Lesson #4: Amazing Pollinators!

Objectives: To demonstrate the critical importance of flowers to natural ecosystems. To understand how wild flowers are designed to match specific pollinators.

Introduction to Activity: In order for students to truly appreciate the importance of plant conservation, they need to know that plants play essential ecological roles. Plants are primary producers that are the foundation of food pyramids. They provide oxygen to breathe, habitat for other living things, and they help keep soil in place so that it does not wash away.

For plants to survive, they must be able to reproduce. Pollination is a vital ecological process, upon which our continued survival, and that of other living things, depends. Oddly, despite its critical importance, it is often forgotten in science text books.

Students should become aware that the entire spectrum of pollinators is required in an ecosystem to pollinate all of the plants. Likewise, a diverse plant population is needed to provide food for the ecosystem's pollinators. Plant and pollinator are dependent upon one another for survival. Maintaining plant and pollinator diversity is, therefore, essential in healthy habitats. Students need to know how significant pollination is and how easily humans can inadvertently disrupt it. Some, hopefully, will also find the complex relationship between flowers and pollinators fascinating.

Materials Needed:

- a copy of the "Pollination Brainteasers" worksheet for each student
- a copy of "Pollination: Part Two" and accompanying worksheet for each student (to be completed at home in preparation for Lesson #5)
- photographs of examples of pollinators visiting plants

Activity:

Begin the activity by reviewing key points in the assignment for the day ("Pollination—Part One"). You might ask your students the following questions:

- What is pollination and why do plants need to be pollinated? (Pollination is when pollen travels from the anthers on flower stamens to the stigmas on female carpals. Pollination is part of the reproductive cycle of flowering plants.)
- Do you know examples of things that can pollinate flowers? (Examples include bees, flies, moths, hummingbirds, bats, and the wind. Even some small mammals pollinate certain flowers.)
- Why do you think flowers are so different in color, size, and shape? (They are attracting very specific pollinators, which are drawn to particular scents and colors.)

- Do you think a particular flower could be pollinated by bees as well as moths and birds? (In order to maximize the chances that pollen will be picked up and delivered to the carpal of another flower of the same species, most flowers have a size and shape designed for specific pollinators.)

Pass out a “Pollination Brainteasers” worksheet to each student. Explain that the packet has facts about important pollinators. The students should read through these facts and use them as clues to help them predict the characteristics (shape, color, scent, etc.) of a flower that needs this particular pollinator to help it reproduce. By going through this thinking exercise, it is intended that your students understand that flowers are designed for specific purposes. They may be surprised to learn that human logic and natural processes can, in the case of pollination, arrive at the same conclusion! Allow students to work together in small groups. Once they have had time to complete the packet, review the answers with the class and show the photo examples provided.

Wrap-up the activity by reviewing the following key points:

- Pollination is a key part of reproduction in flowering plants.
- Without pollination, many of our food crops would disappear (bananas, apples, oranges, cherries, grapes, mango, peas, tomatoes, squash, potatoes, almonds, peanuts—basically, almost all of the fruits and nuts that are eaten around the world).
- Flowers come in diverse sizes, shapes, and colors in order to attract specific pollinators. (If you have already covered the concept of co-evolution, this is a good place to make the connection.)
- When a flower species goes extinct or even has its population fall dramatically, the pollinator population also declines and can go extinct. Then, things that rely on the pollinator are also affected, and a chain reaction goes through the ecosystem. (If you have already covered food chains and food webs, this is a good place to make the connection.)
- Thus, protecting plant diversity is vital to protecting animal pollinators and other living things. Likewise, preserving pollinator diversity is required to protect plant diversity. Plant diversity is essential to healthy habitats.

At the end of the activity, pass out the assignment for the next class, “Pollination—Part Two” and its accompanying worksheet.

Pollination Brainteasers

Student name: _____ **Class/section:** _____

Below you will find facts about important pollinators. Read through them and use them as clues to help you predict what characteristics plants might have to attract each type of pollinator. When you are done, we will review the answers to see how closely you and nature agree.

BATS

Photo: Rex Walters

Throughout most of the United States and Canada, bats feed strictly on flying insects. In tropical areas, however, bats feed on a variety of foods, depending on the species of bat. They might eat frogs, fish, blood (vampire bats), fruit, pollen and nectar. The bats that concern us at the moment are those that feed on pollen and nectar. If you were a plant, how would you attract them? Here are some clues:

- Bats have a good sense of smell. (Remember, many eat pollen and nectar.)
- Bats have a good sense of sight. (They are not blind, although they are colorblind. They can see light and dark.)
- Bats are relatively large for a pollinator, at least compared with insects.
- What time of day are bats active?
- How much food would a bat need compared with, say, a bee?

If you were a flower designed to be pollinated by a bat, what characteristics would you have? (Fill in the blanks below.)

Color: _____

Size: _____

Location of flower on the plant: _____

Shape: _____

Scent: _____

Time of day when in bloom: _____

MOTHS

Photo: Davis Kwan

- Their mouth parts are like long soda straws that they carry curled up like New Years novelty toys. Therefore, their food must be liquid. They do not have jaws.
- Most moths come out at night, as opposed to butterflies which are mostly active during the day.
- They see fairly well at very short distances, and they can see color.
- Their sense of smell, like most insects, is truly amazing. They can detect a few molecules of a scent in the air.

If you were a flower designed to be pollinated by a moth, what characteristics would you have? (Fill in the blanks below.)

Color: _____

Shape: _____

Time of day in bloom: _____

Scent: _____

What the flower might provide the visiting moth: _____

FLIES and CARRION BEETLES

Photo: Laszlo Ilyes

- These charmers like nothing better than to find a dead possum or a pile of dung on which to lay their eggs. The eggs will hatch into maggots and will have a perfect place to feast. Bon appetit!
- Like moths, they see only fairly well at short distances. (You can sneak up on them pretty easily with a fly swatter.)
- They have an amazingly good sense of smell.

If you were a flower designed to be pollinated by flies or beetles, what characteristics would you have? (Fill in the blanks below.)

Scent: _____

Color: _____

Why might flies and beetles visit the flower? _____

_____

BEES

Photo: Joost Witteveen

A huge variety of bees pollinates flowers, ranging from tiny sting-less bees to bumblebees to honeybees. Here are some facts about bees, in general:

- They search out pollen and nectar. Some bees make honey to feed their young.
- They have jaws, not soda-straw mouths like moths.
- They see colors at the short wavelength end of the spectrum, not long wavelengths. Thus, they cannot see red, but they can see ultraviolet light, which we humans cannot see.
- Their vision is OK, but they have a great sense of smell.

If you were a flower designed to be pollinated by a bee, what characteristics would you have? (Fill in the blanks below.)

Scent: _____

Colors: _____

HUMMINGBIRDS

Photo: Windell Oskay

These birds are only found in the Western Hemisphere.

- They have long, needle-like bills.
- They see the same colors that people see.
- They cannot smell.
- They feed on tiny insects and nectar.
- They usually hover when feeding, like a miniature helicopter. They rarely perch when feeding.
- How could a flower attract hummingbirds, but not attract bees and other animals that might steal its nectar and not pollinate your flowers?

If you were a flower designed to be pollinated by a hummingbird, what characteristics would you have? (Fill in the blanks below.)

Color: _____

Scent: _____

Shape: _____

Location of anthers and stigmas: _____

WIND

- Can wind-pollinated plants actually attract wind?
- What flower design might help the wind carry off pollen most effectively?
- What are the chances that a single pollen grain, when blown by the wind, will land on the right flower?

If you were a flower designed to be wind-pollinated, what characteristics would you have? (Fill in the blanks below.)

Color: _____

Scent: _____

Shape of flower: _____

Season of bloom in most parts of country: _____

_____

Location of flowers on plants: _____

Amount of pollen produced: _____

_____

Pollination Brainteasers Answer Sheet

Below you will find facts about important pollinators. Read through them and use them as clues to help you predict what characteristics plants might have to attract each type of pollinator. When you are done, we will review the answers to see how closely you and nature agree.

BATS

Throughout most of the United States and Canada, bats feed strictly on flying insects. In tropical areas, however, bats feed on a variety of foods, depending on the species of bat. They might eat frogs, fish, blood (vampire bats), fruit, pollen and nectar. The bats that concern us at the moment are those that feed on pollen and nectar. If you were a plant, how would you attract them? Here are some clues:

- Bats have a good sense of smell.
- Bats have a good sense of sight. (They are not blind, although they are colorblind.)
- Bats are relatively large for a pollinator, at least compared to insects.
- What time of day are bats active?
- How much food would a bat need compared with, say, a bee?

If you were a flower designed to be pollinated by a bat, what characteristics would you have? (Fill in the blanks below.)

Color: white or pale in color since bats are active at night

Size: relatively large (bats are large)

Location of flower on the plant: at top or on the outside where the flower is exposed and the bats can find it

Shape: open at the top so bat can get its head inside

Scent: sweet smell to advertise the nectar the flower provides bats

Time of day when in bloom: evening—that is when bats are active

MOTHS

- Their mouth parts are like long soda straws that they carry curled up like New Years novelty toys. Therefore, their food must be liquid.
- Most moths come out at night, as opposed to butterflies which are mostly active during the day.
- They see fairly well at very short distances, and they can see color.

- Their sense of smell, like most insects, is truly amazing. They can detect a few molecules of a scent in the air.

If you were a flower designed to be pollinated by a moth, what characteristics would you have? (Fill in the blanks below.)

Color: white or pale colored since moths are active at night

Shape: long, skinny tube for the moth's soda-straw tongue

Time of day in bloom: evening, since most moths are active at night

Scent: fabulously sweet, to advertise the sweet food that flowers provide moths

What the flower might provide the visiting moth: nectar

FLIES and CARRION BEETLES

- These charmers like nothing better than to find a dead possum or a pile of dung on which to lay their eggs. The eggs will hatch into maggots and will have a perfect place to feast. Bon appetit!
- Like moths, they see only fairly well at short distances. (You can sneak up on them pretty easily with a fly swatter.)
- They have an amazingly good sense of smell.

If you were a flower designed to be pollinated by flies or beetles, what characteristics would you have? (Fill in the blanks below.)

Scent: a foul odor like rotten meat

Color: dark reddish-brown or brown, like the color of rotten meat

Why might flies and beetles visit the flowers? The fly or beetle thinks it has found a perfect place to lay eggs, but it has been tricked! The flower doesn't provide anything. Instead, the fly or beetle unknowingly pollinates the flower as it flies from bloom to bloom.

BEES

A huge variety of bees pollinates flowers, ranging from tiny sting-less bees to bumblebees to honeybees. Here are some facts about bees, in general:

- They search out pollen and nectar. Some bees make honey to feed their young.

- They see colors at the short wavelength end of the spectrum, not long wavelengths. Thus, they cannot see red, but they can see ultraviolet light, which we humans cannot see.
- Their vision is OK, but they have a great sense of smell.

If you were a flower designed to be pollinated by a bee, what characteristics would you have? (Fill in the blanks below.)

Scent: sweet since bees have a good sense of smell and seek nectar

Colors: short wavelength colors such as blues and purples. Even white and yellow will work. Often, white flowers have streaks of color that can be seen in ultraviolet light. Bees can see these streaks, but we cannot. Bees are not attracted to red.

HUMMINGBIRDS

These birds are only found in the Western Hemisphere.

- They have long, needle-like bills.
- They can see the same colors that people see.
- They cannot smell.
- They feed on tiny insects and nectar.
- They usually hover when feeding, like a miniature helicopter. They rarely perch when feeding.
- How could a flower attract hummingbirds, but not attract bees and other animals that might steal its nectar and not pollinate your flowers?

If you were a flower designed to be pollinated by a hummingbird, what characteristics would you have? (Fill in the blanks below.)

Color: orange and red: birds can see these colors and they stand out among greenery

Scent: no scent; birds don't have a sense of smell, so producing a scent would be a waste of energy

Shape: tubular shape to fit the hummingbird's bill

Location of anthers and stigmas: protruding from the flowers, where they come into contact with the hovering bird

WIND

- Can wind-pollinated plants actually attract wind?
- What flower design might help the wind carry off pollen most effectively?
- What are the chances that a single pollen grain, when blown by the wind, will land on the right flower?

If you were a flower designed to be wind-pollinated, what characteristics would you have? (Fill in the blanks below.)

Color: neutral colors such as green, tan and brown; wind is not attracted to colors so the plants don't waste energy producing petals with bright colors, or sometimes any petals at all

Scent: no scent; wind is not attracted by scent

Shape of flower: something exposed to the wind; many dangle like wind chimes. Anthers are exposed so wind can catch their pollen and carry it away.

Season of bloom in most parts of country: early spring; most wind-pollinated trees produce pollen before the leaves come out. This makes it easier for the pollen to reach flowers when it is blown. Leaves would block a lot of the pollen. Stigmas are exposed to catch the pollen as it blows by.

Location of flowers on plants: at the ends of branches for exposure to the wind

Amount of pollen produced: an enormous amount; wind pollination completely relies on chance, and most pollen never reaches its intended target. (Have you ever wondered why pollen covers our car windows and so many people have hay fever at certain times of year?)

Photo: William C. Taylor @ USDA-NRCS PLANTS Database

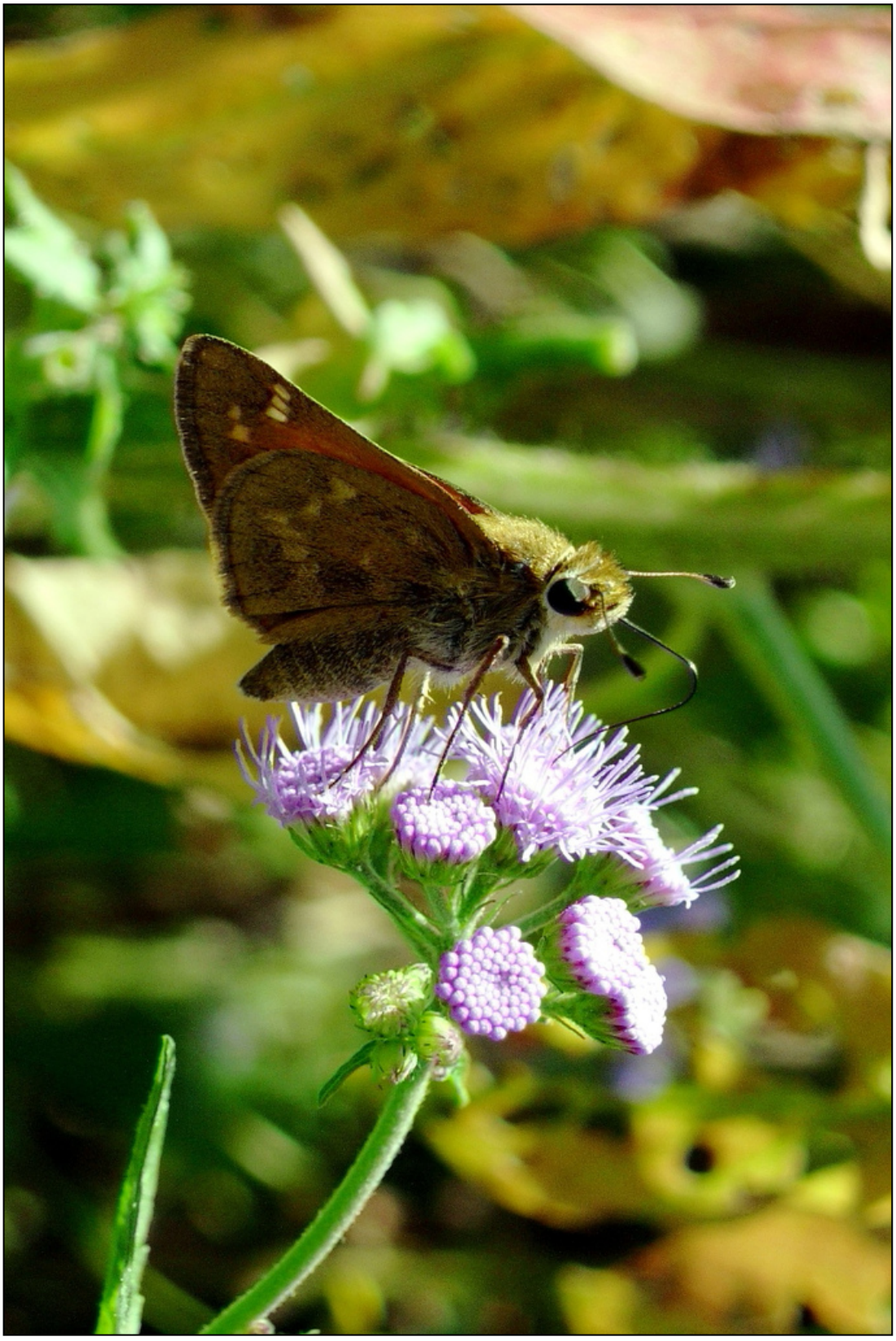

Photo: Brian Sanders

Photo: Jennifer Anderson @ USDA-NRCS PLANTS Database

Photo: Brian Sanders

Photo: Karen Tucker

Assignment: Pollination—Part Two

In the last reading, you learned that most plants depend upon things in the environment, usually the wind and various kinds of animals, to pollinate their flowers. Plants have to do this successfully; otherwise, they will not be able to reproduce. But if plants all want to accomplish the same thing, why do their flowers look so different from each other? Why aren't they all designed the same way to do the same task?

It turns out that flowers vary so much in shape, size, and color because they are all trying to match different pollinators. A flower attractive to a bee, for example, will not necessarily appeal to a bat, butterfly, or bird, and will probably not be capable of being pollinated by the wind. The great diversity of flowers in nature, then, is largely due to the great diversity of pollinators the flowers are trying to match. With this in mind, you can often understand why flowers are designed as they are. Indeed, if you have a specific pollinator in mind, you can even predict what a flower designed to match it will look like!

Photo: Jessica Merz

Take flowers pollinated by hummingbirds, for example. Hummingbirds are incredible animals. The smallest birds in the world, they are no bigger than large moths and butterflies, and, like these insects, they like to feed on flower nectar. To reach the nectar, they often hover like miniature helicopters in front of blossoms and insert their long beaks and tongues deep inside them to reach their sweet, liquid food. The Eastern United States has one species, the ruby-throated hummingbird, but more than a dozen species live in the western United States. Central and South America have hundreds of different species.

If you were a flower and your goal in life was to be pollinated by a hummingbird, what would YOU look like? First, you would want to be noticed. It turns out that hummingbird vision is a lot like humans', so many hummingbird-pollinated flowers are red and orange, because these colors stand out against the green background of plants growing in forests and fields. How would you smell? Hummingbirds, like most birds, have no sense of smell, so flowers designed to match them typically have no scent, whatsoever! How would you be shaped? Take a look at the hummingbird photograph, and you can see that its bill is long and needle-like, like most hummingbirds. So, the typical flower pollinated by these birds is long and tubular, like a miniature trumpet. How would you arrange to cover the hummingbird with pollen, so it would do what you want

(unintentionally!) and carry it off to another blossom? You would have your anthers sticking out of the blossom, ready to brush pollen on the head or bill of the bird hovering in front of you. If you were designed like this, you would stand a good chance of being pollinated by a hummingbird. (Congratulations!)

Photo: David Wilbanks

But, would you also succeed in being pollinated by a bumblebee? Not as likely, for several reasons. First, bumblebees cannot see the color red very well, but they can perceive blue, violet, and even ultraviolet, which neither humans nor hummingbirds can see. Secondly, bumblebees, like most insects, have extraordinarily sensitive senses of smell. To attract them with pollen or nectar to eat, you would do well to have a sweet scent to advertise your wares. And, it wouldn't help to dangle your anthers out of the blossom, because the bumblebee will probably land on the flower and miss them entirely. So, bumblebee-pollinated flowers are often blue or violet. Some of them are also white or yellow with stripes that reflect ultraviolet light, which bees can see but humans can't. Bumblebee-pollinated flowers also have sweet scents to advertise their nectar and pollen, and they are usually sturdy to suit a relatively heavy insect.

Photo: Eric Milot

You can see, then, that flowers are not designed randomly, but rather to match specific pollinators. So, butterfly-pollinated blooms, such as milkweed, are often yellow, pink, or orange and flat across the top to provide a landing strip for the insects to stand on as they sip nectar (left photo). Flowers pollinated by night-flying moths typically bloom at night, are sweet-smelling, and are long and tubular in shape to fit the moths' long tongues. In the American southwest, such as Texas and Arizona, bats serve as pollinators. The flowers that attract them also bloom at night and are white (so they might be seen on moonlit evenings) and sweet-smelling, but they are also very big to hold large amounts of nectar and pollen needed to attract these relatively large pollinators. They also stand exposed at the ends of high branches where they can be noticed. The flowers of the spectacular saguaro cactus of Arizona and the agave plant of Texas are examples of bat-pollinated flowers.

Some flowers, however, offer no nectar or pollen or anything else to bribe pollinators to carry off pollen. Examples are flowers pollinated by wind. Obviously, they don't try to attract the attention of the wind, since wind can't see or smell; they simply wait for the wind to come along and pollinate them. Wind-pollinated flowers often escape our attention; they typically have tiny or even

non-existent petals, are green or brown, and have no scent. Their stamens and pistils often dangle exposed to the air, so that the slightest breezes will be able to pick up their pollen and deposit it on the desired flowers. Whether the pollen does this will depend entirely on chance, so wind-pollinated flowers produce massive amounts of pollen, because most of it will be wasted. Most of the trees and grasses in the United States are wind-pollinated. Though we often don't notice the flowers themselves, we do notice their effects: All this blowing pollen brings about the watery eyes and runny noses of hay fever.

Then, there are some flowers that attract pollinators through deception. Instead of offering food, they misrepresent themselves to trick pollinators into serving them without receiving anything in return.

Photo: hiromama

One example is the skunk cabbage (right photo), found commonly in swampy areas in the eastern United States. The skunk cabbage receives its name from the unpleasant odor its leaves give off when crushed. The flower, too, has a bad smell. Blooming in late winter, it is maroon in color and shaped like a monk's hood. What could find this strange flower attractive? It turns out that flies come to the flower readily, but not for nectar and pollen to eat. Instead, they are looking for dead animals and even animal excrement on which to lay their eggs, and they think that's what the skunk cabbage flowers are! The flies unintentionally carry pollen from flower to flower in their futile quest for a place to lay their eggs.

Photo: Gunnar Norman

And then there are a few flowers that live along the Mediterranean Sea in southern Europe. These actually look and even smell like female bees (left photo). Male bees visit the blossoms and attempt to mate with them, in the process picking up pollen that they carry from flower to flower in their quest for romantic fulfillment!

You can see that the world's incredible variety of flowers is specially designed to attract an equally amazing variety of pollinators. There is no "one size

fits all" flower that is pollinated by everything possible: birds, bats, wind, bees, etc. Likewise, no super pollinator exists that is capable of pollinating everything that blooms. This is very important to keep in mind when we think about how to protect biological diversity on our planet.

If we want to protect a flower, we have to protect its pollinators too. We have to be careful with our insecticides so we do not kill off the bees, moths, butterflies, and other insects that pollinate so many of our plants. We also have to protect the habitats of all of the birds, bats, and other animals that play vital pollination roles. Likewise, to protect animal diversity in our world, we have to protect the many plants that feed them nectar, pollen, and other foods. It is not sufficient to simply preserve only a few pollinators, because that will leave many flowers unpollinated and unable to reproduce. It is not enough to preserve only a few plant species, because many pollinators will be unable to find the food they need.

Plants and pollinators depend upon one another for their survival. We humans depend on them as well. Most of our food plants except for grains and cereals, for example, depend upon animals to pollinate them. Preserving both plant and pollinator diversity is not only vital for a healthy, beautiful, and fascinating planet, it is essential for our continued well-being.

Glossary

Deception: trickery

Habitat: a place where a plant or animal can get the food, water, shelter, and space it needs to live; there are many different habitats for various species

Insecticides: chemicals used to kill insects; they are used by farmers on crops as well as by homeowners in their homes and yards

Nectar: a sweet liquid secreted by the flowers of some plants and consumed by its pollinators

Pollen: the dust-like specks that hold male sperm cells found on the anthers of flowers; some plants produce pollen in large quantities, providing food for their pollinators that visit the flowers because of this food source

Ultraviolet light: electromagnetic (light) waves that are slightly shorter in wavelength than the visible colors that we see; they are invisible to us but can be detected by the eyes of some insects

Worksheet: Pollination—Part Two

Name: _____ **Class/Section:** _____

1. Look at the photographs of flowers below and decide what you think pollinates each flower, and list your reasons why.

Photo: Elisa Bracco

This flower has a very sweet smell.

What pollinates this?

_____

List the reasons for your answer:

_____
_____
_____
_____
_____
_____

Photo: Josh Rosenbaum

This flower has no smell.

What pollinates this?

_____

List the reasons for your answer:

_____
_____
_____
_____
_____
_____

Photo: Karol Miles

This flower has a sweet smell.

What pollinates this?

_____

List the reasons for your answer:

_____
_____
_____
_____
_____

Photo: bcanna

This flower has a sweet smell.

What pollinates this?

_____

List the reasons for your answer:

_____
_____
_____
_____
_____
_____

Photo: Ben Tubby

This flower has a foul smell (to humans) to mimic excrement and dead animals.

What pollinates this?

_____

List the reasons for your answer:

_____
_____
_____
_____
_____

Photo: c rite thru

This plant has no noticeable smell.

What pollinates this?

_____

List the reasons for your answer:

_____
_____
_____
_____
_____

2. If we want to preserve plant diversity, why do we need to preserve pollinator diversity as well? Why can't we just preserve a few pollinators, like honeybees for example, to pollinate flowers?

Answer Sheet: Pollination—Part Two

Name: _____ **Class/Section:** _____

1. Bumblebees
    i. Color: Blue, Violet, Ultraviolet markings
    ii. Scent: Sweet, to advertise nectar
    iii. Shape/design: Sturdy for heavy insects
2. Hummingbirds
    i. Color: Red, orange
    ii. Scent: No scent; hummingbirds can't smell
    iii. Shape/design: Tubular, protruding stamens and stigmas
3. Bats
    i. Color: White
    ii. Scent: Sweet to advertise nectar and pollen
    iii. Shape/design: Large, bowl-shaped, flowers high on ends of branches
4. Moths
    i. Color: White
    ii. Scent: Sweet to advertise nectar
    iii. Shape/design: Tubular, nectar often kept in spurs or tubes to accommodate moth mouthparts
5. Flies
    i. Color: Maroon, brown, dark red

ii. Scent: Foul (to humans), to mimic excrement and dead animals

iii. Shape/design: Varied

6. Wind

i. Color: Green or brown

ii. Scent: No scent

iii. Shape/design: Petals small or absent, dangling stamens and protruding carpals, great quantities of sticky and very light pollen

7. If we want to preserve plant diversity, why do we need to preserve pollinator diversity as well? Why can't we just preserve a few pollinators, like honeybees for example, to pollinate flowers?

   Answer: Flowers and pollinators are specifically suited to each other. No flower attracts every single pollinator, and no pollinator is adapted to pollinate every flower. To preserve plant diversity, it is essential to preserve both plant and pollinator diversity. Losing plant diversity would harm pollinator diversity and vice versa.