# NSDAR Educational Resources Committee

## "Pollinator Flower Preference Behavior Lab" Lesson Plan

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**Grade Level:** Grades 11-12 (Possibly AP Biology Lab or AP Environmental Science Lab)

1. **Identify the standards to be addressed:**
   CCSS.MATH.CONTENT.HSS.ID.A.1
   Represent data with plots on the real number line (dot plots, histograms, and box plots).
   CCSS.MATH.CONTENT.HSS.ID.A.2
   Use statistics appropriate to the shape of the data distribution to compare center (median, mean) and spread (interquartile range, standard deviation) of two or more different data sets.
   CCSS.MATH.CONTENT.HSS.ID.A.3
   Interpret differences in shape, center, and spread in the context of the data sets, accounting for possible effects of extreme data points (outliers).
   CCSS.MATH.CONTENT.HSS.ID.A.4
   Use the mean and standard deviation of a data set to fit it to a normal distribution and to estimate population percentages. Recognize that there are data sets for which such a procedure is not appropriate. Use calculators, spreadsheets, and tables to estimate areas under the normal curve.

2. **Statement of the objective and lesson outcomes**:
   The student will be able to define pollination, flower characteristics and terms and the relationship between flowering plants and pollinators.

   The student will be able to design a plan for collecting data to determine pollinating preferences of native pollinators on native flowering plants or crop plants.

   The student will be able to analyze data to identify possible patterns and relationships
   between data sets, i.e., potting, and statistical analysis such as determination of means, standard deviations, and confidence intervals.

   The student will be able to interpret their experimental results and develop conclusions about pollinator preferences for various flower characteristics.

   The student will be able to connect concepts in and across domain(s) to predict how
   environmental factors affect response to information and change behavior.

   The student will be able to analyze data to support the claim that response to information
   and communication of information affect natural selection

   The student will be able to explain factors, such as pesticides and habitat destruction, that 1) may result in the decline of pollinator populations and 2) the effect of pollinator population decline on biodiversity and flowering plant populations.

3. **Materials, resources, and technology to be used by teacher/students**:

This is a field laboratory lesson that can be worked in small groups/teams of students (4-8 students/group). Student should be accessed individually.

To perform their experiments, students will need access to a flower garden or park that includes pink or purple, yellow and white flowering native plants in a variety of flower shapes, sizes, inflorescence or other flower characteristics.

Some native flowering plant suggestions include: 1) yellow flowering Blacked-eyed Susan (*Rudbeckia*) and/or Golden Rod (*Solidago*), 2) purple flowered Aster (*Symphyotrichum*), Blazing Star (*Liatris*) and/or Hyssop (*Hyssopus),* 3) pink flowering Cone Flower (*Echinacea*) and/or Joe Pye Weed (*Eutrochium*), 4) white flowering Cone Flower (*Echinacea*) and/or white flowering Aster (*Symphyotrichum)* . These perennials will provide flowers for Summer/Fall experiments. Check your location for expected bloom times. Or students may investigate farm crops for students to study. Make sure the crop plants chosen are pollinated by insects. Crops like corn use wind for pollination and are not suitable for this lab.

## Common Summer/Early Fall Flowering Native Plants by Color

| **Flower Color** | | | |
|---|---|---|---|
| Yellow |  Blacked-eyed Susan (*Rudbeckia*) |  Golden Rod (*Solidago)* | |
| Purple |  Aster (*Symphyotrichum*) |  Blazing Star (*Liatris*) |  Hyssop (*Hyssopus),* |
| Pink |  Cone Flower (*Echinacea*) |  Joe Pye Weed (*Eutrochium*) | |
| White |  Cone Flower (*Echinacea*) |  Aster (*Symphyotrichum*) | |

Students will need computers, access to the internet and software, e.g., Excel to perform data analysis. Students will need field identification guides to identify pollinators, e.g. bees, butterflies. They will also need field notebooks for record taking and binoculars to enable close examination of the pollinators. To study pollinators in a plot, they will need meter sticks and markers to measure and mark plots.

4. **Introduction of the topic**:

This investigation explores the environmental choices that pollinators make. Student teams will design and conduct their own investigation based on questions they have raised following initial introduction to pollination, biological pollinators, flower taxonomy and about 30 minutes of observation prior to experimental design.

Pollination is how flowering plants reproduce. It is a process where pollen from the male parts of a flower is transferred to the female parts of the same or another plant. Methods of transfer include wind, water or living pollinators. Biological pollinators, like bees, butterflies and moths, form a mutualistic relationship with flowering plants, where pollinators benefit by food/energy rewards and flowering plants benefit by the exchange of genetic information via sexual reproduction. Unfortunately, pollinator populations are declining world-wide due, at least in part, to human practices.

Taxonomy is the field of study concerned with identifying, naming and classifying organisms. An understanding of taxonomy can help you understand pollinators and their behavior. Plants and animals are often called by different names in different locations. In the scientific naming system, each organism is given a unique combination of two names, one for the genus, which is a group of related species, and one for the species. Scientific names (Genus + species) are denoted in italics in print or are underlined in writing. For this study, the naming of the genus will be sufficient, e.g. *Bombus* (bumble bee).

Pollinators are a key part of healthy ecosystems. A wider diversity of pollinators in many ecosystems is related to greater overall biodiversity, or variety among living organisms. These living organisms include our cultivated plants, which depend on pollinators. As native pollinators lose more and more habitat, they need our support if we want to continue to benefit from the vital pollination services they provide. This study will focus on native "generalist" pollinators that pollinate a wide variety of flowering plants.

Bees are known as efficient pollinators in North America and usually the most influential in pollinating both our native and our cultivated plants. Although not native, the honeybee is a well-known pollinator. However, many native bee species, butterflies, ants, wasps, hummingbirds and other animals are important pollinators. Following is a summary of pollinators that may be observed (https://extension2.missouri.edu/m402).

# Summary of Pollinators

| Pollinator | Image | Description |
|---|---|---|
| Honey bee (*Apis mellifera*) |  | Non-native social bee living in nests or hives above ground. Like most bees, they are efficient pollinators. |
| Bumble bees (*Bombus* spp.) |  | Native social bee living in nests below ground. Like most bees, they are efficient pollinators. |
| Carpenter bees (*Xylocopa* spp. and *Ceratina* spp.) |  | Native bee resembles the bumble bee but has a noticeably darker abdomen. These solitary or weakly social bees make their nests in wood. Like most bees, they are efficient pollinators. |
| Other Apid bees |  | Most of these natives have yellow-and-black-striped bodies covered in hairs, and all of them are solitary ground-nesters. Like most bees, they are efficient pollinators. |

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| Megachilid bees |  | These natives are unique among bees in that they collect pollen on the underside of their abdomen rather than in baskets on their hind legs. Thus, they are usually less efficient foragers because pollen carried on the underside of their abdomen sheds more readily than that carried on the hind legs of other bees. This inefficient method of transporting pollen causes them to have to visit more flowers to provision their young, but they transfer more pollen in the process. |
| Halictid bees |  | Sweat bees are natives and usually a metallic yellow or green color and are much smaller than most other bees. Like most bees, they are efficient pollinators. |
| Andrenid bees |  | Mining bees are usually dark with reddish stripes. They are natives. Like most bees, they are efficient pollinators. |
| Colletid bees |  | These natives are usually dark with white or yellow stripes. Most bees in this family pollinate flowers in the process of foraging for nectar and pollen; however, masked bees carry nectar and pollen internally, which means they do not aid in pollination. |

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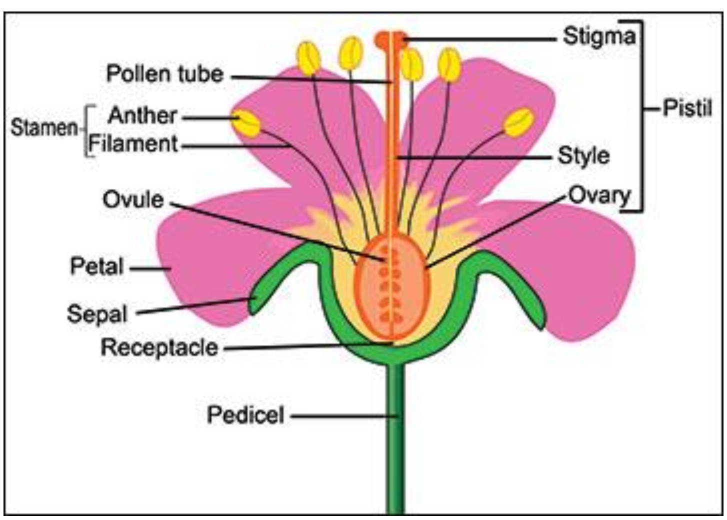
| Wasps (order *Hymenoptera*) |  | The role that wasps play in pollination is less clear than that of bees. Most winged adult wasps visit flowers to drink nectar, but they have fewer hairs on their body than do bees, so they are much less efficient pollinators. |
| Ants (order *Hymenoptera*) |  | Ants often visit flowers to collect nectar, as anyone who has plucked peonies from a garden knows. However, ants are usually inefficient as pollinators. |
| Butterflies (order *Lepidoptera*) |  | The flower preferences of butterflies are diverse, but in general butterflies prefer plants with wide, flat flower surfaces that allow them to easily land and collect nectar. Their host plants are often found in open, sunny habitats. They are not as efficient as bees transferring pollen. |
| Moths (order *Lepidoptera*) |  | Most moths are nocturnal. A moths rubs its head against the flower's anthers as it drinks from deep within the flower, collecting pollen that it then transfers to flowers of other plants. They are not as efficient as bees transferring pollen. |
| Beetles (order *Coleoptera)* |  | Beetles are historical pollinators, but are much less efficient pollinators than bees and butterflies. Beetles are not as faithful to a single plant species and thus waste much pollen. They are also messier, eating their way through flowers with chewing mouthparts instead of the specialized tongue like |

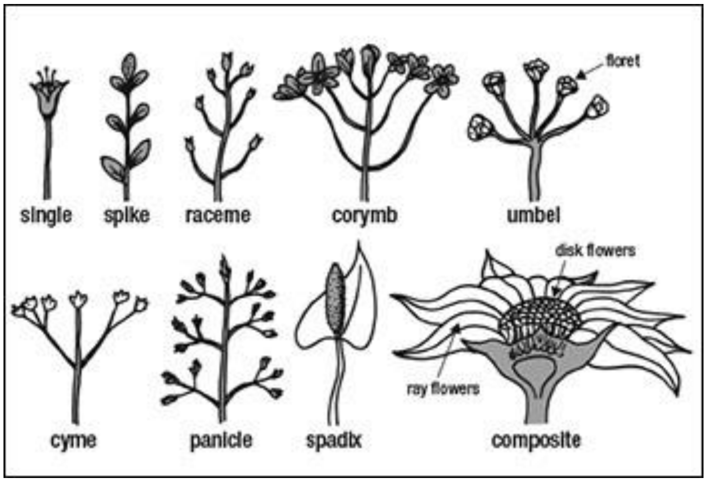
| | | |
|---|---|---|
| | | proboscides, or sucking mouthparts, seen in other pollinators. |
| Flies and mosquitoes (*Dipera*) |  | Some flies are important pollinators and can even resemble bees. In general, flies pollinate flowers that are small and grow in shady, moist environments. Male mosquitoes feed on nectar, aiding in pollination. |
| Hummingbirds |  | These birds are important pollinators for tubular flowers, into which they insert their beaks and then use their tongues to lap up nectar. Pollen collects mainly on a hummingbird's head while it is feeding and is then transferred to the pistils of other flowers. Because they are larger than other pollinators, hummingbirds can move pollen over long distances. |

Flowers are attractive to pollinators and may be distinguished by pollinators by flower color, shape and size. Students should become familiar with flower anatomy, terms, shapes and inflorescence (flower arrangement) ([https://extension2.missouri.edu/m402)](https://extension2.missouri.edu/m402).

## Basic Flower Anatomy

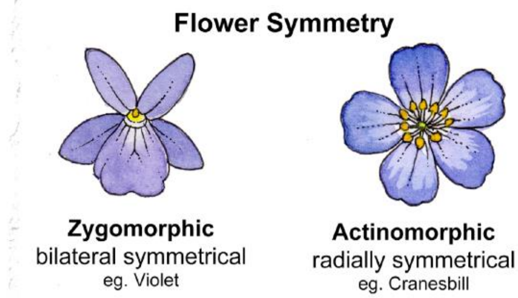


# Kinds Inflorescence

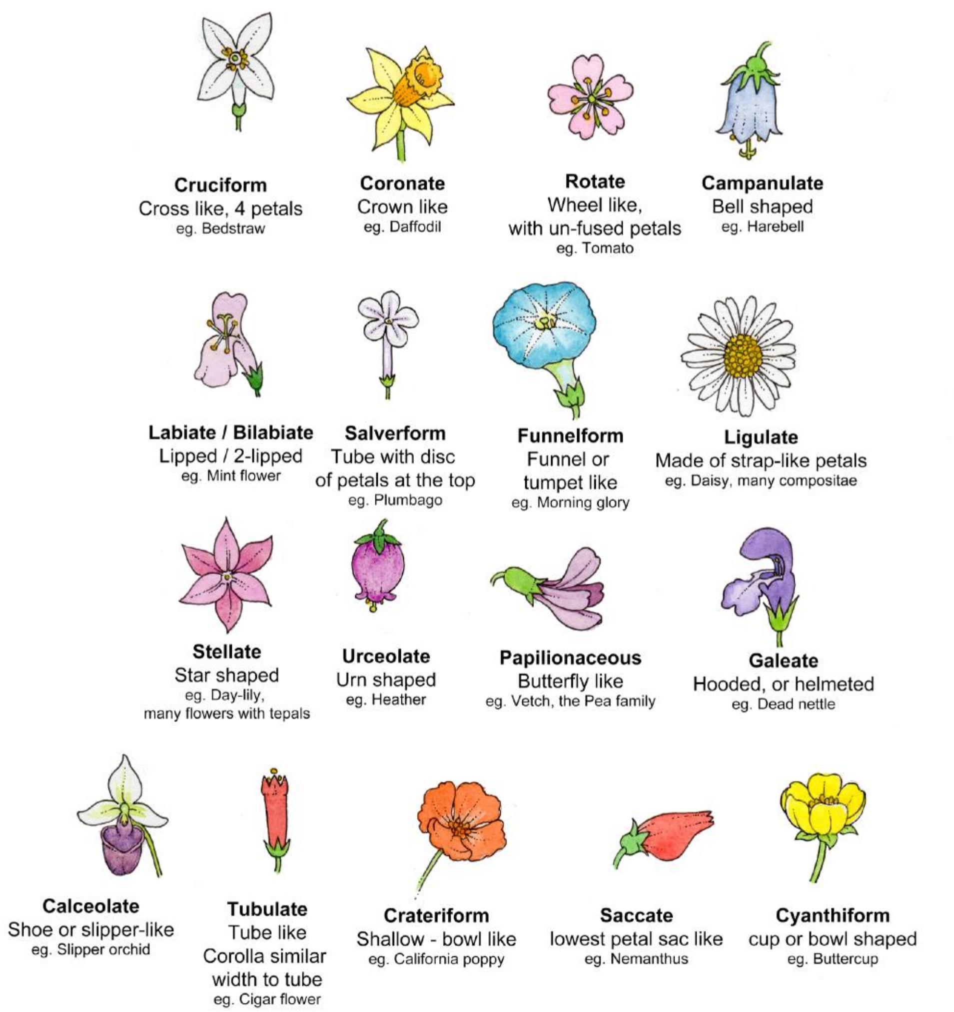


**Flower Diversity and Form**

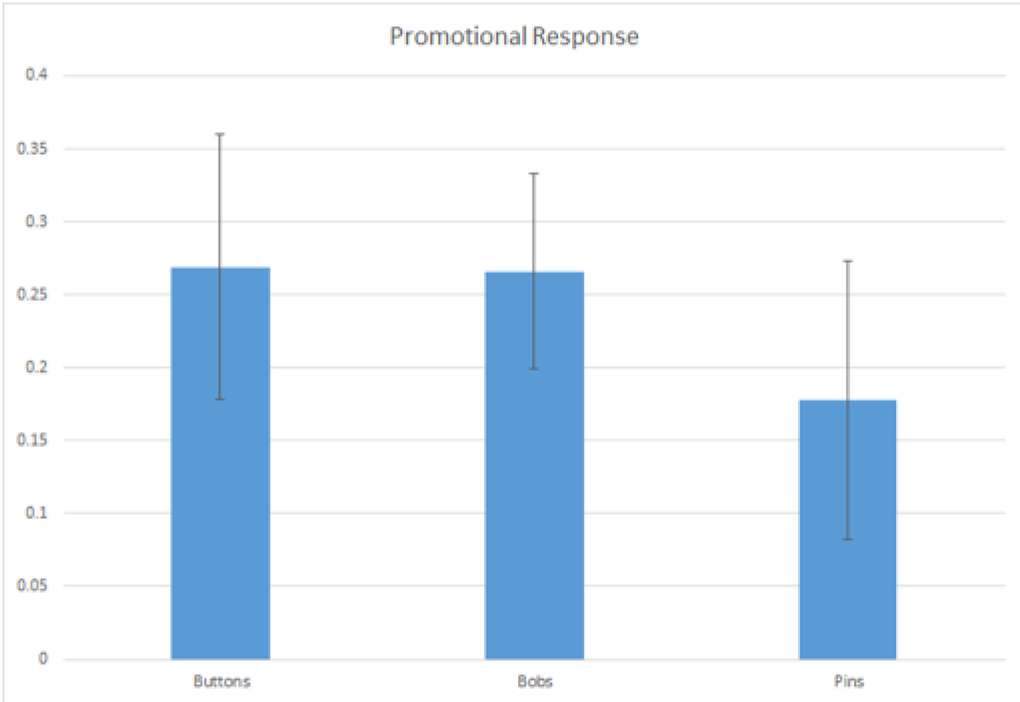
Flowers are incredibly diverse.
They show symmetry, but whether this is bilateral (Zygomorphic) or radial (Actinomorphic) depends on the species.
Consider which your flower is before putting pencil to page.




This handout some of the different shapes they can be, along with the botanical terms for that shape. Don't worry too much about these, botanists don't always use the exact same terms; but I do think it;s useful as an overview of the variiety of form and function we have to consider.




To analyze and compare data sets, students should be able to perform (Excel) statistical calculations including means, standard deviations (STDEV) and confidence intervals at the 95% level (CONFIDENCE). Then, they should be able to interpret the results of these analysis between data sets, whether the null hypothesis is stated and then rejected or accepted. These results should also be plotted and plots should be explained. An example of a histogram generated in Excel showing Confidence Intervals follows:




5. **Procedure for instruction**:
   Introduce pollination, flower characteristics and key groups of pollinators that students will most likely observe. (class time: 45 minutes- 1 hour). If students are not familiar with Excel, a tutorial should be assigned for homework.
   Student groups observe pollinators in the field and make notes (Field time: 30 minutes).
   Students design an experiment that tests the effect of flower characteristics (such as color, shape, size and/or odor) on pollination. The experiment must include a problem, hypothesis, independent variable, dependent variable, Standardized variables (provide at least 4 & explain them), Control treatment (independent variable eliminated or set to a standard value), Method. (class time: 1 hour)
   Students perform their experiments and collect data in the field (Field time: 1-2 hours)
   Students analyze their data using Excel to plot and analyze data sets for center (mean, median) comparison and spread (standard deviation, confidence interval) and interpret these results.
   Each student writes a laboratory report and answers the questions listed in Lesson Closure.
6. **Lesson closure**:
   Students each write a laboratory report that includes your hypothesis, experimental design, methods, and materials results, conclusions, references and answers to the following questions:

   - What flower characteristics that you studied drew the highest pollination rate for each pollinator group observed? (Results will vary, but pink should attract butterflies during the day, yellow should attract bees during the day and white should attract moths at night. It appears that the nectar and scent secretions of flowers are related to floral color change.)

   - What limitations did your experimental design have? What assumptions did you have to make? (These could include number of replications, sample area, sunlight, time of day/night, noise and other distractions, etc.)

   - What local human practices do you think reduce local pollinator populations? How can these be mitigated? (Discussions should include pesticides and habitat destruction.)

   - Make suggestions to measure and promote flower reproductive fitness. (Measurements should include seed and/or fruit production measurements. Discussions should discuss habitat characteristics required, pesticide management, green acre programs, education, etc.)

- Explain the potential and realized impact of the decline of pollinator populations on flowering plant populations and biodiversity. (The decline of pollinator populations reduces flowering plant populations such that biodiversity is reduced in native populations.)

- Provide a specific example from your investigation of how flower preference behavior affects natural selection.

7. **Assessment of student understanding**:
   The assessment should include the laboratory report (experimental design, procedures, data, results, and conclusions) and question answers. Reports may be written, mini-posters or presented to the class.