SMITHSONIAN IN YOUR Classroom

November/December 1997

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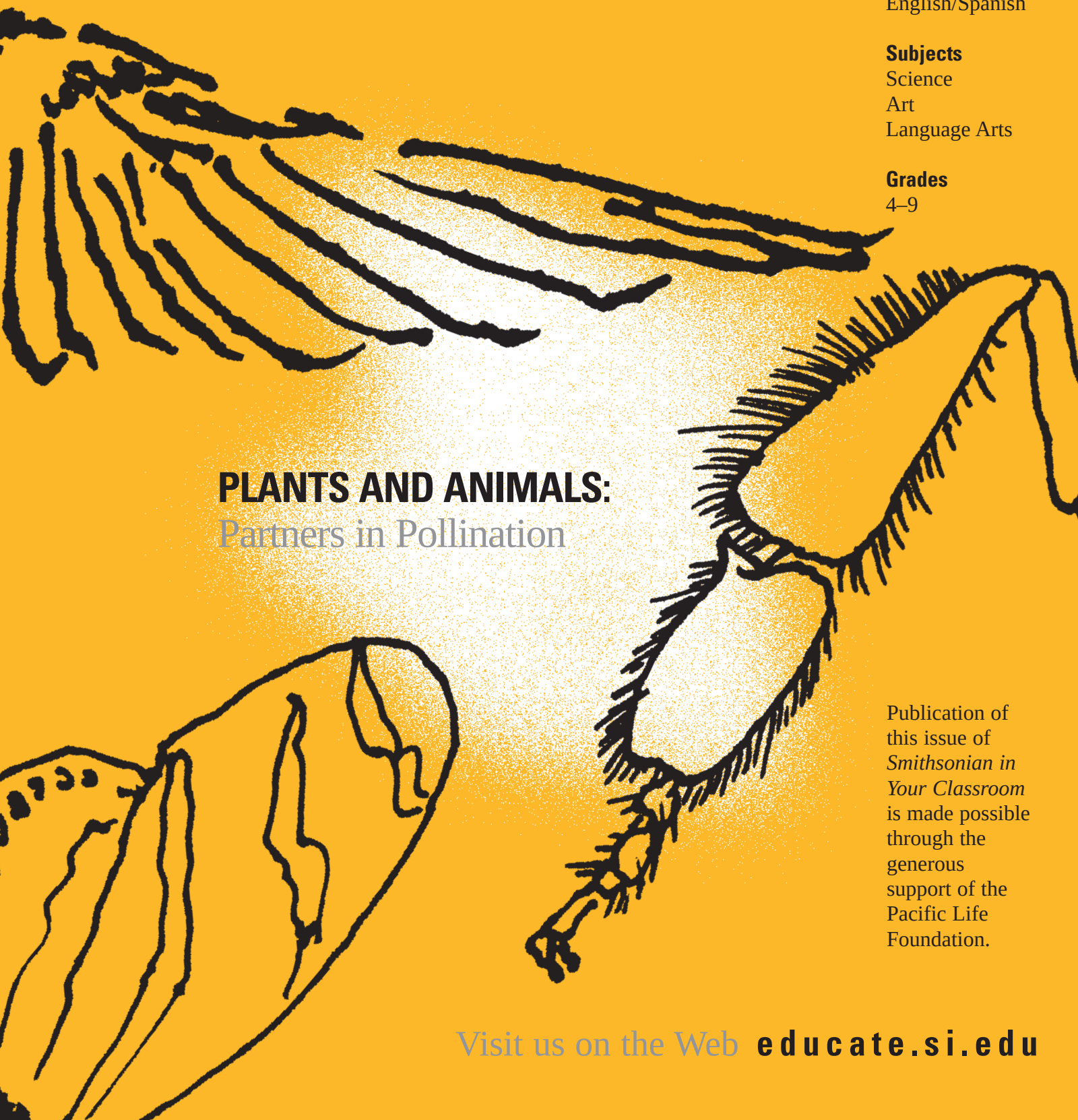

PLANTS AND ANIMALS:
Partners in Pollination

Publication of this issue of *Smithsonian in Your Classroom* is made possible through the generous support of the Pacific Life Foundation.

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Smithsonian in Your Classroom's purpose is to help you use the educational power of museums and other community resources. *Smithsonian in Your Classroom* draws on the Institution's hundreds of exhibitions and programs—from art, history, and science to aviation and folklife—to create classroom-ready materials for grades four through nine. Each of the four annual issues explores a single topic through an interdisciplinary, multicultural approach. The Smithsonian invites teachers to duplicate materials from this publication for educational use.

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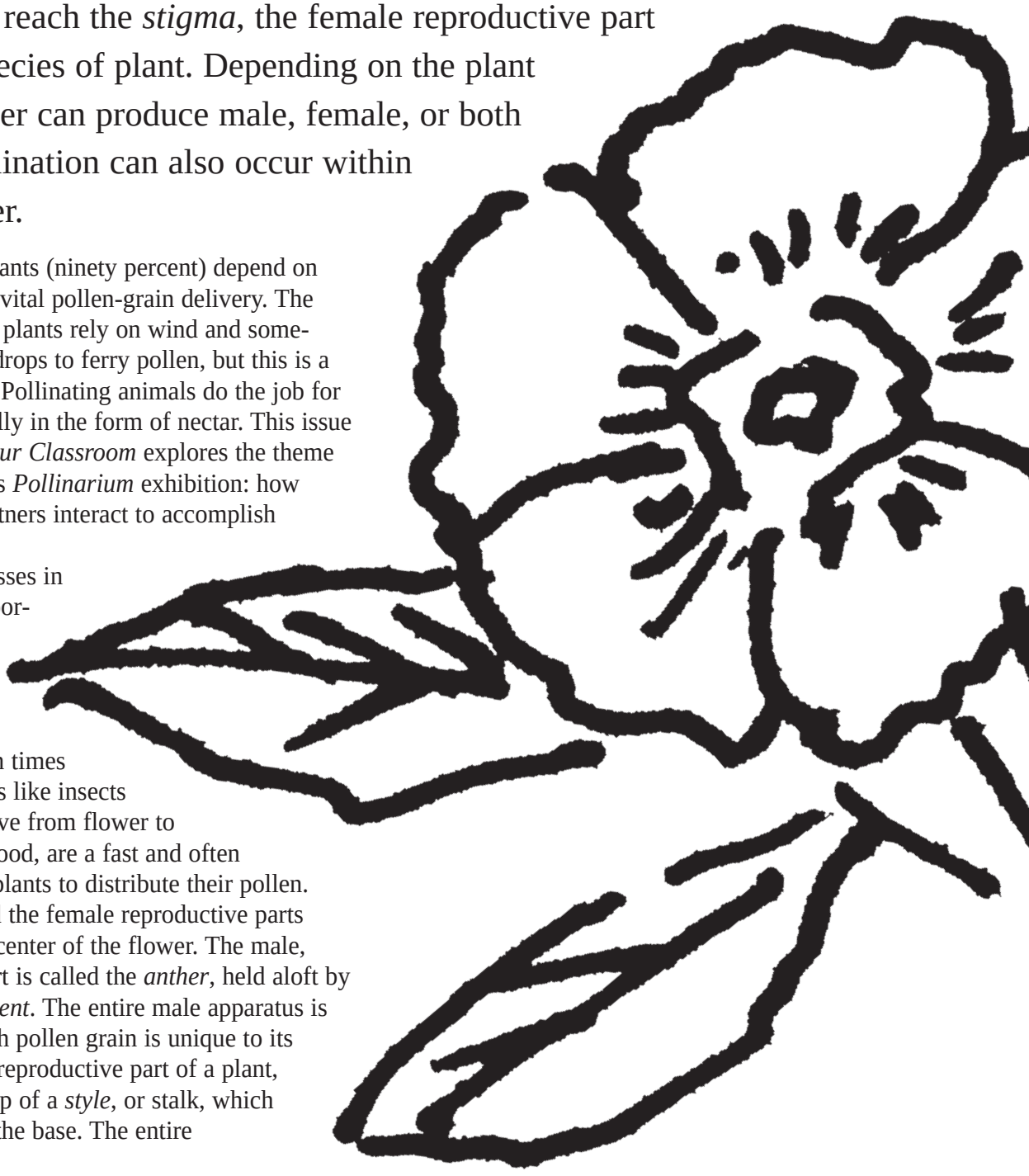
PLANTS AND ANIMALS:
Partners in Pollination

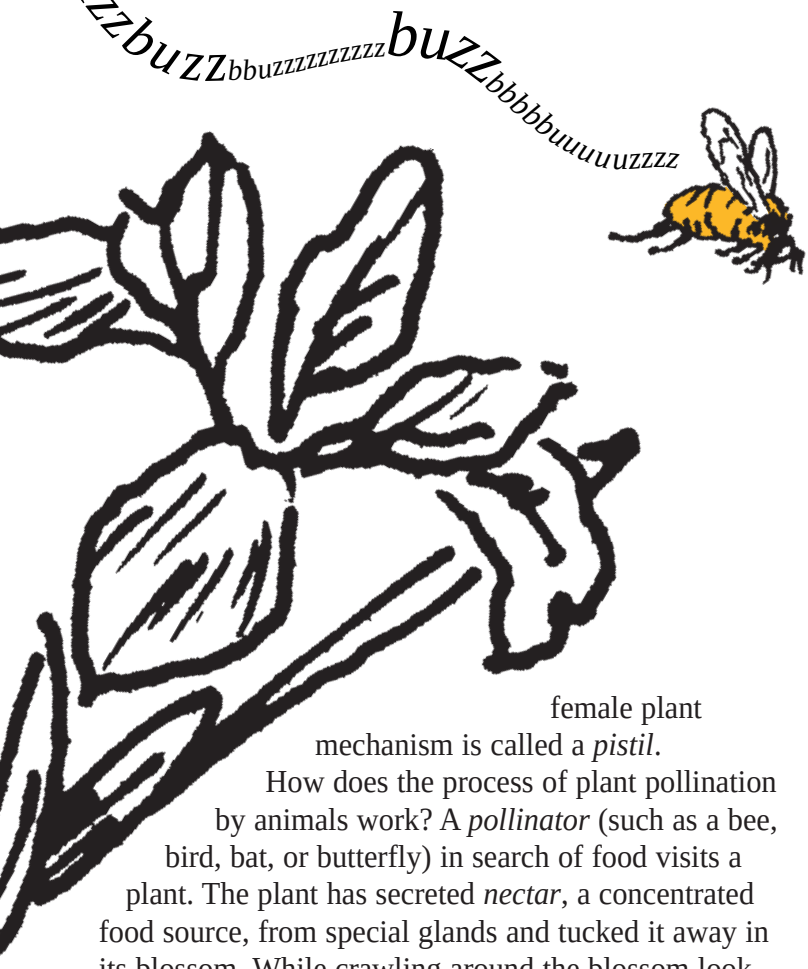
Ultimately, all life on Earth depends on plants to provide food, shelter, and oxygen for other living things. Consequently, plant reproduction is crucial to all other life on this planet. The first step in plant reproduction is the intricate process called *pollination*, which occurs when *pollen* grains, the male germ cell of a plant, reach the *stigma*, the female reproductive part of the same species of plant. Depending on the plant species, a flower can produce male, female, or both structures. Pollination can also occur within the same flower.



Most flowering plants (ninety percent) depend on animals to make the vital pollen-grain delivery. The remaining flowering plants rely on wind and sometimes splashing raindrops to ferry pollen, but this is a less precise method. Pollinating animals do the job for a reward: food, usually in the form of nectar. This issue of *Smithsonian in Your Classroom* explores the theme of the National Zoo's *Pollinarium* exhibition: how plant and animal partners interact to accomplish pollination.

As in many processes in nature, timing is important. The female reproductive part of a flower is receptive to pollen only at certain times of the year. Creatures like insects and birds, which move from flower to flower in search of food, are a fast and often guaranteed way for plants to distribute their pollen.

Both the male and the female reproductive parts of a plant are in the center of the flower. The male, pollen-producing part is called the *anther*, held aloft by a stalk called a *filament*. The entire male apparatus is called a *stamen*. Each pollen grain is unique to its species. The female reproductive part of a plant, the stigma, sits on top of a *style*, or stalk, which leads to an *ovary* at the base. The entire



female plant mechanism is called a *pistil*.

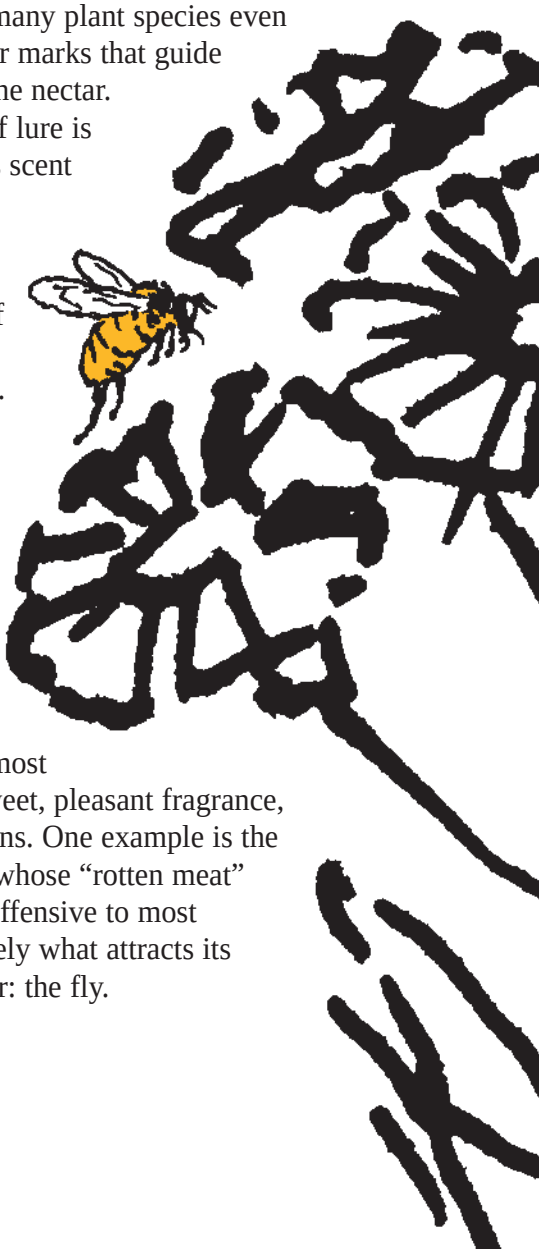
How does the process of plant pollination by animals work? A *pollinator* (such as a bee, bird, bat, or butterfly) in search of food visits a plant. The plant has secreted *nectar*, a concentrated food source, from special glands and tucked it away in its blossom. While crawling around the blossom looking for nectar, the pollinator rubs against the pollen, which becomes attached to different parts of the pollinator's body. When the pollinator visits another blossom, it transfers the pollen grains from its body onto a strategically placed stigma. After it reaches the stigma, the pollen grain grows a tiny pollen tube down the style and into an egg-filled ovary. Eventually, the pollen and the egg form a *seed*.

Scientists estimate that there are many thousands of animal pollination partners, ranging from invertebrates (animals without backbones) such as bees, butterflies, wasps, flies, and beetles to vertebrates (animals with backbones) such as birds, bats, and other mammals. In North America, most of the pollinators are insects like bees, butterflies and beetles, or vertebrates like hummingbirds and bats. But elsewhere in the world pollinators can be primates (like lemurs), Australian possums, arboreal (tree-dwelling) rodents, or even reptiles like the gecko lizard.

The animal pollinators carry the pollen in different ways. Vertebrate pollinators like birds or bats carry pollen in their feathers or hair. Although invertebrates like bees and butterflies lack hair, they have something just as suitable for carrying pollen: bristles situated on their legs, head, and other body parts. Honeybees have tiny baskets on their legs for carrying pollen back to the hive. When butterflies use their long *proboscis*, or nectar-gathering appendage, to sip nectar from tubular flowers, they get peppered involuntarily with pollen on the proboscis or the head.

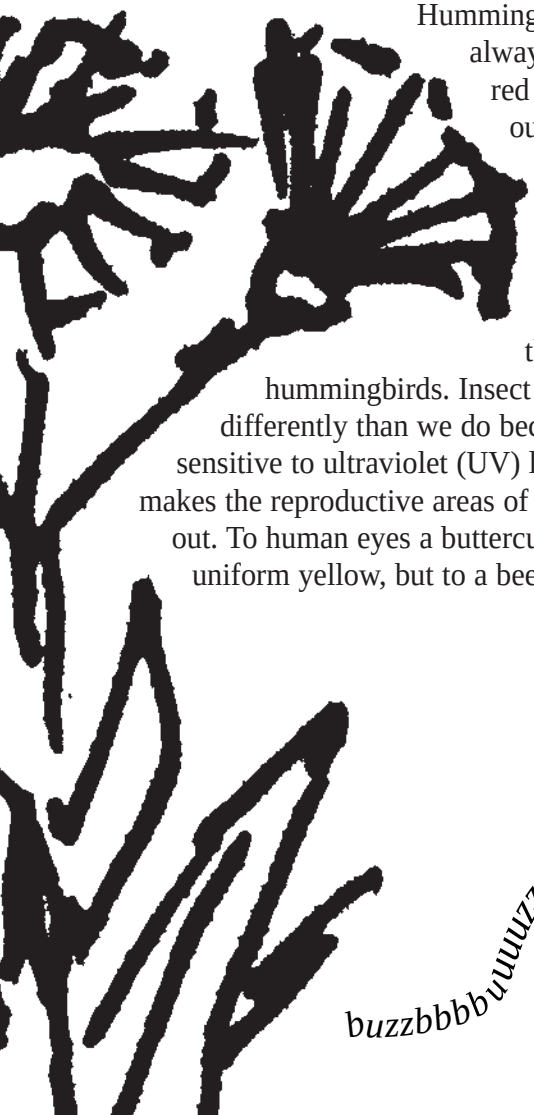
Plants use various techniques to attract their particular animal partners. Flowers are actually cleverly designed reproductive organs that incorporate all kinds of lures. The petals, for example, may serve as a landing platform for a visiting insect. When a bee lands on the lower petal of a snapdragon, its weight causes a stamen to swing down and dust the bee with pollen. Petals of many plant species even have lines or other marks that guide the pollinator to the nectar.

Another type of lure is aroma. A flower's scent must appeal to its pollinator. Many people appreciate the sweet smell of honeysuckle on a midsummer night. At that time, it's at its strongest to draw the honeysuckle's pollinators: nocturnal moths who "smell" with their feathery antennae. While most flowers have a sweet, pleasant fragrance, there are exceptions. One example is the Rafflesia flower, whose "rotten meat" aroma, which is offensive to most humans, is precisely what attracts its pollination partner: the fly.



Plant structures, too, are designed to attract specific pollinating partners. The Queen Anne's lace flower places its nectar right at the base of its tiny flowers where pollinators with a short proboscis (nectar-gathering appendage) such as honeybees, ants, wasps, flies, and beetles can reach it when they crawl on the flower. On the other hand, bumblebees, butterflies, and moths have long proboscises, which enable them to reach nectar in less accessible places. For example, the long shape and curve of the columbine flower complements the long tongue of a bee, butterfly, or hummingbird. By concealing the nectar deep within its trumpet-like blossoms, the columbine prevents animals who are not its pollination partners from taking the nectar and transferring any pollen.

Plants also use colors to attract their ideal animal pollinators. Hummingbirds often, but not always, are attracted to red flowers. As it turns out, red flowers are typically loaded with carbohydrate-rich nectar, which provides almost instant energy for the fast-moving hummingbirds. Insect pollinators see color differently than we do because they are sensitive to ultraviolet (UV) light. UV light makes the reproductive areas of some flowers stand out. To human eyes a buttercup appears as a uniform yellow, but to a bee's eyes the flower's center (where the reproductive structures are) is darker because it reflects UV light. Bees are also attracted to blue and violet flowers. Flowers pollinated by animals who search for food at night are often pale so they'll be visible.



Through *natural selection*, a process in which living things become better adapted to their environments, some plants have evolved to match a particular animal pollinator. While this may be efficient because the pollinator will always visit the right species, it can also be dangerous for both partners should one or the other become extinct.

On a worldwide scale, animals pollinate more than three-fourths of the staple crop plants that people eat. Scientists estimate that one out of every three bites of food we take is the result of a successful animal-plant pollination system. For instance, consider a hamburger or hotdog with "the works": ketchup, relish, mustard, and onions. Several different bee species pollinated the flowers of the plants that produce these condiments: tomatoes, cucumbers, mustard seed, and onions. Other bees were responsible for the side dishes. For example, hardworking bees pollinated the potato plant that eventually became potato chips and French fries. And for dessert, an endless variety of ice cream flavors, such as strawberry, chocolate, and vanilla, is also the result of successful plant-animal partnerships. A world without pollinators, and thus without flowers, and so many types of food, would be a poor world indeed!

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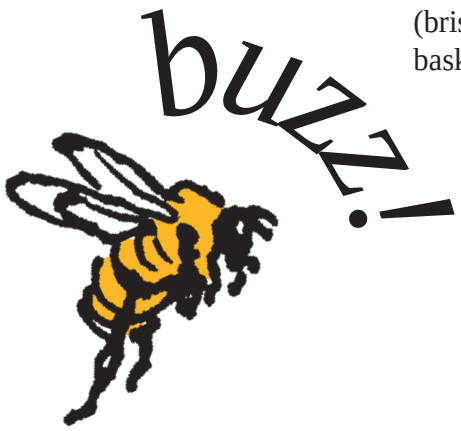
LESSON PLAN Step 1
How Does Pollination Work?

Objectives
- Identify the plant parts involved in reproduction.
- Identify the animal (bee) structures involved in pollination.
- Demonstrate how pollen moves from the male stamen to the female stigma.

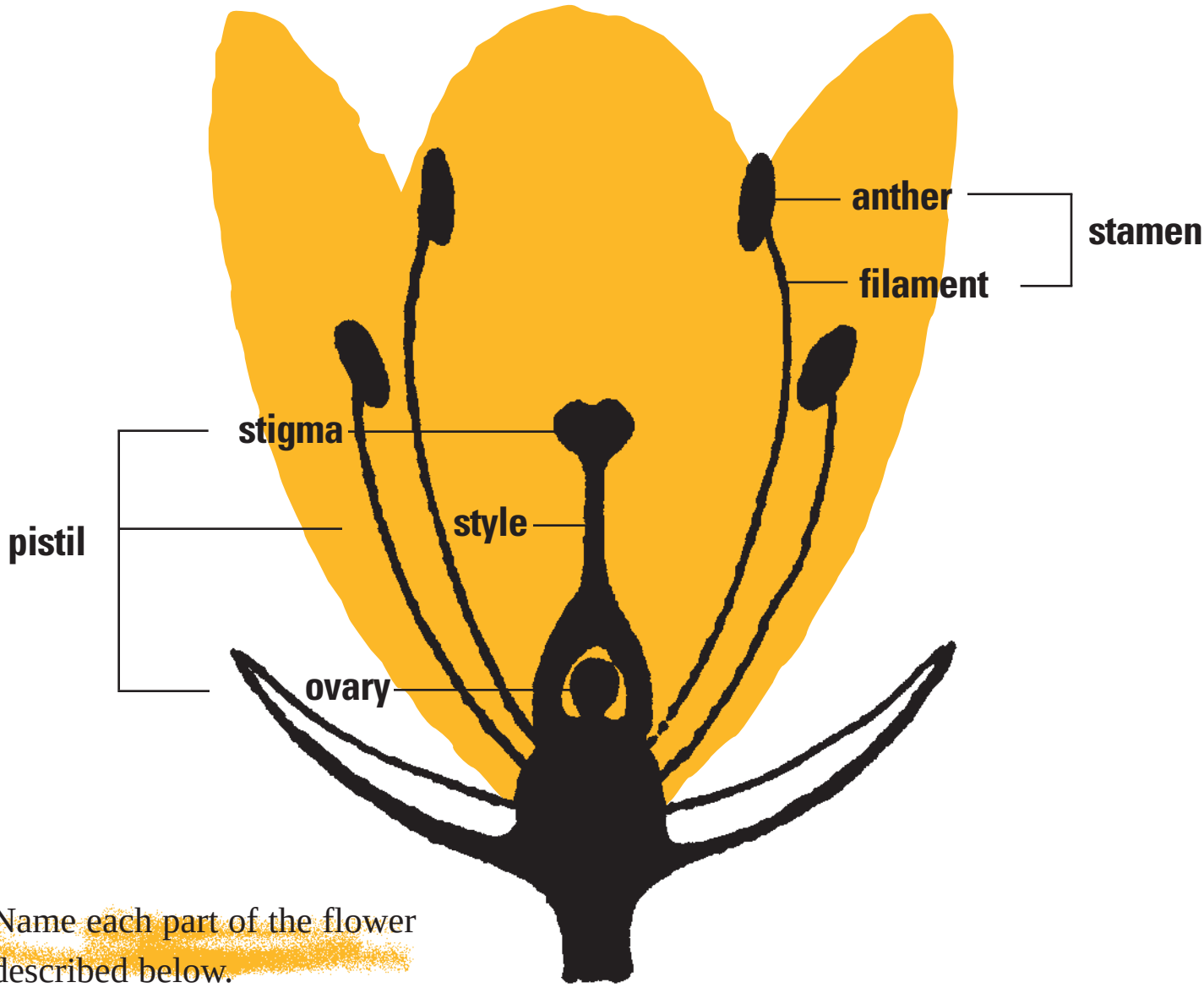
Materials
- Copies of Activity Pages 1A and B.
- A small dish or container filled with talcum powder. You can also use corn starch, flour, or different colors of chalk dust.
- Cotton swabs

Subjects
- Science, language arts



Procedure
1. Give each student a photocopy of Activity Page 1A. Have them study the line drawing of the flower. Ask them to identify and write down each plant part described below.
   - Female and sticky or feathery to trap pollen (the stigma)
   - Female and holds up the stigma (the style)
   - Female and contains the egg-producing ovary (the pistil)
   - Male and produces pollen grains (the anther)
2. Give each student a photocopy of Activity Page 1B. Have them study the line drawing of the bee. Ask them to identify and write down the bee structure or structures that do the following:
   - collect nectar (proboscis)
   - may carry pollen (bristles, legs and baskets, head)
3. Divide the students into two groups: the pollinators (bees) and the plants. Give each member of the plant group a cotton swab and a small amount of "pollen" (talcum or other type of powder) in a container or dish. Instruct each member of the pollinator group to visit a member of the plant group and dip a finger into the pollen. At this point, ask the class to name the part of the plant that the pollinators touched (the stamen, which consists of the anther and the filament) to get the pollen on their fingers. Have them determine whether it is a male or female part. Ask the students what parts of the pollinators' "bodies" (represented by their finger) touched the stamen that could carry the pollen to the next plant. Ask what they were looking for when they got to the plant (nectar) and what appendage they used to get it (proboscis bristles).
4. Have each member of the plant group hold aloft a cotton swab. Explain that the pollinators have just visited one plant and will now move on to another plant of the same species. Instruct the pollinators to visit a different member of the plant group and rub some of the pollen they are carrying onto that plant's swab. Ask the students what part of the flower the swab represents (stigma) and whether it is a male or female part (female).
5. Have each group meet separately to discuss its specific role as a pollination partner and how it benefitted from the pollination process. Have each group select a spokesperson who will take notes and report the findings to the class.

ACTIVITY PAGE 1A
Flower Anatomy



Name each part of the flower described below.

1. Female and sticky or feathery to trap pollen:

_____

2. Female and holds up the stigma:

_____

3. Female and contains the egg-producing ovary:

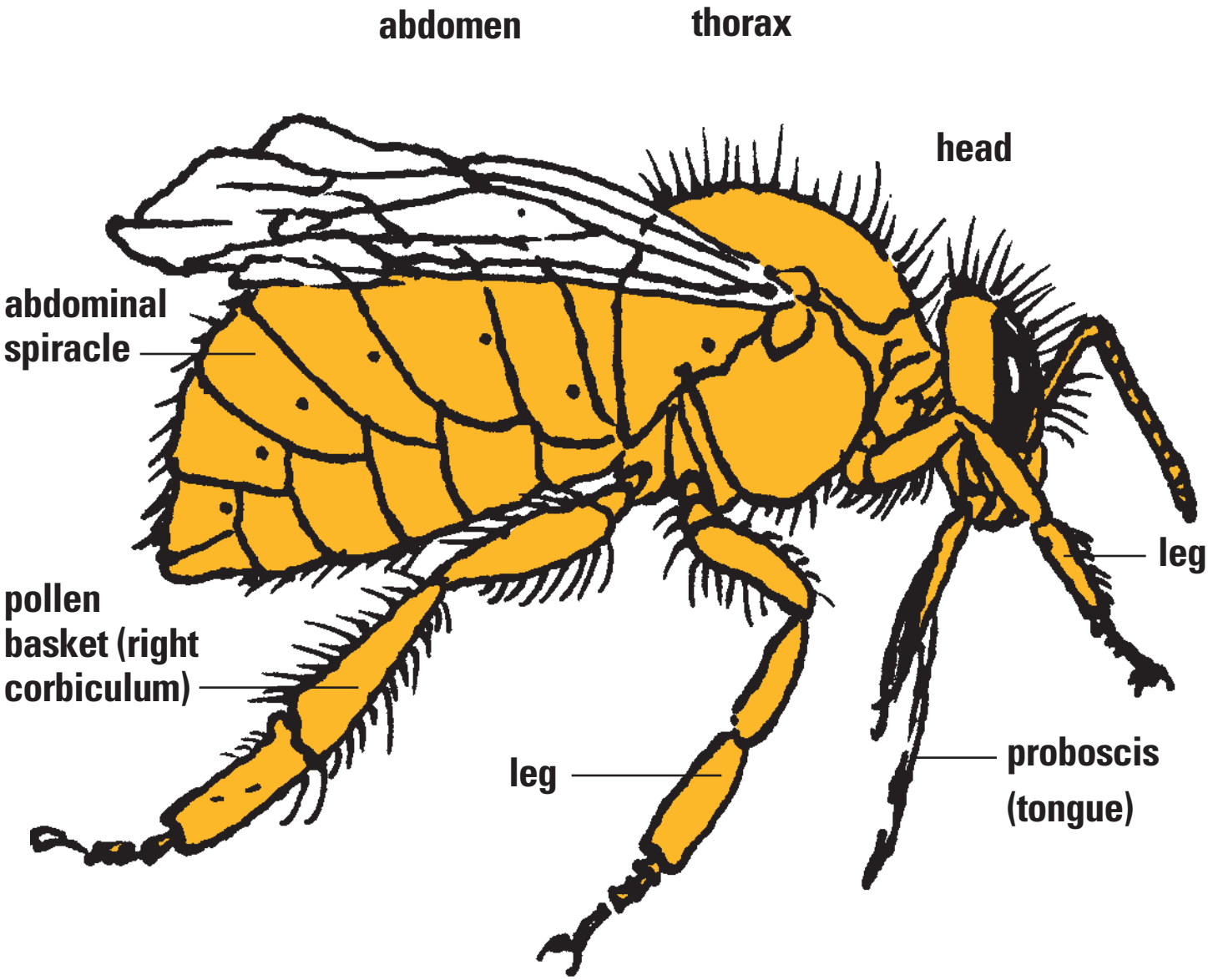
_____

4. Male and produces pollen:

_____

ACTIVITY PAGE 1B

Bee Anatomy



Name the part or parts of the bee that do the following:

1. Collect nectar: _____

2. Carry pollen: _____

LESSON PLAN Step 2

Understanding How Pollination Affects the World's Food Supply

Objectives

■ Interpret the links between pollination and food production.

Materials

■ Copies of Activity Page 2.
■ Pens or pencils.

Subject

■ Science

Procedure

1. Explain to your class that most of the foods we eat (one out of every three bites) are the result of a pollination partnership. Add that different species of bees pollinate many of the plants that make up our food supply. Ask your students whether they like bees. Naysayers will undoubtedly mention that bees sting or that they are allergic to bees. Tell your students that they are going to explore a world without bees and, in particular, what the food supply would be like if bees no longer existed.

2. Direct your students to Activity Page 2. Ask students to imagine a world without bee-pollinated plants: the "Bee-Free Zone." Explain that they are going to attend a barbecue in the Bee-Free Zone and that hamburgers are on the menu. Have the students read the list of bee-pollinated plants that appears at the top of the page.

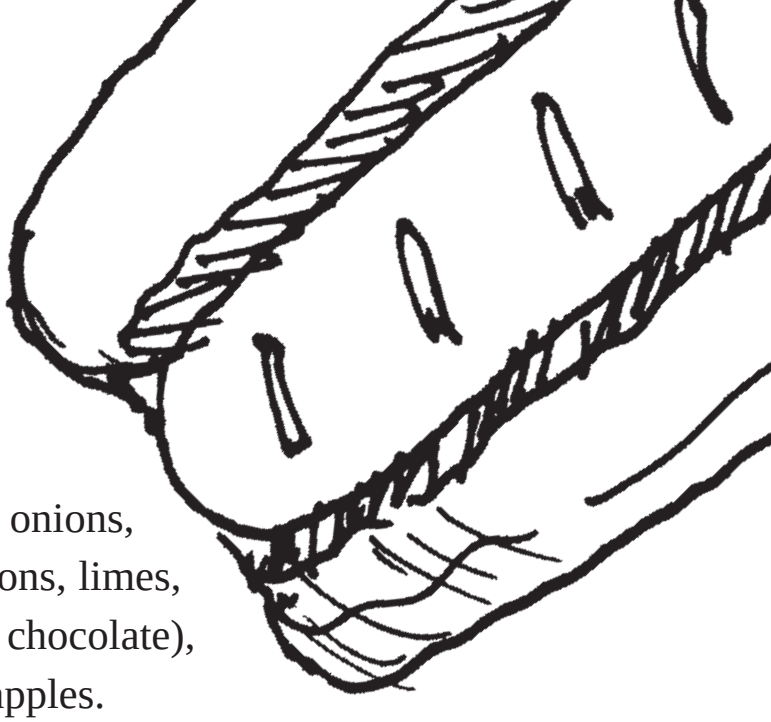
3. Tell your students that they have chosen a hamburger or hot dog from the grill. Explain that they can now choose what they will have with their hamburger or hot dog. Remind them that this is the bee-free barbecue and that the foods listed under "Plants Pollinated by Bees" won't be available. These include tomatoes, onions, cucumbers, lettuce, potatoes, oranges, lemons, limes, mustard seed, cacao bean used in making chocolate, vanilla, sugar, almonds, watermelon, and apples.

4. Have your students select the items on the checklist that they could not have at the bee-free barbecue. After they've eliminated the bee-pollinated items from the list, have them describe the meal that would remain.

5. Conclude the lesson by asking your class to decide whether the availability of bee-pollinated food items is worth the risk of getting stung by a bee in their lifetimes.

ACTIVITY PAGE 2

Bee-Free Barbecue



Some of the more common products from animal-pollinated plants include tomatoes, onions, cucumbers, lettuce, potatoes, oranges, lemons, limes, mustard seed, cacao bean (used in making chocolate), vanilla, sugar, almonds, watermelon, and apples.

Welcome to the Bee-Free Barbecue!

If all the animal pollinators were to become extinct, which of the foods listed below could you not have with your hamburger or hot dog?

- ☐ mustard
- ☐ lemonade
- ☐ ketchup
- ☐ potato chips
- ☐ pickles
- ☐ strawberry milkshake
- ☐ cheese
- ☐ mayonnaise
- ☐ french fries
- ☐ onions
- ☐ hot fudge sundae
- ☐ tomatoes
- ☐ apple pie
- ☐ watermelon

Describe the rather dull meal you would have left.

LESSON PLAN Step 3
How a Plant Attracts the Right Pollinator

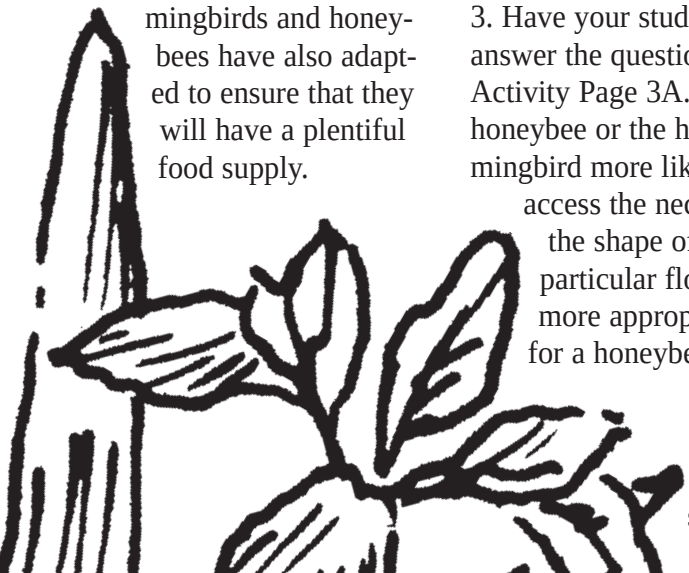
Objectives
■ Describe the complementary relationships between pollinators and the plants they pollinate.
■ Identify adaptations that flowers have developed to "encourage" pollination.

Materials
■ Copies of Activity Pages 3A and B and the Take-Home Page.
■ Pens, pencils, crayons.

Subjects
■ Science, language arts, art

Procedure
1. Begin the lesson by explaining that over time flowers have developed adaptations to ensure that the best pollinator (one that will carry pollen onto another flower of the same species) will return again and again.

Pollinators such as hummingbirds and honeybees have also adapted to ensure that they will have a plentiful food supply.



2. Give each student a copy of Activity Page 3A. Explain that you're trying to determine which animal would make the best pollinator for the trumpet flower. Have your students study the pictures while you provide the following background:

• The trumpet flower is red in color, has an upside-down "tube" shape, has no "landing" spot, and has little fragrance.

• Hummingbirds have a poorly developed sense of smell; are attracted to the colors red, pink, orange, and yellow; "hover" at, rather than land on, their flowers; and have a long bill and tongue.

• Honeybees have a short proboscis, cannot see red, must land and crawl, and are attracted to sweet fragrances.

3. Have your students answer the questions on Activity Page 3A. (Is the honeybee or the hummingbird more likely to access the nectar? Is the shape of this particular flower more appropriate for a honeybee or a hummingbird? Which pollinator would be more attracted to the flower's color? Would a honeybee be lured by the trumpet flower's scent? Is there a place for a honeybee to land? Which animal would make the best pollinator for the trumpet flower?)

4. Give each student a copy of Activity Page 3B. Remind them that flowers are designed to attract pollinators with specific tastes and attributes. Have your students answer the following questions on Activity Page 3B:

What is your favorite color?

What is your favorite shape?

What smells good to you?

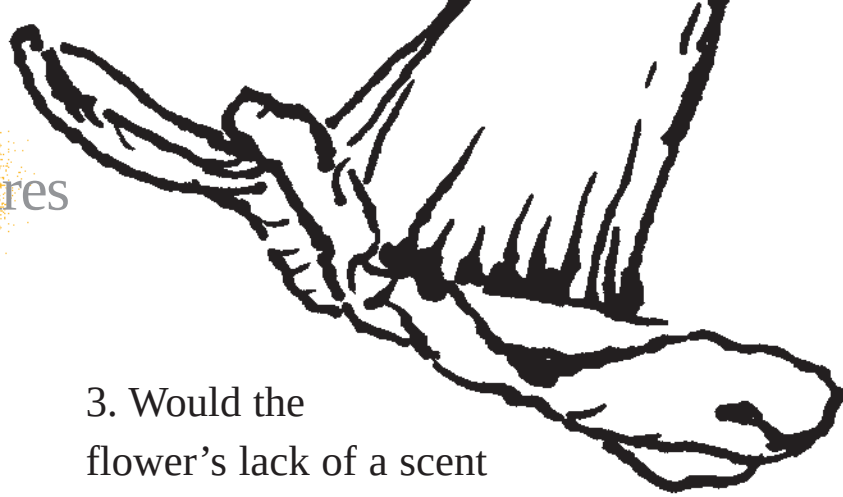
What is your favorite snack?

5. Have your students pair off. Instruct them to state their preferences, which they've listed on Activity Page 3B. Then have each of them draw simultaneously their partner's "designer flower." For fun, have them make it as unreal as possible. For example, one might design a flower that is black, triangular in shape, smells like fresh-baked brownies, and provides pizza as a reward. Have each pair present their "designer flowers" to the class. As an extension, have the artist be the flower, designing "adaptations" suited to his or her partner's preferences.

6. Direct your students to the Take-Home Page. Tell them to think up and draw a fictional pollinator-plant pair. (*For example, a flower that smells like Swiss cheese would likely attract a rodent pollinator*.) Remind students that the goal is to get the animal to pick up the pollen and carry it to another plant of the same species. Have them list the attributes of the plant that attract the pollinator and the mechanism or mechanisms by which the pollinator carries the pollen to the next plant.

ACTIVITY PAGE 3A

Looking at Adaptive Structures



1. In the trumpet flower, the nectar is located at the bottom of the long, curved blossom. Which animal(s) are more likely to get nectar from the trumpet flower? Why?

2. Would the flower's color attract the honeybee? Why or why not?

3. Would the flower's lack of a scent turn away a hummingbird? Why or why not?

4. Does the trumpet flower have a place where a pollinator can land and crawl around?

5. Based on your observations, which animal do you think would make the best pollinator for the trumpet flower?

ACTIVITY PAGE 3B

Design Your Own Flower

1. Fill out your preferences below and give them to your partner.

What is your favorite color? ______

What is your favorite shape? ______

What smells good to you? ______

What is your favorite snack? ______

My "Designer" Flower

2. Now imagine that you are a flower adapting to your partner's preferences. In the box above, create a "designer" flower to suit your partner's preferences. In the lines below, describe why the flower you designed would appeal to your partner.

______

______

______

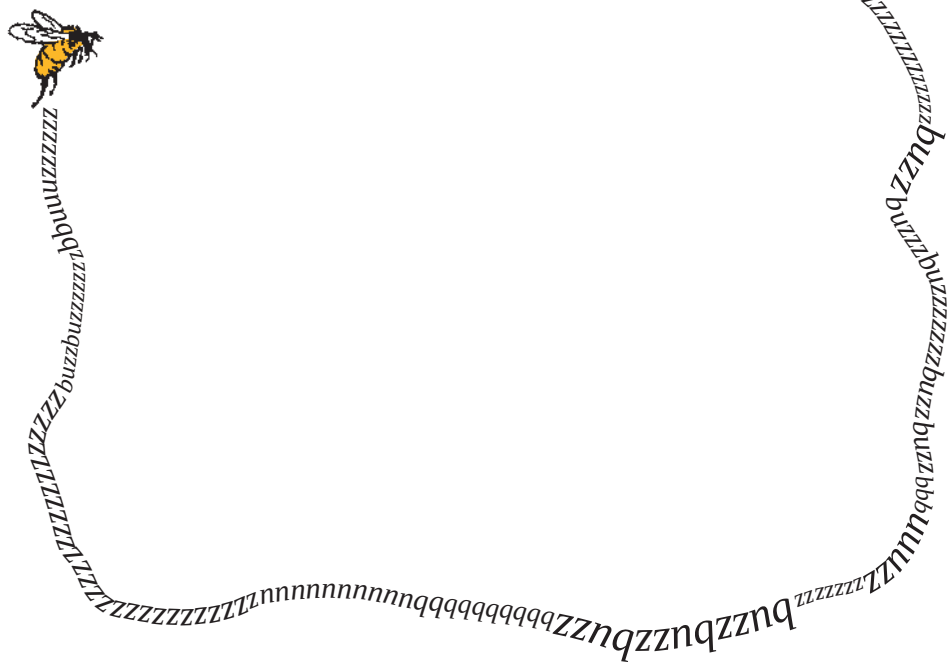
______

TAKE-HOME PAGE
TRABAJO PARA HACER EN LA CASA

Pollinator
Polinizador

Draw a real or made-up "pollinator" in the box above. Label your pollinator's pollen-carrying structures.

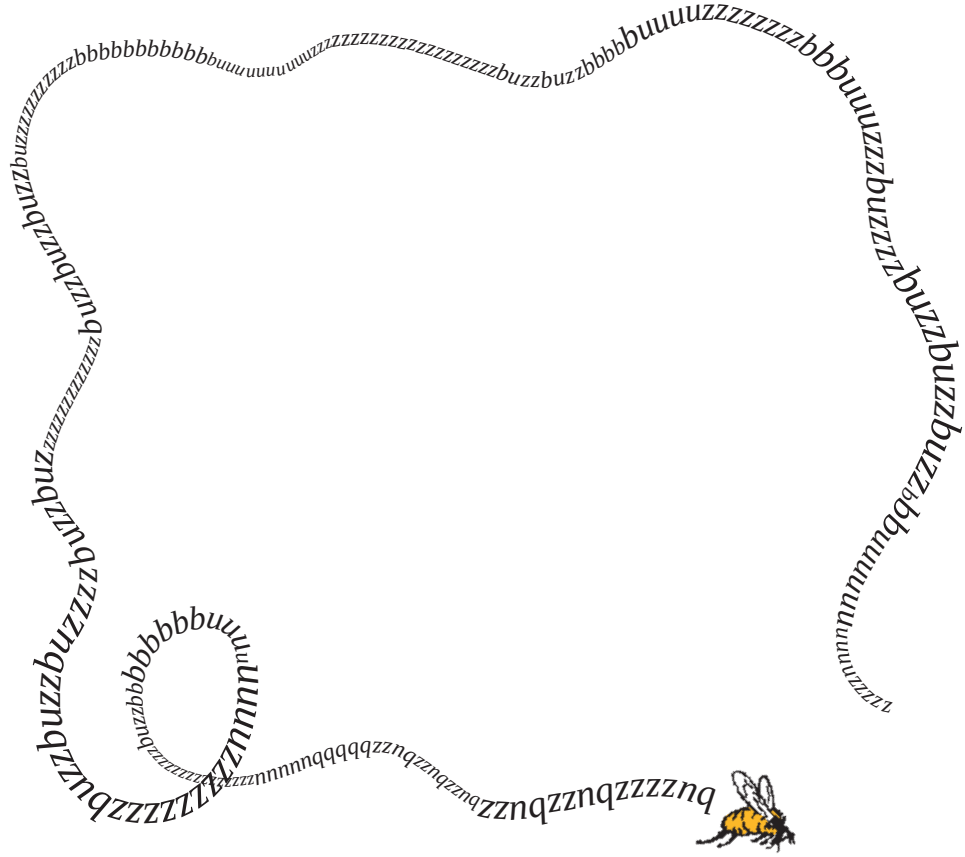
Dibuja un polinizador real o imaginario. Nombra las partes del cuerpo que tu polizador usa para dispersar el polen.



Flower
Flor

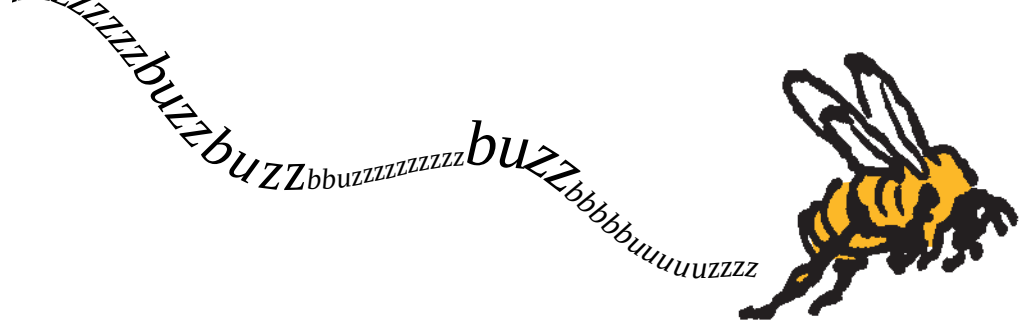
Now try to draw a real or made-up flower that would attract your "pollinator." Label the features of your flower that attracted your pollinator. Label the features of your flower that transferred its pollen grains to your pollinator's body.

Dibuja una flor real o imaginaria que atraería a tu "polinizador." Nombra las características de tu flor que atrayeron a tu polinizador. También nombra las partes de tu flor que transfirieron los granos de polen a tu polinizador.



Publication of *Smithsonian in Your Classroom* is made possible through the generous support of the Pacific Life Foundation.
Esta publicación ha sido posible gracias al generoso aporte de la Pacific Life Foundation.

RESOURCES



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ELECTRONIC RESOURCES

Many government and educational organizations sponsor sites on the World Wide Web pertaining to pollination. All of the sites listed below describe the process of pollination and provide information on plant-animal interactions as well as adaptations.

The U.S. Department of Agriculture's Global Entomology Agriculture Research Server (GEARS) is an award-winning site dedicated to promoting the latest entomological research findings. The site's Internet Classroom section at **http://gears/tucson.ars.ag.gov** provides a number of excellent links to information on pollination and related topics.

What Is Pollination? A Sticky Question, a pollination unit developed by the Missouri Botanical Garden, offers online lesson plans, definitions, activities, and "virtual biomes" for use in the classroom. You can access this site through MBGnet (**http://www.mobot.org/MBGnet**), which is produced and maintained by the Evergreen Project, Inc.

A Passion for Butterflies **http://www.si.edu/organiza/museums/zoo/zooview/animals/butterfl.htm**

Pollination and Benefits of Insects **http://www.ento.vt.edu/Courses/Undergraduate/IHS/ENT2004/Pollen.htm**

Pollination: The Art and Science of Floral Sexuality**http://www.fonz.org/pollinat.htm**

The Structure of a Flower and Pollination **http://www.biohaven.com/biology/flower.htm**

Pollination Adaptations **http://koning.ecsu.ctstateu.edu/Plants_Human/pollenadapt.html**

ACKNOWLEDGMENTS

Judy Manning
Friends of the National Zoo

Tamsen M. Gray
Department of Invertebrates
National Zoo

SMITHSONIAN IN YOUR CLASSROOM

Smithsonian in Your Classroom is a publication of the Smithsonian Office of Education, Smithsonian Institution, Washington, DC 20560.

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