Pollinators on the Move

Overview

Pollinators on the Move is a two-part experience in which participants explore flower pollination through the eyes and actions of animal pollinators. The activity *Be a Pollinator* provides an interactive experience with three pollination syndromes (traits that flowers possess to attract their pollinators) to investigate why animal pollinators are attracted to specific floral traits. *The Pollinating Game* explores ecological interactions using a case study of a Madagascar Sphinx moth and Orchid. Participants consider and form hypotheses about how ecological relationships and interactions may affect fitness, lead to dependence, and result in coevolution.

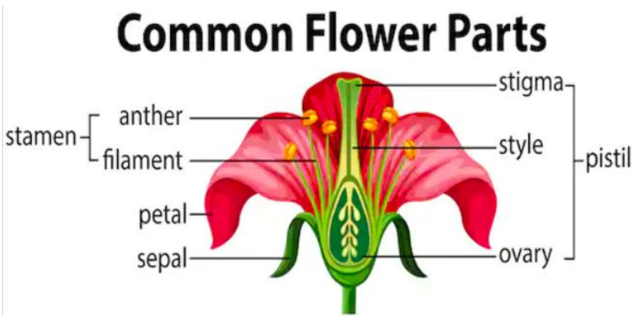
Source: https://www.annualreviews.org/doi/full/10.1146/annurev.ecolsys.34.011802.132347

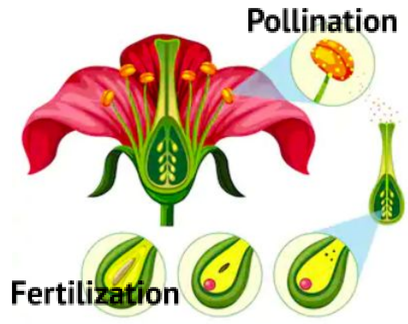
Background Information

Pollination in flowering plants is the process of a pollen grain moving from an anther to a stigma. It is important for plants to out-cross, meaning pollen from one individual plant makes it to the stigma of a different individual plant. This maintains genetic variation and increases gene flow between populations of plants, which is vital for their reproductive fitness.

There are many types of pollination, including biotic and abiotic. One of the reasons why there is such extreme diversity in floral traits is as a result of pollinator selection pressures. There are defined pollination-syndromes, groupings of traits for common animal pollinators, because of strong associations between these traits and the corresponding pollinator. Animal pollinators are crucial for plant reproduction. In fact, 35% of crop plants are reliant on animal pollination.

It is important to remember that animals do not know that they are pollinating. To them, they are foraging for essential resources (i.e. nectar, pollen, shelter). In this sense, the pollinators rely on plants for fitness. This can create a mutualistic relationship between plants and their associated pollinator. Plants benefit from the pollinator moving pollen for the plant's fitness, in which case they show off to the pollinator to attract them. Pollinators benefit from the resources the plant provides, cueing in on these floral traits.



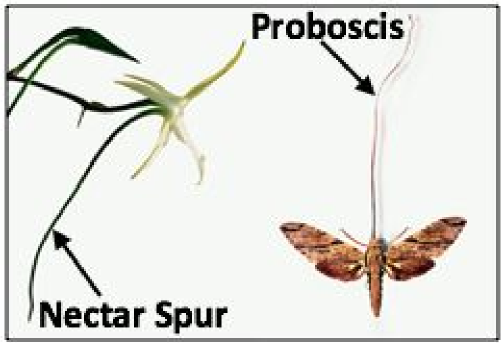


Flower Type with traits and linkage

Cactus - Bat Pollinated	
Night blooming flowers	Nocturnal
Large, funnel shaped flowers	Echo-location, blind
Fruity-sweet-nutty scents	Reward, nectar-feeding
Aster - Bee Pollinated	
UV pigments	UV vision, signaling/directing
Nectar guides	Signaling/directing
Floral-sweet-minty scents	Reward, nectar-feeding
Stink Flower - Fly Pollinated	
Flesh-like petals	Carrion, larvae
Large flowers	Compound eyes
Rancid scent	Carrion, larvae

Case Study: Charles Darwin, a great naturalist and botanist, was amazed by an impressive orchid (*Angraecum sesquipedale*) from Madagascar with a 12-inch nectar spur. The nectar spur is a tube formed by petals that produces and/or stores nectar (sugars). Darwin hypothesized that there must be a sphinx moth that had a 12-inch proboscis (an elongated, tubular structure that is used for sucking food into the body) that was able to pollinate this orchid, but he never got this answer. It took until 2004 for a scientist to record the interaction on film between the orchid and the sphinx moth (*Xanthopan morganii*). Darwin was right! Researchers found that the orchid relies on the moth for pollination and the moth relies on the orchid for its nectar meals. This mutualistic relationship drove coevolution between the two organisms. Both organisms experience reciprocal selective pressures that have resulted in some extreme morphological features.

Source: http://blogs.ifas.ufl.edu/entnemdept/2018/04/05/bug-word-day-proboscis/



Learning Goals

1. Many plants are reliant on animal pollinators for reproductive fitness.
2. Animal pollinators are foraging for resources. They do not know that they are pollinating.
3. Animal pollinators are attracted to particular floral traits. why? Plants attract animal pollinators by displaying their resources with showy traits.
4. Ecological interactions are not always perfect. However, with natural selection and time, ecological relationships and interactions can evolve to become mutualistic. A mutualistic relationship is beneficial to all organisms involved.
5. Coevolution can occur from these relationships and interactions, and result in unique adaptations by reciprocal selective pressures on two or more organisms.

Materials

Activity 1: *Be a Pollinator*

- **Bat**
  - Bat-glasses
  - Bat scent
  - Cactus plant
  - White Funnel Flower
  - Blank pot, pole, small green foam block

- **Bee**
  - UV flashlight
  - Bee scent
  - Purple Aster Flower
  - Blank pot, pole, small green foam block

- **Fly**
  - Fly-glasses
  - Fly scent
  - Red Stink Flower
  - Bright green foam block

Activity 2: ***The Pollinating Game***

- (2) Interaction charts and dry erase pens
- (2) Dice
- (6) Sphinx Moths
- (6) Orchids
    - (6) Numbered nectar tubes (varying lengths)
    - (6) Pollen poms
    - (6) White Orchid Flowers
    - (6) Numbered pots
    - (6) Poles and small green foam blocks

Set-up

- Group materials together. By activity and by flower type (bat, bee, fly). Shake the scents *well* before use.
- It is helpful to weigh down the pots for stability.
    - 1. Small bags of sand on each side of the foam.
    - 2. Small pebbles/rocks on each side of the foam.

Activity 1: ***Be a Pollinator***

Bat

1. Place a small piece of foam block in the blank pot. *It is recommended to add weight* to the pot for stability.
2. Place the pole in the center of the foam block.
3. The cactus plant has a channel created for the pole to go through, add the cactus.
4. Place the white funnel flower on top of the cactus so the pole goes through the funnel spout.
5. Remove the round diffuser pad inside the flower and spray the bat scent (shake well) 1-2 times (and as needed) and place back inside the flower.
6. Open bat-glasses.

Bee

1. Place a small piece of foam block in the blank pot. *Recommended, add weight.*
2. Place pole in the hole on the bottom of the purple aster flower
3. Insert the pole into the center of the foam block inside the pot.
4. Remove the round diffuser pad on the center of the flower and spray the bee scent (shake well) 1-2 times (and as needed) and place back on top of the flower.
5. The UV light works by squeezing or can be locked *on* by moving the switch.

Fly

1. Place the red stink flower in the hole on top of the bright green foam block.
2. Open the fly scent jar and place inside the flower. **Warning:** *The fly scent is stinky!*
3. Open fly-glasses.

Activity 2: ***The Pollinating Game***

1. Group numbered pieces together (pot, flower, nectar tube).
2. Place a small piece of foam block into each numbered pot (1-6). *Recommended, add weight.*

3. Push nectar tubes through the spaces in the orchid flower, push the rounded end from the front face of the flower, until the edge is just past the entrance. Should be a snug fit.
4. Place the pole into the circled hole at the bottom of the flower in the foam portion. The bottom petal is the big curvy one.
5. Place the flower with the pole into the pot with foam.
6. Attach the pollen poms onto the front of the flowers, magnet to magnet.
7. Set the 6 moths and dice out front.

Procedure

Short Form

Activity 1: *Be a Pollinator*

1. Let participants explore the three flower types on their own. You can hint at key floral traits at this point.
2. Ask what participants are experiencing.
3. Encourage participants to compare and contrast animal traits and floral traits.

Definition of Success: Participants connect why floral traits attract specific pollinators and why pollination is important and why or how it occurs.

Activity 2: *The Pollinating Game*

1. Begin by having the participant roll the dice. One dice number, or roll, will be for the flower they select and one dice number, or roll, will be for the moth that they select.
2. Participants will fly the selected moth (numbered side up) to the selected flower.
3. The proboscis will enter through the hole and go in as much as it possibly can.
4. Rolling a double will result in a perfect fit. The moth gets a meal and the orchid is pollinated. This is mutualistic.
5. Participants can roll as many times as they like. They can see how many rolls it takes to make a mutualistic interaction.
6. Participants can use the interaction chart to document and tally their encounters. They can visualize what interaction is occurring most often and how this may lead to selective pressures along with how that will affect the population of the moths and orchids. Connect how this can result in coevolution.

Ecological Interactions

1. **Antagonistic**: One organism benefits and one organism experiences a negative result.
   - The moth is a thief – If the proboscis is long and the nectar spur short, the moth will get a meal (+) but will not pollinate the orchid (-).
   - The flower is fooling the moth – If the proboscis is short and the nectar spur long, the moth will not get a meal (-) but will pollinate the orchid (+).
2. **Mutualistic**: Both organisms benefit.
   - If there is a match in the length of the proboscis and the length of the nectar spur both moth and orchid will benefit (+ +).
3. **Competitive**: Both organisms experience a negative result.

- This can occur between different pollinator types as well as between different plant species (- -). Multiple pollinators may be competing for the floral resources from the same plant species. Mimic flowers may reduce the number of pollinator visits from another flower.

Definition of Success: Participants roleplayed as a pollinator. They defined the relationship between the orchid selected and the moth selected. Participants learn not all interactions in nature are perfect or benefit all organisms.

Long Form

1. **Engage:** Review what pollination is, the types of pollination (biotic and abiotic), why pollination occurs, and why it is important for the plant and animal pollinator's fitness at the age-appropriate level. Ask students why do animal pollinators pollinate? Validate the basic answer (they are foraging for resources), then connect this to the showy traits plants present to lure in pollinators by displaying their resources. Include that this kind of interaction results in an ecological relationship between the two organisms.

2. **Explore:** Setup the room into 4 stations: Bat, Bee, Fly, and The Pollinating Game. Divide the students into groups and have them self-direct through each of the stations, rotating every 5-10 minutes, with students taking turns within each group at each station. At the end of the activity, have them share and discuss what they experienced and what were their results during The Pollinating Game. You can tally each student's result on the ecological chart or board to compare the class as a whole.

3. **Explain:** Help make comparisons between the different animal pollinator traits and floral traits. What are tradeoffs the plants face in putting so many resources into attracting pollinators? What are tradeoffs the animal pollinators face pollinating without a reward? What maintains these interactions? Discuss how this results in selective pressure on the organisms, and if it is a reciprocal selective pressure the organisms may coevolve. Discuss the different ecological interactions that occurred during The Pollinating Game and how these affect the relationships of the organisms involved. Which interaction was most common?

4. **Elaborate:** Introduce population ecology and genetics. A population is all the organisms of a single species living in a particular geographic area that can interbreed. Consider there is a population of plants where the animal pollinators will only visit flowers in which they receive a reward, the plants that are offering that reward will be the individuals that pass their genetic material to the next generation within that population. In this case, it is likely for flowers not offering a reward to decrease within the population because they are not passing their genetic material to the next generation by not being visited by the pollinator. This will ultimately change allele frequencies in the population and over time can result in evolution. If appropriate, have the students complete the table (can be completed individually, in groups, or as a whole) using the given rules.

Rules:

- In this community, there is a population of sphinx moths with an intermediate-length proboscis.
- In the same community, there is a population of orchids with variation in the length of their nectar spur. This trait is heritable. The plants do not have the ability to self-pollinate.
- Each generation the individuals with an **intermediate** nectar spur increase by 2x.
- Each generation the individuals with a **long** nectar spur change by 0.5x. Round up.
- Each generation the individuals with a **short** nectar spur result in 0 offspring.

Population Structure	Orchids with **long** Nectar Spurs	Orchids with **intermediate** Nectar Spurs	Orchids with **short** Nectar Spurs	Generation
	20	20	20	1
				2
				3
				4
				5
				6
				7

Discuss results using the following questions: Which orchid trait is most dominant in the population, compare generation 1 to 7? Why do the orchids with the short nectar spur have such poor fitness? What is happening to the numbers of orchids with long nectar spurs in the population? If the sphinx moths can pollinate the long nectar spur orchids, why would the numbers of individuals with this trait still decrease? Mention how this scenario represents a change in allele frequencies (genetic traits) over time within a population, and this is evolution.

Think about what types of real-world examples may alter the outcome. What if the sphinx moth also has variation in its proboscis length? What if there are multiple pollinators in the community? What if there was a mimic flower in the community?

5. **Evaluate:** Ask students to research a flower they are familiar with, that was also not explored at a station. Ask them to predict what animal pollinator they think would be able to pollinate this flower. Have the students describe the floral traits and why this would attract the pollinator they have chosen. Ask students to discuss other types of ecological relationships and the effect on the organisms involved.

Definition of Success: ***Participants will be able to understand how pollination works, the traits involved, and the importance for both the animal and the plant. The types of ecological relationships between plants and animal pollinators and how these relationships affect organisms at a genetic level.***

Guiding Questions

Activity 1: *Be a Pollinator*

- Do you know what pollination is?
- Can you name an animal pollinator?
- When you think about a specific animal pollinator, can you name flowers that they like? What do those flowers look like? Why would the animal be attracted to these traits?
- What does that smell like?
- What do you notice about the flower?

<u>Pollinators</u>

- Bat
    - Do you know how bats find flowers if they are almost blind?
    - What are pollinator bats searching for at night?
- Bee
    - Did you know that bees see colors we can't see? Did you know flowers produce pigments we can't see?
    - Can you name a way that flowers attract bees?
- Fly
    - Did you know that this is the largest flower in the world?
    - Why would flies be attracted to these unique traits?

Activity 2: *The Pollinating Game*

- Want to try and pollinate a flower?
- Take your chances. Who will benefit?
- What is happening? Did you get a nectar meal? Did you get pollen on your body?
- What do you think will happen if the moth continues to not get a reward?
- What will happen to the fitness of the orchids if they continue to not be pollinated? (consider that the orchids are not capable of self-pollination)

Further Resources

- What are Pollinators and why we need them
- Ecological Interactions
- Moth Tongues, Orchids, and Darwin

NGSS Standards

2-LS2-2 Ecosystems: Interactions, Energy, and Dynamics

Develop a simple model that mimics the function of an animal in dispersing seeds or pollinating plants.

MS-LS2-4 Ecosystems: Interactions, Energy, and Dynamics
Construct arguments supported by empirical evidence that changes to physical or biological components of an ecosystem affect populations.

MS-LS1-4 From Molecules to Organisms: Structures and Processes
Use argument 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.

HS-LS4-3 Biological Evolution: Unity and Diversity
Apply concepts of statistics and probability to support explanations that organisms with an advantageous heritable trait tend to increase in proportion to organisms lacking this trait.

HS-LS4-4 Biological Evolution: Unity and Diversity
Construct an explanation based on evidence for how natural selection leads to adaptation of populations.

1-LS1-1 From Molecules to Organisms: Structures and Processes
Use materials to design a solution to a human problem by mimicking how plants and/or animals use their external parts to help them survive, grow, and meet their needs.

MS-LS2-5 Ecosystems: Interactions, Energy, and Dynamics
Evaluate competing design solutions for maintaining biodiversity and ecosystem services.

5-LS2-1 Ecosystems: Interactions, Energy, and Dynamics
Develop a model to describe the movement of matter among plants, animals, decomposers, and the environment.