

FLIGHT OF THE POLLINATORS

A REPEATABLE, OUTDOOR/INDOOR, HANDS-ON EXPLORATION OF PLANT PHENOLOGY FROM A POLLINATOR'S PERSPECTIVE



This activity is designed to help participants experience the importance of plant phenology from a pollinator's perspective. After adopting the role of a bee, moth, butterfly, or hummingbird (or other pollinator), participants learn why pollinators visit flowers and what color, shape, and size of flowers their pollinator prefers to visit. Once familiar with their adopted pollinator's preferences and requirements for flower visitation, participants "fly" around the activity area (while wearing biologically-accurate costumes!) to discover and record how many flowers are open and appropriate for their visitation. Participants can then exchange wings, beaks, and antennae and repeat the circuit from another perspective. Pollinators and activity leaders then assemble their observations in a chart format (examples are shown below) that can be used to illustrate a number of concepts and patterns, regardless of whether the activity is conducted once or multiple times (over one or more years). The activity ends with a discussion about how we can help to support pollinator diversity in our backyards and schoolyards by planting phenologically diverse gardens.

A modified version of this activity is also provided so that similar educational goals can be achieved indoors or in more constrained outdoor settings. This may be a helpful alternative when classroom, schoolyard, or garden logistics preclude "flying" around outside.

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All photos in this activity guide were taken by Brian Haggerty and UCSB's *Kids In Nature* environmental education program.

The *Flight of the Pollinators* activity was designed to align with the goals of the USA National Phenology Network (www.usanpn.org). The USA-NPN is a nationwide effort among academic and government scientists, educators and students at all levels, and professional and citizen scientists to monitor phenology in order to detect impacts of climate change on plants and animals. In this activity, instructions and materials are provided so that the collected data contribute to this important scientific effort.

More phenology activities and lesson plans are available online, including guides to establishing phenology gardens and activities that can be run in phenology gardens, school yards, back yards, or National Parks. To learn more and to download materials, visit the Education section of the California Phenology Project website (www.usanpn.org/cpp/education) or the USA National Phenology Network (www.usanpn.org/education).

Audience – The core concepts of this activity are appropriate and fun for all ages and abilities, including amateur naturalists, students, educators, citizen scientists, and professional scientists. Some materials and terminology may need to be adjusted according to the specific audience. This activity can easily be modified to suit a variety of educational goals or logistical constraints (see the end of this activity guide for an ‘indoor’ version of the activity developed by undergraduates at UC Santa Barbara).

Conducted one time only, this activity provides participants with a hands-on opportunity to learn that different types of pollinators are attracted to different types of flowers (“pollination syndromes”), and that floral diversity and the flowering phenology of a garden or landscape can support different types of pollinators on any given day.

Continued on the next page...

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Conducted several times across the seasons, however, this activity enables participants to experience how floral resources for each type of pollinator fluctuate across the seasons as different plant species transition in and out of flowering.

- **Activity can be repeated by one activity leader for the same set of participants** as a recurring educational activity (e.g., a teacher in “formal” K-12 and college settings);
or
- **Activity can be repeated at a place-based institution, by any number of activity leaders, for any number of unique or repeat participants** (e.g., an “informal” setting such as a botanic garden or a National Park that relies on docents or rangers to run programs for each of many one-time or repeat visits by local classrooms).

For both of these repeatable scenarios, the maximum value of this phenology-based activity lies in the accumulation of knowledge of how flowering phenology changes at one place over time, and what that means for the animals that rely on flowers for nectar and pollen (and don’t forget the animals that, weeks later, rely on the ripening fruits and seeds from those pollinated flowers!). The key is simply to maintain an ongoing awareness of changes in flowering phenology (by chart or graph – see examples below), and to integrate that accumulating knowledge into the activity’s introduction by the leader and in “teachable moments” that occur as the activity progresses (examples provided below).

Educational standards for formal K-12 settings – This activity could satisfy many educational standards for STEM subjects, social sciences, and – with just a bit of planning – fine arts. Homeschoolers and families might also find this activity enriching and could adapt it for the community garden, neighborhood park, or backyard garden.

Materials needed to complete this activity

- Guide to pollination syndromes (example provided at the end of this activity guide)
- Data sheets (ready-to-print data sheets are provided at the end of this activity guide)
- (Optional) Pollinator costumes (wings, antennae, beaks, etc.)
- (Optional) Plant species ID guide or signs
- (Optional) Visual aids, hand lenses & magnifying glasses, cameras, journals or paper for journaling activity



This activity could be modified to be conducted from different ecological perspectives

Frugivores | fruit-eating animals

Herbivores | leaf-eating animals

Granivores | seed-eating animals

Pathogens | plant-killing fungi & viruses

PREPARATION BY ACTIVITY LEADERS BEFORE LEADING A GROUP

- **Become more familiar with pollinators and pollinator conservation. For example:**
 - ✓ The Xerces Society website – www.xerces.org
 - ✓ Handbook on bee pollinators (downloadable PDF) – http://www.fs.usda.gov/Internet/FSE_DOCUMENTS/stelprdb5306468.pdf
 - ✓ North American Pollinator Protection Campaign website – www.pollinator.org
- **Determine the “pollination syndromes” in your activity area.** *If you’re not familiar with this, don’t worry!* It’s actually quite simple, and doesn’t require that you know plant species or plant ecology.

A pollination syndrome is, technically, a suite of flower traits such as size, shape, color, and scent which, together, tend to attract a particular pollinator or suite of pollinators. For example, hummingbirds tend to be attracted to red tubular flowers with lots of nectar; this is a “hummingbird pollination syndrome”.

See the appendix at the end of this activity for an example guide to determining the pollination syndrome of many different types of flowers. A quick internet search should provide many helpful images to accompany this table.

- **Create data sheets for the participants.** Here is an example of how a data sheet could be formatted. *A ready-to-print data sheet is located at the end of this activity guide.*

Flight of the Pollinators		
Pollinator Type: _____		Date: _____
<i>In the plant column, record any features about the plant so you don’t count it twice!</i>		
PLANT	NUMBER OF FLOWERS (circle one)	TOTAL NUMBER OF FLOWERS
1.	0 5 10 20 40 >60	
2.	0 5 10 20 40 >60	
3.	0 5 10 20 40 >60	
4.	0 5 10 20 40 >60	
5.	0 5 10 20 40 >60	

- **(Optional) Create pollinator costumes.** This is an excellent “hook” for many students (up to a certain age, and surprisingly enough, even for many college students!). Costume creation can

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comprise a biology lesson for students during their arts/crafts time. Here are some costume compositions that you might consider; they can be constructed with inexpensive materials available at most craft stores. See photos below for ideas (moths not shown):

- ✓ **Bees:** Construct four clear wings (for each wing, bend a wire clothes hanger or pipe cleaner into the shape of a wing and then wind plastic wrap around the boundary of each wing to create the clear surface) and draw veins on them using black markers or Sharpies); make antennae with pipe cleaners. Providing each participant with an elastic headband into which antennae can be inserted (and from which they can be removed) enables participants to change their pollinator identity very rapidly (that is, they can remove their current antennae and then insert new ones associated with other pollinator types: see Butterflies and Moths, below).
- ✓ **Butterflies:** Provide a curled proboscis (pipe cleaners or colored wire may be used), four colorful wings, and antennae with bulbs (e.g., small Styrofoam or cotton balls) at their tips.
- ✓ **Moths:** Construct four brownish wings (paper obtained from paper shopping bags will work well), and construct antennae without bulbs at their tips.
- ✓ **Hummingbirds:** beak (yellow cone with strap to affix to head), two feathery wings.



- **(Optional) If you are able, identify any local plant species that are producing flowers and that correspond to any of the pollination syndromes. This will add educational value to the activity (described below).** If you are able to do this, then participants should record (in the Plant column) the name of each identified plant species as they conduct the activity. Activity leaders may need to accompany participants in order to help them identify plants as they go “fly” among them. Alternatively, plants may be labeled with hanging tags or stakes signs on which their names are written. *If you are not familiar with the plant species in your area... that’s ok! Knowing plant species is not a requirement for running this activity, it only enhances it.*
- **(Optional) Determine which of the species in your area are being monitored by the USA National Phenology Network, and try to focus the activity on these species (as well as any other species).** Focusing on species that are currently flowering will be of greatest immediate interest to the “pollinators” in your group, but it is also important for participants to observe how many species are NOT in flower at a given time. Many will be surprised to find that the proportion of all available species that are actually flowering can be very low even when the weather is warm, depending on the time of year and the location at which you’re conducting this activity. See below for how to align your activity so that it contributes to this growing nationwide effort designed to engage professional and citizen scientists in monitoring plant and animal phenology in order to learn more about climate change.

HOW TO ALIGN THIS ACTIVITY WITH THE USA NATIONAL PHENOLOGY NETWORK

This activity was designed so that it can be aligned easily with a nationwide phenological monitoring program – the USA National Phenology Network (www.usanpn.org). Thus, the activity could be conducted with plant species that are currently being monitored nationwide through the USA National Phenology Network (www.usanpn.org/species_search). This way, not only is an effective and fun activity conducted, but the resulting phenological data collected by citizen scientists can contribute to a much larger effort to detect the effects of climate change on plants and animals (*tip: use this as leverage in grant proposals!*).

To align this activity with the USA-NPN’s targeted species, first become familiar with the program (www.usanpn.org), being sure to click on the “Participate” tab. Then determine which of the USA-NPN’s targeted species occur in your region (www.usanpn.org/participate/species_search). If you are unfamiliar with the species at your site, consult with colleagues, docents at nearby botanic gardens and natural reserves, and local sources of botanical expertise such as nurseries, colleges, and Extension offices. The local chapter of your state’s Native Plant Society is also likely to include many amateur and professional botanists who will be eager to help you integrate this activity with the USA-NPN.

- If USA-NPN targeted species do not occur at your site, or you otherwise don’t have the capacity to join the USA-NPN, that’s ok! This activity can be run anywhere, by anyone.
- If USA-NPN target species do occur at your site, then all you have to do is to make sure that those particular plants get integrated into this activity. Also adjust the data sheet to accommodate the USA-NPN’s “Yes/No” questions for phenological monitoring. One example is provided below, and **a ready-to-print data sheet is located at the end of this activity guide.** On the following page you’ll see how to use this data sheet to contribute phenological data to the USA-NPN.

Flight of the Pollinators

Pollinator Type: _____ Date: _____

Plant name (or ID from tag)	Do you see flowers? (circle one)	Number of flowers (circle one)	Do you see flower buds? (circle one)
	Y N ?	0 5 10 20 40 >60	Y N ?
	Y N ?	0 5 10 20 40 >60	Y N ?
	Y N ?	0 5 10 20 40 >60	Y N ?
	Y N ?	0 5 10 20 40 >60	Y N ?

After you've completed a "flight" around the area and have filled the rows above, add up the total number of flowers per species and enter it below.

Plant species	Total number of flowers

Once you're familiar with the data reporting interface on the USA National Phenology Network's website, you'll notice that these highlighted cells contain all of the necessary data to contribute to the online database.

All you need to do is register your site and the individual plants on your *Nature's Notebook* account, and then update your registered plants each time you run a *Flight of the Pollinators* activity.

A ready-to-print data sheet is located at the end of this activity guide.

Flight of the Pollinators

Pollinator Type: _____ Date: _____

Plant name (or ID from tag)	Do you see flowers? (circle one)	Number of flowers (circle one)	Do you see flower buds? (circle one)
	Y N ?	0 5 10 20 40 >60	Y N ?
	Y N ?	0 5 10 20 40 >60	Y N ?
	Y N ?	0 5 10 20 40 >60	Y N ?
	Y N ?	0 5 10 20 40 >60	Y N ?
	Y N ?	0 5 10 20 40 >60	Y N ?

After you've completed a "flight" around the area and have filled the rows above, add up the total number of flowers per species and enter it below.

Plant species	Total number of flowers

PROCEDURE – FLIGHT OF THE POLLINATORS

- 1. Activity leader introduces the activity.** The activity leader may introduce some of the plant species, plant communities, and other botanical features that will be encountered by the participants, including the general phenological status of those species and communities. Generally, although participants will explore only the current status of the surrounding natural resources, the activity leader can help to provide the ongoing seasonal context by describing what the landscape looked like weeks ago and what it might look like in a couple weeks.

Leaders may also help participants to recall that fruits and seeds develop from pollinated (and fertilized) flowers. Thus, the flowers that are visible today represent the forthcoming food supply for birds, deer, bears, caterpillars, squirrels, and many other animals including (possibly) humans.

Other topics and questions that could be discussed include:

- General phenology awareness – What’s happening with the plants in your neighborhood or schoolyard right now? What about the plants that are surrounding us? Are they actively producing new leaves, or are the leaves changing their colors and senescing?
- What foods are currently in season? What foods are you looking forward to in the coming season? Are the plant foods that you like to eat most reproductive structures (flower buds, flowers, fruits, seeds) or vegetative structures (leaves, stems, roots)?
- What is pollination? (transfer of pollen from male to female botanical structures). How is pollination different from fertilization?
- What/Who is a pollinator? (name as many as possible); what types of flowers are they each attracted to? (most people recall that hummingbirds are attracted to red tubular flowers; expand on this).
- Why do pollinators visit flowers? (nectar, pollen)
- Has anyone heard of the global pollinator crisis? <http://www.xerces.org/nrc-nas/>
- Have you ever hand-pollinated a flower? (this activity is an excellent opportunity to allow participants to hand-pollinate receptive flowers)



- 2. Participants select or are assigned to represent a pollinator type and then learn the features of its pollination syndrome.** Examples in this activity were developed with bees, moths, butterflies, and hummingbirds in mind – there are many other pollinator types though, so activity leaders could modify the materials for their setting and educational goals. These steps also could be adjusted to fulfill the activity leader’s educational goals and to encourage interaction among participants.

Here are a few suggested examples:

- a. Activity leader first distributes pollinator syndrome guides (see the table at the end of this activity guide), and assigns pollinator types based on answering pop-quiz questions. Questions might draw connections among pollinator morphology and behavior, energy requirements, and pollination syndrome. For example, *I hover while drinking nectar, I prefer to visit red tubular flowers, and I must drink nectar constantly because my metabolism is so high (answer: hummingbird).*
- b. Activity leader distributes some type of additional guide on the morphological features of each pollinator (i.e., a labeled image of a bee with its abdomen, thorax, antennae, etc. labeled). This knowledge becomes the basis of the pop-quiz questions in the previous option.
- c. Activity leader assigns pollinator types to the participants in some manner, distributes pollinator syndrome guides, and then pollinators group together by syndrome (bee group, moth group, etc.). Then each pollinator group describes to the other groups the components of their pollination syndrome.
- d. Participants spin a wheel to select pollinator type, or draw blindly from a sack, etc.

3. Pollinators take flight!

- a. **Activity leaders distribute data sheets and any other optional materials.** Data sheets could include several types of columns and be organized according to the activity leader’s goals and botanical knowledge (see examples in the introductory section of this activity guide). Hand lenses and cameras can help facilitate additional educational goals.
- b. **With data sheets in hand, pollinators roam the activity area in search of flowers that fit their pollination syndrome.**

Pollinators can explore the area in different ways:

1. Individually (particularly effective for confident students)
2. By pollination syndrome (bee group, moth group, etc.)
3. In groups that contain each pollinator type (e.g., each group contains one bee, moth, butterfly, and hummingbird)

Data collection can be managed in different ways:

1. Each pollinator records his/her own observations
2. Pollinators work in pairs (by pollination syndrome, or not) – one counts flowers, the other records the counts
3. Pollinators work in groups, the data sheet exchanging hands often so that everyone counts flowers at some point and everyone records data at some point.

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Keep an eye out for real pollinators visiting flowers! If they are spotted, track them to discover how they interact with each flower. Before the human “pollinators” set out on their flights, the activity leader should describe the kinds of observations that they may make if they encounter live pollinators or insect visitors to flower. For example:

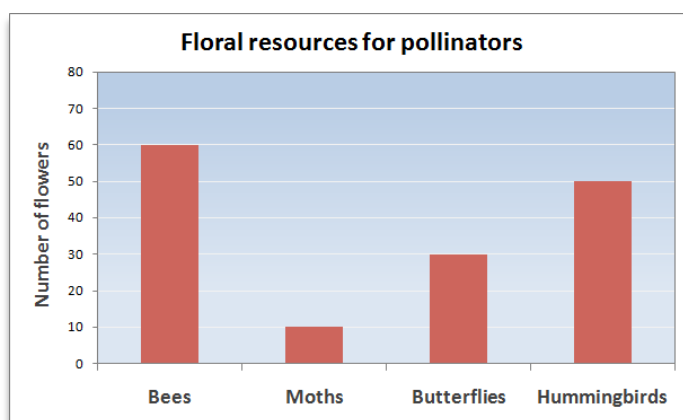
- Are the flower visitors eating nectar, collecting or eating pollen, or both?
 - Do the visitors crawl inside the flower, stay perched on top of the flower, or hover in front of the flower?
 - Do they tend to visit several flowers on the same plant, or just one flower per plant?
 - After a pollinator visits a flower, can you see pollen deposited on the stigma, or can you see signs that pollen was removed?
 - What aspects of the flower are likely to be attracting the kind of pollinator observed? For example, if a bee is seen visiting the flower, is the flower bilaterally symmetrical, blue or yellow, multi-colored, or with a landing platform?
- 4. Pollinators return to the group to report their observations.** The activity leader can direct this process and format the data in different ways depending on the activity leader’s goals and the skill level of the participants.

Two suggestions for the basic activity of counting flowers are illustrated below:

- a. For the “one-time only” activity,** a simple table and column graph may be best (shown with example data):



Pollinator type	Total number of flowers
Bees	60
Moths	10
Butterflies	30
Hummingbird	50

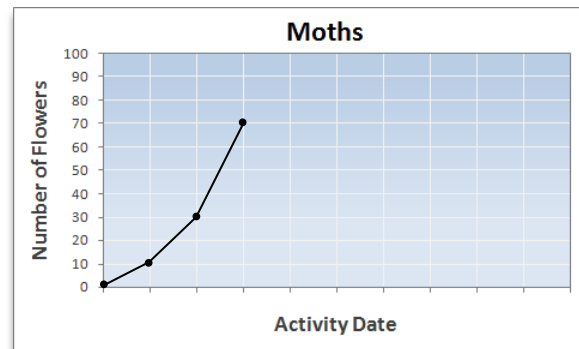
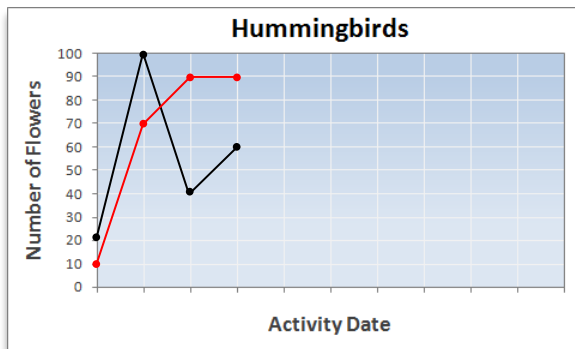
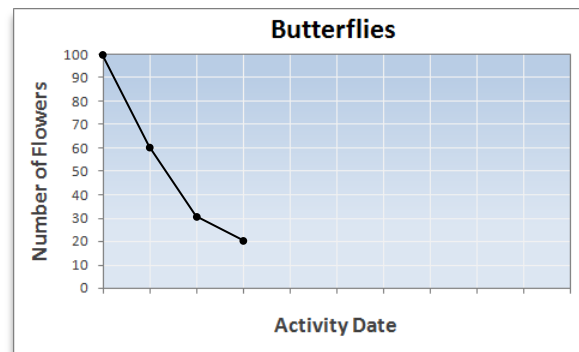
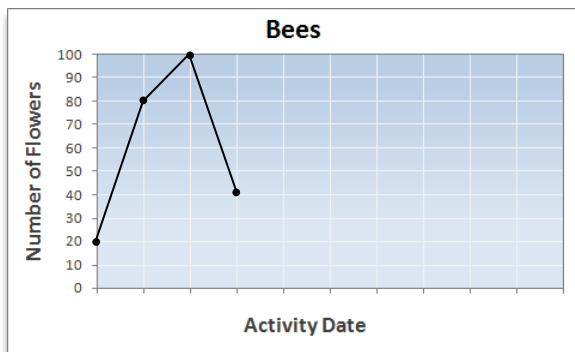


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- b. **When repeating the activity over a season(s)**, a table and line graph per pollinator type may be best. An example is provided below. Cells in the table can be filled with the total number of flowers that are counted in the garden.

If the identity of flowering species is recorded as well (for groups who can identify the plants), then each row in the table corresponding to a pollination syndrome could be subdivided by the number of appropriate plant species. Then separate lines (one for each species) could be drawn in each graph. For example, the hummingbird graph could have two lines on it – one that shows the number of hummingbird sage (*Salvia spathacea*) flowers over time (black line below) and another line that illustrates the number of California fuchsia (*Epilobium canum*) flowers over time (red line below).

Pollinator type	Activity Date	Activity Date	Activity Date	Activity Date
Bees	20	80	100	40
Moths	0	10	30	70
Butterflies	100	60	30	10
Hummingbird	20	100	40	60
Hummingbird	10	70	90	80



5. **(optional) Pollinators exchange costumes and repeat the circuit from another pollinator’s perspective.** In this scenario, the activity leader could lead pollinators through the process of calculating the average number of flowers observed for each pollinator type during each “cycle” of this activity. For example, the first Bee group might count 60 flowers, the second Bee group might count 56 flowers, and so on. The leader could then take the average of all Bee flower counts and graph that value. For more mathematically-minded groups, the amount of variation about the

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mean (the deviation) could be graphed as well. Taking it a step further, the mean and variance of the data set could be statistically analyzed to detect significant changes in the number of flowers observed over the season for each pollinator type (and whether flower counts over the season differ among pollinator groups).

6. Activity leader engages participants in a discussion about their observations and about the graphed results. Discussion questions may depend on the type of activity – for example, one-time versus repeated activity, or basic flower counts versus additional data collection for the USA National Phenology Network. Some topics that may provide a common foundation, however, might include:

a. Observations of real pollinators

Did anyone see real pollinators? What were they doing? How did they interact with each flower? Were some pollinators more abundant than others (did you see more bees than you saw moths)?

b. Interpreting the graphs with different biological contexts

i. *From the pollinator perspective* – Do generalist pollinators (bees, butterflies) have more flowers (and food) available than the specialist pollinators (moths, hummingbirds)?

ii. *From the flower perspective* – which flowers are more likely to receive visitation from their respective pollinator? In other words, while many open flowers could be great for the pollinators, we have to remember that plants are getting a service out of the interaction too. So, if a lot of bee-pollinated flowers are open today, this may mean that the probability of all flowers being visited may be low. (This would be an example of density-dependent pollinator visitation, where the density of flowers and the density of pollinators both affect the probability that a flower will be visited).

iii. *From a fruit-eating or seed-eating animal perspective* – how might pollination today affect the amount of available food for these animals in the coming weeks?

c. The human influence of the activity area

Is this activity being conducted in an intensely-managed area or in a relatively pristine wild area? Are plants irrigated and, if so, might that influence the number of flowers observed today?

7. Activity leader updates, manages, and stores data until the next round of the activity. They also may integrate the cumulative seasonal patterns into their subsequent introductions to the activity.



8. Flight de-briefing – example topics for the summary discussion

The seasonal pulses of flowers in our gardens, schoolyards, and wildlands do much more than brighten up our days with colorful displays – they provide the foundation of complex food webs supporting pollinators, fruit-eating animals, and seed-eating animals.

From a pollinator's perspective, the phenology of flowering plants directly controls the availability and amount of food. If pollinator foraging times aren't synchronized with the appearance of flowers – especially their preferred flowers – then the pollinator's ability to eat, to grow, and to reproduce may be severely affected.

From a plant's perspective, if the timing and intensity of flower production doesn't match pollinator foraging times – especially the pollinators that are attracted to and that physically fit their flowers – then the plants may not be able to reproduce and to create fruits and seeds. If this were to happen, then animals (including humans) that rely on the fruits and seeds for food may also be affected. It has been estimated that every third bite of food that we take – every third bite – is due to a plant-pollinator interaction at some point in the past.

Fortunately, there often is enough *phenological variation* both among species of flowering plants and among pollinator types that most individual plants and their pollinators can be supported each season. Over recent decades, however, as the timing of the seasons has changed quickly with the rapidly changing climate, scientists have become more concerned that the synchrony between plants and pollinators is breaking down. Reports from long-term monitoring efforts indicate, for example, that butterflies are foraging up to a month earlier now than they did just two decades ago, whereas plants are flowering at the same time or just a week or two earlier.

On any given day, a garden or landscape may support a low to a high diversity of pollinators – we can begin to quantify this by examining the types of pollinator syndromes that are represented. Cultivating a garden in which the plant species represent several pollination syndromes at all times of the year is one way that we can make a simple and real contribution to pollinator conservation. Taking plant phenology into consideration when planning the landscaping around our neighborhoods and cityscapes is one simple way to support pollinators in urban environments. To learn more about pollinator conservation, visit the Xerces Society website (www.xerces.org), and participate with the USA National Phenology Network in monitoring the phenology of plants and pollinators.

Scientists are tracking the seasonal availability of flowers, pollinators, and the fruits and seeds that develop from their interactions in order to learn more about the relationships among plants, animals, and our climate system. So many important components of wild plant and animal communities, as well as our own livelihoods, are so closely tied with the timing of the seasons that thousands of people across the U.S. are tracking the phenology of plants and animals around them and reporting their observations to the USA National Phenology Network. This effort includes professional scientists, academic scientists, citizen scientists, and teachers and students. Participation in the USA-NPN takes place in easily-accessible places such as backyards, schoolyards, wildlife refuges, neighborhood parks, and National Parks. Together, we are tracking the pulse of our planet and learning more about how plants and animals respond to environmental variation and changing climatic conditions. Learn more about the national effort at www.usanpn.org, and about the effort in California at www.usanpn.org/cpp.

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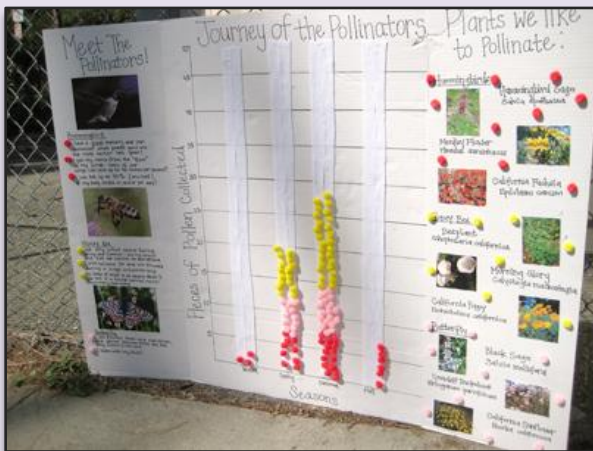
ALTERNATIVE PROCEDURE FOR *FLIGHT OF THE POLLINATORS*

DEVELOPED AND TESTED BY HARRISON ABRY, SARA HEALY, LAUREL PHELPS, AND BRIAN HAGGERTY.

Although there are many lessons to learn from the *Flight of the Pollinators* activity even when there are few plants in flower, a slight modification of the procedure can allow activity leaders the opportunity to achieve similar educational goals without sending participants to visit nearby plants. This modification may be a helpful alternative when bad weather or schoolyard logistics preclude “flying” around outside. This procedure was implemented with 5th grade students in their native plant phenology gardens as part of the *Kids In Nature* environmental education program at UC Santa Barbara (KIN was developed and is run by Dr. Jennifer Thorsch, Director of UCSB’s Cheadle Center for Biodiversity and Ecological Restoration; <http://www.cber.ucsb.edu/>).

Preparation by activity leaders in advance of leading the activity

- ✓ **Obtain several colors of felt balls** (as many colors as pollination syndromes), and an equal number of sacks or bags in which to store them.
- ✓ **Construct a central graph** with “number of flowers” on the y-axis and “seasons” (split into spring, summer, fall, winter categories) on the x-axis. See our example below; notice the vertical placement of white Velcro strips in each season. Also notice how one to several colors of felt balls (representing the number of open flowers for each pollinator type in each season) are stacked vertically for each season once the activity has been completed.



Notice that we integrated pollination syndrome lessons into the sides of this central graph – we discussed pollination syndromes and quizzed students before they took flight. The left side of the board reads “Meet the pollinators!”; the right side reads “Plants we like to pollinate”.

Hummingbirds are red; bees are yellow; butterflies are pink.

- ✓ **Create four pollinator graphs** – one graph per pollinator type, and each one with the same axes as the central graph. An example of a hummingbird graph and station is shown below. You might hand-draw these graphs, or create them on a computer. Regardless of the method of creation, the graphs should show fluctuating availability of flowers across the four seasons. Care should be taken to make this seasonal trend biologically relevant (e.g., bees should find more flowers in the summer and fewer in the winter; hummingbirds should find more flowers in the spring than in the autumn).

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The activity begins with the activity leader introducing the *Flight of the Pollinator* activity at a central location where there is one “central graph” that will be completed by the group. The activity leader assigns pollinator types to participants and they learn pollination syndromes as in the above activity procedure. Instead of roaming the area to count flowers, however, each pollinator type flies to a station that the activity leader has set up in advance anywhere in the area (i.e., indoors or outdoors).

While at their pollinator station, pollinators read the graph that depicts the number of open flowers in each of the four seasons. The activity leader calls out a season (e.g., summer) and students read the graph to determine how many flowers are open. At this point the activity leader(s) can engage each pollinator group with questions about the prevailing weather conditions during that season and how that might affect the availability of flowers for their pollinator type. Then the pollinators reach into a sack (shown above with red felt balls) and pull out the corresponding number of felt balls (activity leaders already will have stocked the sack with a color of felt balls that is specific to the pollinator type – for example, hummingbirds would select red felt balls and bees would select yellow felt balls). The pollinators then carry the felt balls over to the central graph where they stick them to Velcro strips corresponding to the same season.

Once this “reporting” step is complete, pollinators fly back to their station and activity leaders call out another season, and pollinators again determine from the graph how many felt balls they should collect. Activity leaders can ask participants more questions about the weather conditions for this season before pollinators return to the central graph to deposit the felt balls on the Velcro column corresponding to the correct season. This cycle continues twice more (or for as many seasons as the activity leader desires).

Once pollinators have cycled through each season and have deposited the correct number of corresponding felt balls on the central graph, the activity leader gathers everyone around the central graph. A discussion ensues about the seasonal patterns of flower availability, at two scales:

- ✓ describe the total flower availability in each season and across the year (regardless of pollinator syndrome); and
- ✓ describe the flower availability for each pollinator type in each season and across the entire year.

In the ensuing discussion, activity leaders can ask students questions about the trends on the graph, focusing on the biological relevance of those trends (e.g., *Did any of the pollinators go hungry in any season?*). See suggestions for discussion topics on page 14.

QUICK-GUIDE TO POLLINATION SYNDROMES

Modified from North American Pollinator Protection Campaign – www.pollinator.org

	Bats	Bees	Beetles	Birds	Butterflies	Flies	Humming-birds	Moths
Color	White, green, or purple	Bright white, yellow, blue, or UV	White or green	Scarlet, orange, red, or white	Bright, including yellow, red, and purple	Pale /dull to dark brown and purple; flecked with translucent patches	Red mostly, but also orange or yellow	Pale and dull red, purple, pink, or white
Nectar guide	Absent	Present	Absent	Absent	Present	Absent	Absent	Absent
Odor	Strong musty, emitted at night	Fresh, mild, pleasant	None to strongly fruity or foul	None to slight	Faint but fresh	Putrid	None to slight	Strong, fresh, sweet; emitted at night
Nectar	Abundant, somewhat hidden	Usually present	Sometimes present, not hidden	Ample, deeply hidden	Ample, deeply hidden	Usually absent	Abundant, deeply hidden	Ample, deeply hidden
Pollen	Ample	Limited to ample, often sticky, scented	Ample	Modest; anthers dangle outside flower	Limited	Limited	Ample; anthers dangle outside flower	Limited
Flower shape	Bowl-shaped; closed during day	Shallow to tubular, with landing platform	Small to large; bowl-like	Large, tubular to cup; strong perch support	Narrow tube with spur; wide landing pad	Shallow; funnel-like or complex with trap	Large, tubular to bell-shaped; no landing platform	Regular, tubular without a lip

Flight of the Pollinators

Pollinator Type: _____ Date: _____

In the plant column, record any features about the plant so you don't count it twice!

PLANT	NUMBER OF FLOWERS <i>(circle one)</i>	TOTAL NUMBER OF FLOWERS
1.	0 5 10 20 40 >60	
2.	0 5 10 20 40 >60	
3.	0 5 10 20 40 >60	
4.	0 5 10 20 40 >60	
5.	0 5 10 20 40 >60	
6.	0 5 10 20 40 >60	
7.	0 5 10 20 40 >60	
8.	0 5 10 20 40 >60	
9.	0 5 10 20 40 >60	
10.	0 5 10 20 40 >60	

Flight of the Pollinators

Pollinator Type: _____ Date: _____

Plant name (or ID from tag)	Do you see flowers? (circle one)	Number of flowers (circle one)	Do you see flower buds? (circle one)
	Y N ?	0 5 10 20 40 >60	Y N ?
	Y N ?	0 5 10 20 40 >60	Y N ?
	Y N ?	0 5 10 20 40 >60	Y N ?
	Y N ?	0 5 10 20 40 >60	Y N ?
	Y N ?	0 5 10 20 40 >60	Y N ?

After you've completed a "flight" around the area and have filled the rows above, add up the total number of flowers per species and enter it below.

Plant species	Total number of flowers