator looked like. Almost every participant drew a bee or a butterfly. On occasion, that bee or butterfly was next to or on a flowering plant. After the program, I would ask about pollinators and participants would list birds, bats, moths, butterflies, flies, bees, and wind (K. Royal, Personal Observation).

Furthermore, at the conclusion of the presentation portion of the program, I asked participants to write down their observations of the specimens and how those observations made them a good pollinator. Many participants wrote down observations such as bees, butterflies, and moths all having fuzzy bodies. I would inquire how that would make them good at pollination, which would elicit the response of then describing that pollen would be able to stick to their bodies, which would help it travel to another flowering plant (K. Royal, Personal Observation). Other students would note that the scales on the wings of moths and butterflies would help them transfer pollen (K. Royal, Personal Observation). While this is a small portion of pollination, allowing the participants to think critically about how this could contribute to pollination was successful (Daniels, Johnson, & Peter, 2020). Size of the pollinator was another adaptation that was observed by participants. Many pointed out that small bees would be able to pollinate flowers that larger-bodied pollinators would not be able to fit into (K. Royal, Personal Observation). Along with directly linked pollination adaptations, many participants pointed out that camouflage, such as looking like bark, or mimicry, such as eyespots, helps pollinators survive, which then in turn allows them to pollinate more (K. Royal, Personal Observation).

The program was successful in reaching 56 participants across 5 libraries. Some libraries hosted programs with more participants than others. For instance, Meadville Public Library, the largest of the libraries, had the most participants attend the program. Oppositely, the smaller libraries, such as Cambridge Springs Public Library had the smaller number of participants. Furthermore, the target age group, 6th-8th grade, was mostly absent from the attendees. At two

of the programs, there were no participants in the target age range. Many of the librarians expressed during informal conversations that the target age group in this study was a difficult age group to attract and involve in similar past programs for reasons such as sport involvement and other after school extracurriculars (K. Royal, Personal Observation).

Another explanation for the lack of attendance could be due to seasonal learning. This research took place from December to February. In Western Pennsylvania, the weather during this time was colder, snowy, and there were no pollinators or flowers in sight. Since there was little context to be immediately seen before or after attending the program, there may be a loss of knowledge due to not being able to apply it until warmer months. Additionally, a lack of seasonal context may have deterred potential participants from attending the program. In future environmental education research, presenting on season-conscious topics may help improve attendance.

If this lesson was presented during the summer months, incorporation of new and engaging scientific technologies could possibly improve learning outcomes. One learning model used video cassette recordings, which proved to be successful in enabling middle school students to collect data and enrich their learning (Reid-Griffin & Carter, 2008). One possible alteration to this research program would be to incorporate more technology and data collection. For example, an additional extension to this activity would be to send participants out in the field, for instance a meadow with wildflowers would be an appropriate location, with a device able to take pictures and/or videos. They could record the species of pollinators that they see visiting flowering plants. As participants see the variety of pollinating species visiting flowering plants, it would assist in highlighting the importance of pollinator biodiversity. If pictures of pollinating species could be captured, they could be uploaded to iNaturalist, an online wildlife identification application for mobile devices. Classroom education has used iNaturalist to promote inquiry-based learning and has been successful in engaging students outdoors with biological lessons (Eden, 2023). This application is free and downloadable on most mobile devices.

Another way to increase attendance would be to find a host location with a captive audience. One such location would be to contact and be hosted by a classroom teacher. At the beginning of this research, a middle school classroom was contacted to be the host site, but due to IRB limitations, this research was unable to be completed within the public school system. However, holding such events within a classroom could potentially increase attendance and

resources available. If hosted by a science classroom with access to multiple microscopes, participants would have more time using a core scientific tool, which could transfer to deeper learning with technical educational equipment (Silverstein & Veeraraghavan, 2021). While not on the formal assessment, using the microscope during this program visually increased participant interest, with many participants remarking how interesting the wings of butterflies and moths were beyond what we can see with the naked eye (K. Royal, Personal Observation). In future research, it would be beneficial to find a similar host site that would provide a larger audience and access to more scientific tools.

Conclusion

This project has been successful in reaching a group of local individuals and teaching about pollination and the local pollinating species found in Western Pennsylvania. Presenting this program increased learning about the basics of the topic, but also encouraged and educated about conservation actions that individuals can take to conserve pollinator biodiversity in our area. By equipping participants with a mixed wildflower seed packet, this program is directly supporting conservation efforts. While this project is not taking direct conservation action, it is educating and informing participants on how they can take action and take ownership in protecting a locally essential group of organisms. This program can be used as a way to introduce the topics of pollination and pollinator species and should be used as a resource in both formal and informal learning situations.

Since this research had a substantially low sample size, there are limitations to the statistically relevant data collected. Even so, the inferences and informal assessments show that learning and improvements were made by participants, which shows value in using this educational model. By replicating this research in the future and increasing sample size, there will be more accurate results, which may inform changes to the lesson that would prove it to be more effective in meeting learning outcomes.

Furthermore, this research can inform the effectiveness of one-and-done environmental education lessons. Oftentimes, this is how many environmental education topics are presented to the public, so being able to analyze the effectiveness of lessons only presented to a group once is important for environmental education as a field. Conducting this research within the appropriate season and with the extensions described above would provide more information about how best to educate on pollinating species.

In doing this research, I have found myself learning more about the topic, environmental education, and community outreach. Compiling this program has led me to dive deeper into research about pollination, pollinator species, and conservation efforts. I have been able to meet professionals in the field, such as local beekeepers, to deepen my knowledge and add to my experiences, which help to inform my program. Researching how best to present and share this knowledge has aided in developing my environmental education pedagogy, which includes tactile, hands-on experiences that enhance learning outcomes. Lastly, this project has provided me with an avenue to do community outreach and build my local contacts. I was able to expand

my contacts to include all the libraries that I worked with and some of the participants. One participant's parent reached out and inquired if I could do the same program for a Girl Scouts group. In all, this research has made me a better environmental educator and community member.

Appendix

Attachment 1. Lesson Plan

Attachment 2. Library Approval Letters

Attachment 3. Informed Consent Forms

Attachment 4. Lesson Presentation

Attachment 5. Pre-/Post-Surveys

Attachment 6. IRB Approval Letter

Attachment 1. Lesson Plan

Examining Pinned Pollinating Insects of Pennsylvania

Overview

This activity is intended to introduce pollinating insects and their role in the local ecosystem. By examining pinned pollinating insect specimens (bees, butterflies, and moths), students will observe adaptations that make that insect an effective pollinator. The class will discuss why these adaptations make these insects good vessels for natural pollination. Through hands-on experience handling specimens, students will have an opportunity to observe stinging pollinating insects, bees, in a much closer, risk free fashion. Along with conversations about pollinator conservation, students will understand pollinator's importance and develop a desire to conserve such species.

Time allotted: 1 Hour

Grade levels: 6th-8th

Learning Standards: 3.1.6-8.D -Use arguments based on empirical evidence and scientific reasoning to support an explanation for how characteristic animal behaviors and specialized plant structures affect the probability of successful reproduction of animals and plants, respectively.

Objectives/Learning Goals:

- Students will have an increased understanding of pollination and the pollinating insects in our area.
- Students will have a decreased fear of stinging pollinating insects.
- Students will have an increased desire to conserve pollinators and have an idea of how to implement conservation themselves.

Student Materials:

- Hand-held magnifying glasses (1/student)
- Honey Sticks (1/student)
- Pollinating Seed Mix Packets (1/student)

Other Materials

- Pinned Specimens (a mix of butterflies, moths, and bees)
- Pinning Supplies (pins, boxes, etc.)

Procedure

- Before the lesson begins, set up one table with butterfly specimens, one table with bee specimens, and one table with moth specimens.
- As students are filing in, have them take a honey stick to snack on before the lesson, pollinator journal, seed packet, and pencil.
- While waiting for the lesson to begin, ask students to draw what they think a pollinator looks like in their journals.
- Once the lesson begins, focus on what pollination is and how it occurs (animals, insects, wind).
- Discuss what pollinators do or have that make them effective in pollination.
- Discuss what relevance pollination has on everyone's life... agriculture depends on pollination! Ask a few students what their favorite food is and discuss what it might look like without pollinators. Loop back to honey sticks that were distributed before the start of the lesson.
- Have students break up into three groups. Rotate tables every 10 minutes. At each table, focus on what makes each group of insects good pollinators. Ask what adaptations allow for pollinating success for that insect.
- After the final rotation, students will regroup and discuss their findings. I will remind them of dangers facing pollinators and students will brainstorm conservation actions.
- At the conclusion of the lesson, talk about how they can plant their pollinator seed packet as a "pollinator friendly" action.

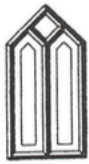
Notes

- Students should be aware that specimens are extremely fragile, so it is important to be respectful of the specimens.
- Have a sugar-free option of a snack for students who have dietary restrictions.

Extension

- If you have access to a microscope, set it up with a butterfly/moth wing to show scales.

Attachment 2. Library Approval Letters



Linesville Community Public Library

111 Penn Street, P.O. Box 97, Linesville, Pennsylvania 16424

October 18, 2023

To whom it may concern,

We are excited to welcome Kaitlyn Royal into our library to run a pollinating insect program for our kids here at Linesville Library. We understand that this is a research project she is doing for her degree and she has our permission to utilize any and all information she gathers while running this program.

Sincerely,



Renee Grout
Director

Cambridge Springs Public Library



158 McClellan Street
Cambridge Springs, PA 16403
814-398-2123 (Fax/Phone)
cspl@ccfls.org

November 2, 2023

The Cambridge Springs Public Library has approved hosting Kaitlyn Royal to conduct an environmental education experience focusing on pollinating insects. We understand that Kaitlyn's research project focus is on 6th-8th grade students although all are welcome to participate. Further, we are aware that pre- and post-survey evaluations will be taken.

I am available for further discussion on this approval if needed.

Sincerely,

Amanda Scott
Library Director

Shontz Memorial Library

145 South 2nd Street
Conneaut Lake, PA 16316

Ruth Young, Ed.D.
Executive Director

814-382-6666
shontzpl@ccfls.org

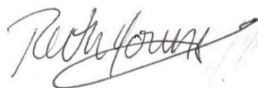
Allegheny College
c/o Institutional Review Board
520 N. Main Street
Meadville, PA 16335

Dear Review Board Members,

We are looking forward to having Kaitlyn Royal conduct a workshop on pollination and pollinator insects, here at the Margaret Shontz Memorial Library. Kaitlyn Royal has my full permission to use the Margaret Shontz Memorial Library and our audience for her research purpose.

Please let us know if you have any questions or concerns about our facility in her efforts to conduct research.

Best regards,

A handwritten signature in dark ink, appearing to read 'Ruth Young', with a stylized flourish at the end.

Ruth Young, Ed.D.
Library Director



Meadville Public Library

November 6, 2023

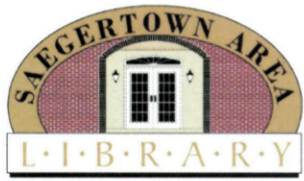
Allegheny College
c/o Institutional Review Board
520 N. Main Street
Meadville, PA

Dear members of the Board,

We are looking forward to having Kaitlyn Royal conduct workshops on pollination and pollinator insects, here at the Meadville Public Library. The Library has the space available and the resources to provide her if needed during the surveys she conducts. We can also help with distributing the date and time on our website or social media accounts if needed. Kaitlyn Royal has my full permission to use the Meadville Public Library and our audience for her research. Please let us know if you have any questions or concerns about our facility in her efforts to conduct research.

Best regards,

Steven Utz
Assistant Director, Teen and Youth Services Librarian
steve.utz@ccfls.org



Saegertown Area Library
325 Broad Street | PO Box 871
Saegertown PA 16433
saegertown.ccfls.org | 814-763-5203

November 22, 2023

Dear Ms. Kaitlyn Royal,

On behalf of Saegertown Area Library, it is my pleasure to inform you that we would like to formally accept your request to facilitate your learning activity, "Pinning Pollinating Insects of Pennsylvania" here at Saegertown Area Library. Furthermore, you have our permission to use the information gleaned from performing this activity as part of your research.

Thank you for thinking of our library as a venue for sharing your knowledge with our community. Providing free community relevant educational programming is a cornerstone of library services, and your proposed learning activity will be a perfect fit. I look forward to its implementation.

Please feel free to reach out to myself or our Children's Librarian, Tina Hunt, regarding any needs or developments on your end, including program scheduling and advertising.

Sincerely,

Lauren Lowery, MSLS
Library Director

Attachment 3. Informed Consent Forms

Parental Informed Consent Form

An Educational Experience Evaluation Highlighting Pollinating Insects

Allegheny College

Department of Biology and Environmental Science and Sustainability

Purpose of Research: The purpose of this study is to examine insect-based education, which can take many forms. In this research, we will be evaluating attitudes towards pollinators and how single environmental education experiences can alter those attitudes and encourage learning.

Method/Procedure: I understand that I will be asked to take a pre- and post-survey regarding the information presented in the pollinating insect lesson taking place today, of which I will actively participate in.

Length of Participation: I understand that the pre- and post-survey will collectively take approximately 10 minutes to complete.

Risks to the Individual: I understand that there will be no more risk other than what is normally experienced in everyday life.

Benefits of the Research: I understand that this research will enrich the participants' knowledge about local pollinating insects and will be an interactive and engaging experience. The data collected will inform researchers about the effectiveness of engaging in similar lessons in the future.

Confidentiality, Recording Information, and Data Security: I understand that my child's name will not be collected on their survey. The only identifier on the surveys will be a number that corresponds with both their pre- and post-survey. Only the research team will view the child's answers, and all data will be deleted after the completion of the research. The results from this research will be shared in academic presentations and reports.

Voluntary Nature of Participation: I understand that I do NOT have to participate in this research project. Furthermore, I may choose to withdraw my participation at any time without penalty. I understand that I may skip any individual questions that I do not wish to answer, and I may choose not to participate in any part of the study without being questioned.

Results of Research Project: I understand that I am entitled to a copy of the results once this study is completed, which will be available at the public libraries in May 2024 if a copy is desired. Additionally, the copy may be found on D-space via Allegheny College's website.

Contact Information: If I have any questions about this research project, I can contact Kaitlyn Royal at royal01@allegheny.edu or the research advisor, Dr. Terrence Bensel at tbensel@allegheny.edu. If I have questions or concerns about the treatment of research participants in this IRB-approved project, I can contact the Chair of the Allegheny Institutional Review Board (IRB) at IRB@allegheny.edu.

* Honey is provided during this presentation. Please indicate if the participant has a known allergy to honey products. *

- ☐ My child **is not** allergic to honey products.
- ☐ My child **is** allergic to honey products.

I have read and understood this form and I understand what my child would be participating in if they participate in this study. I consent for my child, _____, to participate. I have received a copy of this informed consent form. I have carefully read and understood the information on this form and all of my questions thus far have been answered.

I agree to participate in the study.

Guardian of
Participant's Signature

Date

Participant's Name (print)

Researcher's Signature

Date

Child Informed Assent Form

An Educational Experience Evaluation Highlighting Pollinating Insects
Allegheny College
Department of Biology and Environmental Science and Sustainability

I am Kaitlyn Royal from Allegheny College. I am doing a study to figure out if this lesson about pollinating insects allows people to learn certain things about species in our area. We are asking you to take part in the research study because you and your parent/guardian came to this pollinator program at your local library.

For this research, we will ask you some questions about how you feel about pollinating insects and what you know about them. We will keep all your answers private, and will not show them to your parent(s)/guardian. Only people from Allegheny College working on the study will see them.

We don't think that any big problems will happen to you as part of this study, but you might learn something about pollinators that makes you feel sad. You also might be upset if other kids see your answers, but we will try to keep other kids from seeing what you write in your surveys before and after the lesson.

By helping in this research, you will learn about pollinating species in your backyard! You might learn some new facts to share with others! You can feel good about helping us to see if this lesson might help others learn about this later.

You should know that:

- You do not have to be in this study if you do not want to. You won't get into any trouble with Allegheny College, your teacher, or the library if you say no.
- You may stop being in the study at any time. If there is a question you don't want to answer, just leave it blank.
- Your parent(s)/guardian(s) were asked if it is OK for you to be in this study. Even if they say it's OK, it is still your choice whether or not to take part.
- You can ask any questions you have, now or later. If you think of a question later, you or your parents can contact me at royal01@allegheny.edu.

Sign this form only if you:

- have understood what you will be doing for this study,
- have had all your questions answered,
- have talked to your parent(s)/legal guardian about this project, and
- agree to take part in this research

Participant's Signature

Date

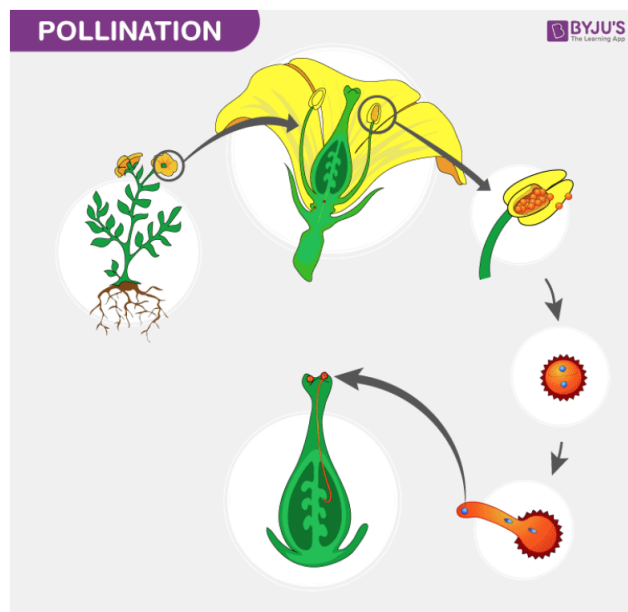
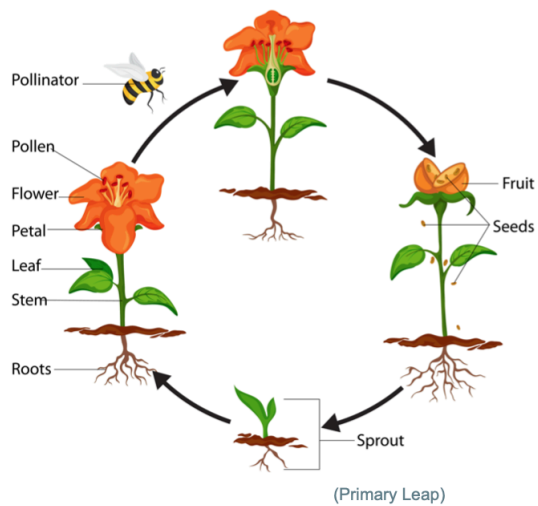
Participant's Name (print)

Researcher's Signature

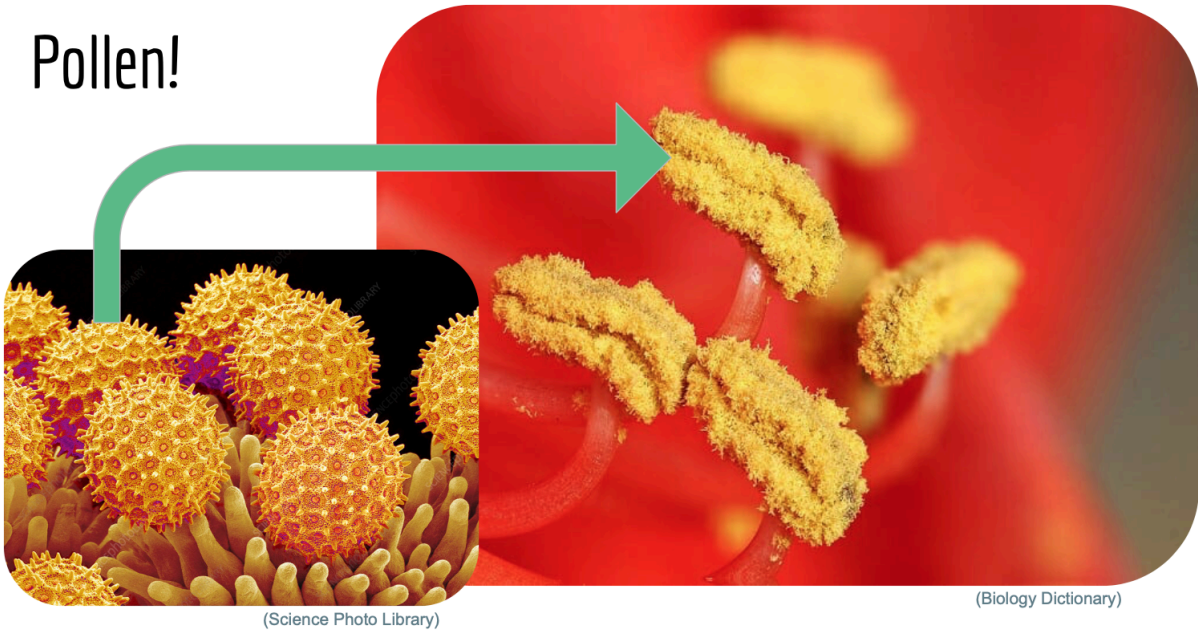
Date



What is Pollination?



Pollen!



1

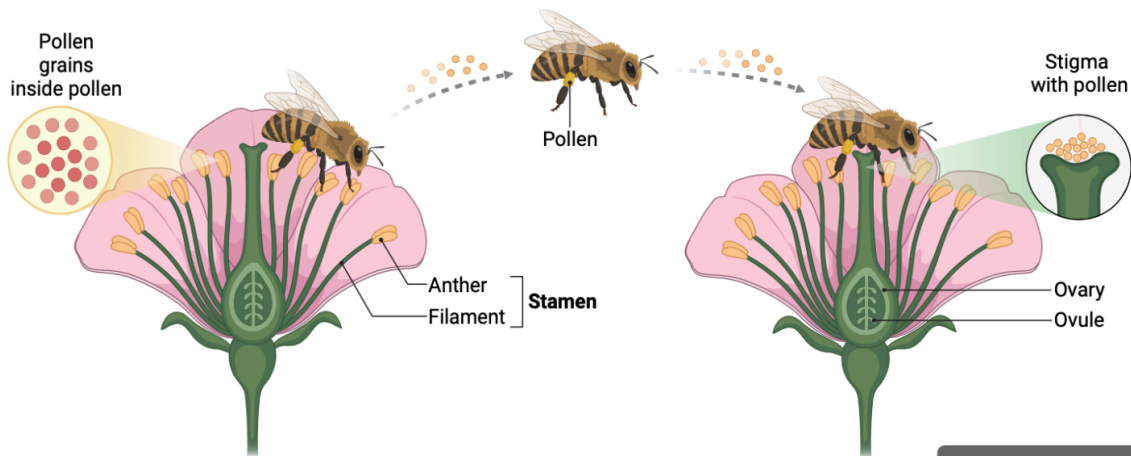
Pollen from stamens stick to the pollinator's body when it collects flower nectar

2

Pollinator carries pollen to another flower

3

Pollen from the pollinator's body is deposited on the stigma to complete pollination



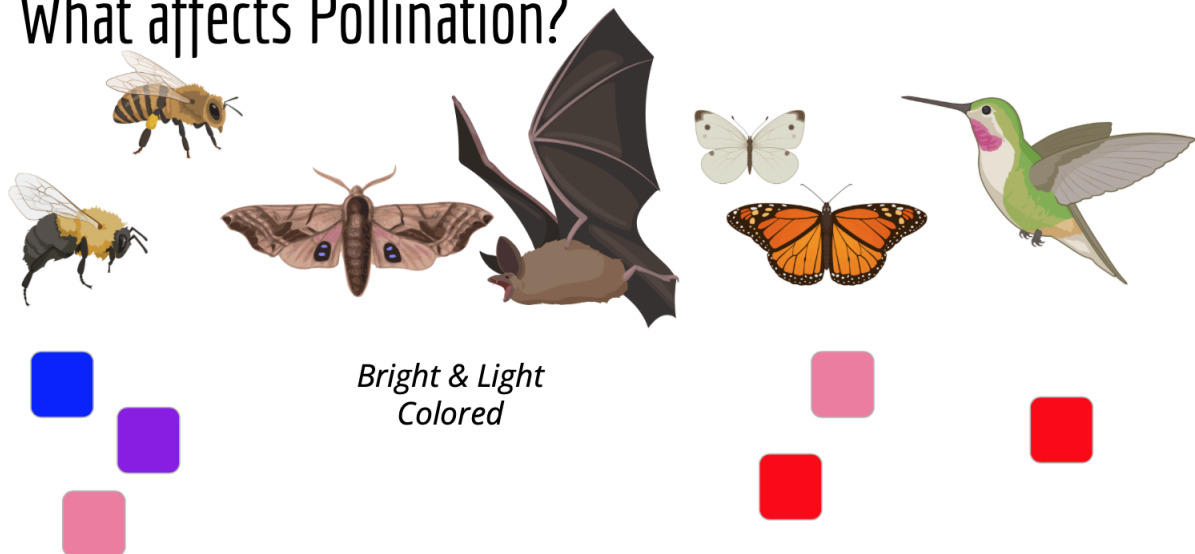
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Pollinators Around Us! ➡



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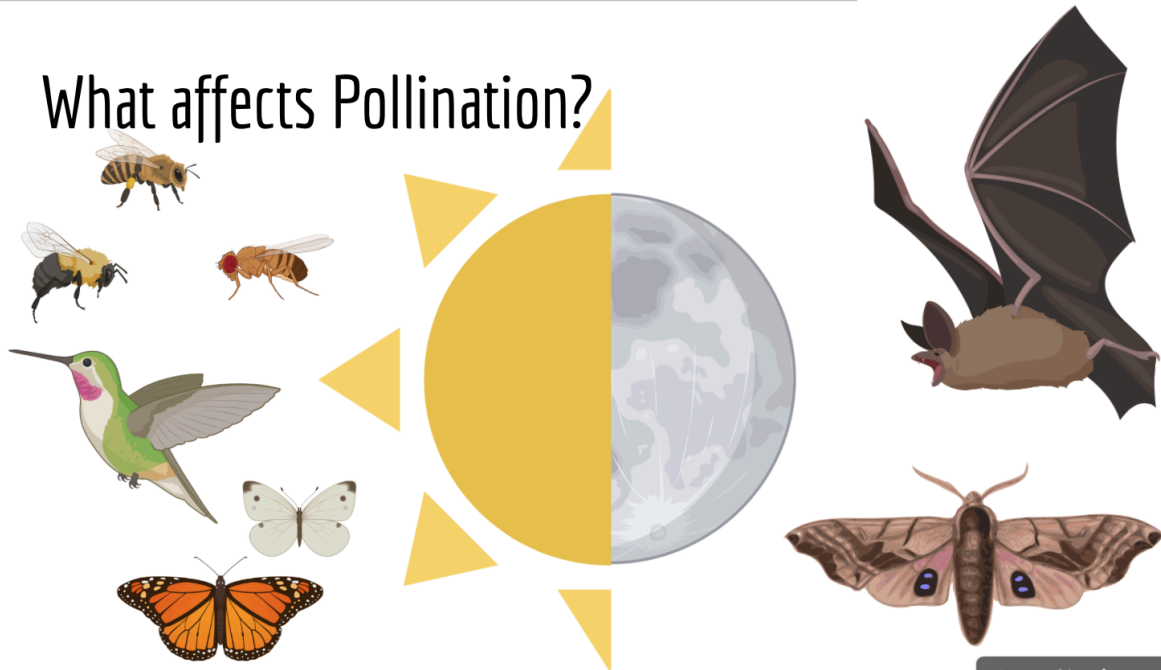
What affects Pollination?



*Bright & Light
Colored*

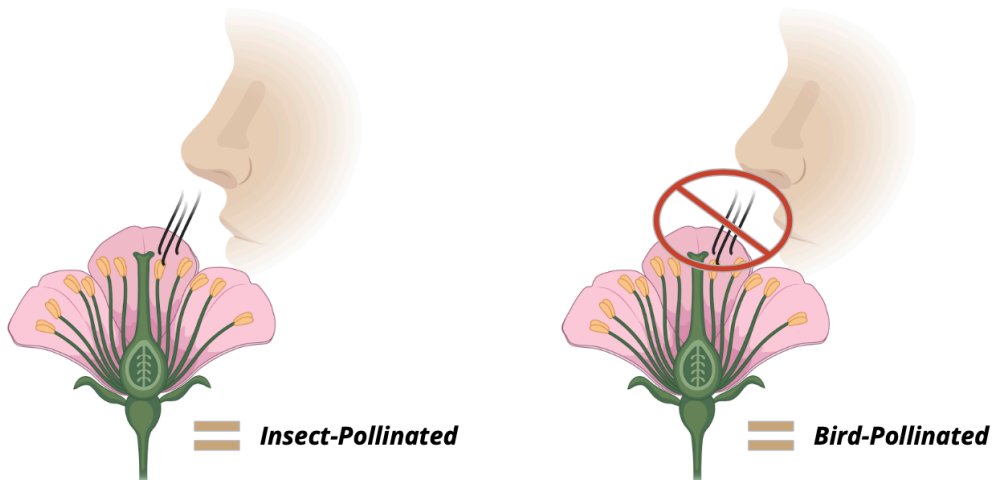
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What affects Pollination?



Created in BioRender.com

What affects Pollination?



Created in BioRender.com

Why Insects?

- Nectar
- Pollens
- Place to Lay Eggs
- Protection



(Sari ONeal)

What Makes a GOOD Pollinator?

- **Smell**
- Behavior
- Body Features
- Vision



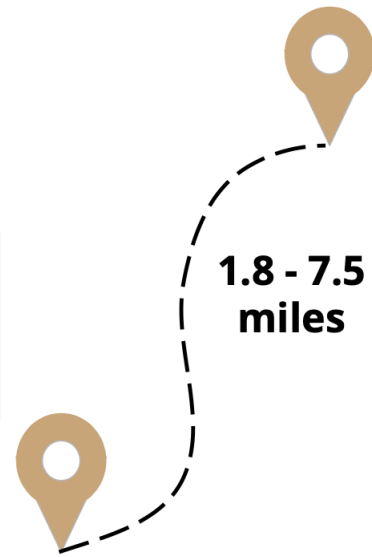
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What Makes a GOOD Pollinator?

- Smell
- **Behavior** →
 - Weather
 - Distance
 - Food Quality
 - Food Quantity
- Body Features
- Vision



What Makes a GOOD Pollinator?

- Smell
- Behavior
- **Body Features**
- Vision



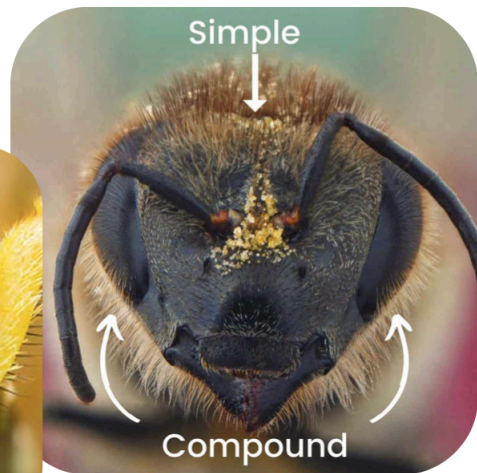
(Beatriz Moisset)

What Makes a GOOD Pollinator?

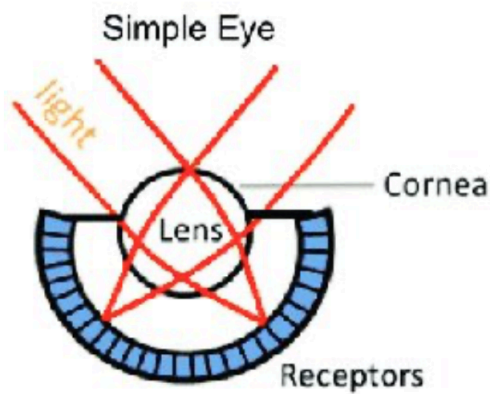
- Smell
- Behavior
- Body Features
- **Vision**



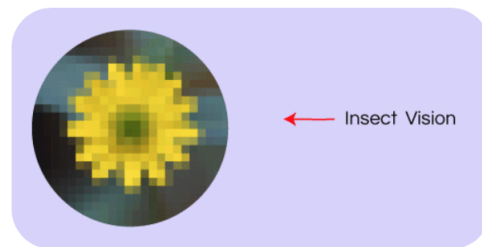
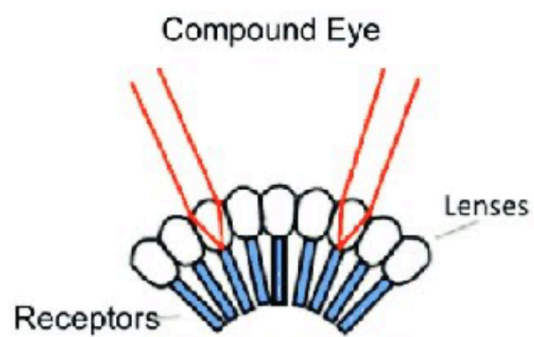
(Ganchaonan2518)



(Charlotte Anderson)



← Human Version

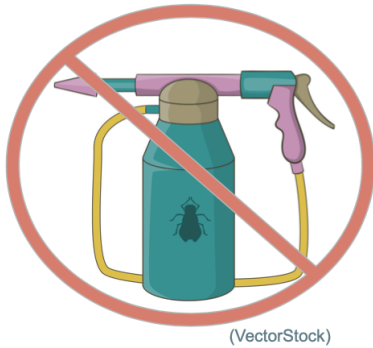


← Insect Vision

Would it be around without Pollinators?



What Can YOU Do?



What makes these insects good pollinators?

A Scientist Might Ask...

What **ADAPTATIONS** make these insects good pollinators?

Attachment 5. Pre-/Post-Surveys

Pre-Survey Number _____

1. How much time do you spend outdoors during a week?
 - ☐ Less than 1 hour
 - ☐ 1-2 hours
 - ☐ 3+hours
2. Do you go camping?
 - ☐ Never
 - ☐ Once a year
 - ☐ More than once a year
3. Does your family have a garden or flowers planted by your home?
 - ☐ Neither
 - ☐ Only a garden
 - ☐ Garden and flowers planted
 - ☐ Only flowers planted
4. What happens during pollination?
 - ☐ Pollen transported to stigma to fertilize plant
 - ☐ Seed germination
 - ☐ Opening of a flower for the first time
 - ☐ none of the above
5. How does pollination occur in nature?
 - ☐ Insects
 - ☐ Birds
 - ☐ Wind
 - ☐ All of the above
6. List 1 example of a pollinator in our area.

7. Why do scientists use insect specimens to study in scientific research?
 - ☐ To be able to observe species closer
 - ☐ To keep records of species discoveries
 - ☐ To compare specimens from now to specimens from the past and future
 - ☐ All of the above
8. What actions can YOU take to protect pollinators?

9. On a scale of 1-5, how scared are you of bees?

No fear

A Little Bit Scared

Sort of Afraid

Really Afraid

Extremely Afraid

←

1

2

3

4

5 →
10. How excited are YOU to protect pollinators?

No Excitement

A Little Bit Excited

Kind of Excited

Really Excited

Extreme Excitement

←

1

2

3

4

5 →

Attachment 6. IRB Approval Letter



IRB Committee

To: Prof Bensel
From: Amelia Finaret, Chair IRB
Re: Proposal 2023-24-14
Date: 19 December 2023
IRB Decision APPROVED
Proposal Approval Date: 19 December 2023
Project Expiration Date: 19 December 2024

Dear colleague,

Thank you for submitting an application regarding your human subject research affiliated with Allegheny College. The IRB at Allegheny College reviews and approves human participant research protocols, as directed by the U.S. Department of Health and Human Services' (HHS) Office for Human Research Protections (OHRP) <http://www.hhs.gov/ohrp/>, (<http://www.hhs.gov/ohrp/humansubjects/guidance/45cfr46.html>). The Allegheny IRB mission is to ensure that studies involving human participants are conducted in an ethical, beneficent, respectful, and just manner. The IRB views its role as part of the overall educational mission of the college.

The IRB has reviewed your application, and its decision with comments and recommendations is contained at the end of this response. .

Allegheny College IRB Review Form

AY 2023-24

RECOMMENDATION

Proposal No.

PI Name(s)

Proposal type

☐ Exempt ☒ Expedited ☐ Full

Date

Approval Decision

☒ Approved ☐ Revisions Required ☐ Not suitable for review

IRB Checklist¹

Approved	Revise	N/A	
X			List of all researchers included
X			CITI certificates for all researchers complete & included
X			Appropriate level of review selected
X			Project description
X			Methods
X			Data sharing
X			Data storage
X			Data type identified
X			Compensation plan complete & inline with new guidance
X			All elements of informed consent form were included or waiver granted
X			All elements of disclosure were included or waiver granted
X			All questionnaires, questions, or other data collection materials included
X			All signed approval forms included
X			All recruitment materials

¹ *Approved* – proposal is acceptable in its current form; project may proceed

Revise – changes/more specific information is needed; project may not proceed until revisions have been approved by IRB

N/A – not applicable (not all proposal types need the same components)

Approved. You may begin work on the project immediately.

If your proposal review was FULL or EXPEDITED, then your approval expires 365 days later. Please note that if your FULL or EXPEDITED project continues for more than one year, then you must complete a Continuing Review form prior to the expiration date. You are **not** permitted to collect data past your approval expiration date until your project has been updated, reviewed, and re-approved by the IRB. EXEMPT projects must submit a continuing review proposal to the Allegheny College IRB only when there is a change to the protocol and/or change to the personnel. All proposals, including EXEMPT, must file a Protocol Amendment Form when applicable. If there are any incidents during the study or if there is a departure in the approved procedure during the research process, then you must promptly file an Incident Report to the IRB. A link to these forms can be found on the IRB website (<http://sites.allegheny.edu/committees/institutional-review-board/>).

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