THE BLOSSOMS, THE BIRDS AND THE BEES

A POLLINATION INVESTIGATION FOR PRE-K - GRADE 2

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LESSON OVERVIEW:

LESSON GOAL: to explore the biological process of pollen transfer and one kind of relationship between different species.

AUDIENCE: Pre-K – Grade 2

BIG IDEA: plants and pollinators depend on each other and the traits of each partner shapes the relationship.

KEY CONCEPTS:

- Animals have many different kinds of bodies.
- Animals use their bodies to find the food they need to survive.
- Animals and plants depend on each other.

LEARNING OBJECTIVES:

- Students will be able to describe "pollination" in simple terms.
- Students will be able to identify several common pollinator species.
- Students will be able to name different floral traits, including shape and color.
- Students will be able to describe how plants & pollinators depend on each other.

VOCABULARY:

Pollination, pollinate, pollen, petal, seed, plant, insect, mammal

DESCRIPTION:

This playful lesson plan includes three hands-on activities designed to grow young learners' understanding of the relationships between plants and pollinators, and spark their interest in these important living things. Students will play a matching game to discover why hummingbirds, bees, and butterflies choose the flowers they do, "fly" pollinators around the classroom in search of nectar, and use their senses to explore diversity in nature. This lesson plan is made to be adapted, and includes suggestions for extensions and additions to fit the needs of every classroom.

ALIGNED ACADEMIC STANDARDS:

SC09-GR.P-S.1-GLE1	SC09-GR.P-S.2-GLE2	SC09-GR.1-S.2-GLE2
SC09.GR.P-S.1-GLE2	SC09-GR.K-S.1-GLE2	SC09-GR.2-S.2-GLE1
SC09-GR.P-S.2-GLE1	SC09.GR.K-S.2-GLE1	SC09-GR.2-S.2-GLE2

INSTRUCTIONAL CONTEXT

The Blossoms, the Birds and the Bees was originally developed to fulfill the requirements for the Miami University and *Project Dragonfly* graduate course *Issues in Evolution,* and was modified for enactment during a Free Day event the Denver Museum of Nature & Science. The activities included in the below lesson plan incorporate learnings from its implementation.

MATERIALS

This lesson plan is divided into three activity centers: *Naturalist's Nook, Stop and Smell the Flowers,* and *Pollination Imagination*. Each center should be set up either on a tabletop or a suitable floor space, with enough room for students and facilitators to move around the center. Materials may be arranged as facilitators see fit, and facilitators should provide enough of each material for the number of students in each rotation unless otherwise specified.

SUGGESTED MATERIALS LIST

NATURALIST'S NOOK

- Printed photographs of plant and pollinator species (*Appendix 1)*
    - Bee species, including honeybee and others
    - Butterfly species
    - Moth species
    - Hummingbird species
    - Bat species
    - Common primrose (*Primula vulgaris*)
    - Milkweed (*Asclepsias spp.*)
    - Trumpet vine (*Campsis radicans*)
    - Cactus flower (various species)
- Magnifying lenses
- Writing utensils and paper
- **If available:** several fresh flowers of various shapes and sizes
- **If available:** pressed flowers and mounted specimens of pollinator species
- **Optional:** writing utensils and paper
- **Optional:** iPad(s), laptop(s) or other Internet-accessible device(s), showing videos of pollinator species visiting plants. Some suggested media:
    - Schwartzberg, L. [Louie Schwartzburg]. (2011, Dec 23). *The Beauty of Pollination - Moving Art* [Video File]. Retrieved August 2018 from https://youtu.be/MQiszdkOwuU.
    - [Waldo haedo]. (2014, Mar 7) *Flowers and Pollination* [Video File]. Retrieved August 2018 from https://youtu.be/jWC2NfXpbTQ.

STOP AND SMELL THE FLOWERS

- Extracts or essential oils in 2-5 different floral scents
- 2 cotton balls per scent
- 2 containers per scent: small tupperware containers, (cleaned) pill bottles, jars, or bags make suitable containers

POLLINATION IMAGINATION

- Cutouts of a honeybee, butterfly, hummingbird and bat (*Appendix 3*)
- Photos of various plants (*Appendix 1*)
- Fabric flowers of various shapes
    - Bowl-shaped flowers (cactus flowers, wild roses, poppies, and similar)
    - Shallow flowers (sunflowers, daisies, zinnias and similar)
    - Funnel-shaped flowers (lilies, morning glories, petunias, and similar)
    - Tubular flowers (penstemon, columbine, bee balm and similar)
- **Optional:** one popsicle stick (or similar) per cutout
- **Optional:** hot glue guns and sticks

SETUP

NATURALIST'S NOOK

- Print the photographs included in *Appendix 1*. Laminate printed materials if you choose.
- If using fresh flowers, cut all blossoms from their stems, leaving a stem of an inch or less. Prepare the flowers for student examination:
    - Keep some flowers intact for students to observe whole.
    - Remove all petals from some flowers. Keep both the detached petals and the interior of the flower for students to observe.
    - Remove some, but not all petals from some flowers to expose the stigma, style, ovary, and anthers in a "cross section". *Appendix 2* depicts the arrangement of these organs in a simple flower.
    - Use a scalpel or knife to cut through the middle of the flower, cutting through the ovary and the stigma.

STOP AND SMELL THE FLOWERS

- Place several drops of each chosen essential oil or extract onto cotton balls, ensuring the scent is easily detectable. Use 2 cotton balls per scent.
- Seal one cotton ball in each container, making two containers per scent.
- Arrange containers on the table in two groups, with one container per scent in each group.

POLLINATION IMAGINATION

- Print and cut out the pollinator species in *Appendix 3*. Lamination will make these materials sturdier, and is suggested for the set of cutouts used at this center.
- Make enough copies of *Appendix 3* that every student in each rotation will be able to have one pollinator at all times.
- Print copies of the photos of flowers included in *Appendix 1*.
- Place silk flowers around the classroom or space, a short distance away from the table and in places accessible to students.
- **Optional:** use hot glue to attach wooden popsicle sticks to the tails and abdomens of the cutout pollinator species.

LESSON PLAN

SUGGESTED INTRODUCTION:

Begin the lesson by showing students photographs and/or specimens from the *Naturalist's Nook* center. Ask: *do you recognize these animals? What kind of animals do you see?* Encourage students to name each species aloud. Ask: *where have you seen these animals before? What were they doing?* Student responses will vary.

Explain: *we call these animals "pollinators".* Encourage students to repeat the word several times, breaking it down into syllables if needed (pol-lin-ate-ors!) or using a variety of voices to encourage repetition. *Pollinators are animals that move pollen from flower to flower. When flowers receive pollen, they can make seeds.*

So we know that these pollinators help plants make seeds, but how do you think plants help pollinators? Guide students to recognize to the existence of nectar inside flowers. *Pollinators drink nectar, and get a tasty meal whenever they visit flowers. So plants and pollinators help each other: pollinators move pollen, and plants give pollinators a meal.* Encourage students to remember this relationship by repeating a few actions: have them pretend to give pollen to a neighbor and receive pollen from another. Say "thanks for the pollen!" Next, have students rub their stomachs and say "yum, yum, nectar!"

Describe the purpose of the lesson and the centers. *Today, we will be learning about how plants and pollinators help each other. At each center, you will learn about this relationship in a different way.* Reference the following at each center, varying the language in accordance with your materials:

> *Naturalist's Nook: at this center, you can use your senses and use tools to observe different plants and pollinators. You can draw a picture of the species you see, examine real flowers, and watch a few videos to see pollinators in action.*
>
> *Stop and Smell the Flowers: at this table, you can use your sense of smell to find matching flowers' scents, just like pollinators do.* Demonstrate the process of opening a container, smelling the scent inside, and smelling others to find a match.
>
> *Pollination Imagination: here, you will do as pollinators do and travel around the room in search of the right flower.* Show students the pollinator cutouts: *each person will get one pollinator at a time. Before you go on your search, you will need to guess out which flower shapes your pollinator's body matches. Once you have decided, you may "fly" your pollinator around the room to find a flower to visit.*

STATION FACILITATION:

Divide the class into three groups of roughly equal size, and explain or remind students of your classroom's procedure for rotating through centers. Depending on your typical classroom practice, you may choose to have students rotate through centers at specific time intervals, or free rotate through the centers as they choose. Establish expectations for rotations and for behavior, and devise a strategy for getting students' attention.

Depending on the age and number of students present, a varying number of facilitators (paraprofessionals, classroom volunteers, et cetera) may be required to guide students through the activities. Facilitators should add their own observations to scaffold students' thinking and connections, and ask questions to spark discussion and curiosity. Each center will require that facilitators follow a few steps to guide students through the activities.

NATURALIST'S NOOK

- Demonstrate the proper technique for handling specimens and fresh flowers: handling specimens with two hands and touching the specimen itself (if possible) using one or two fingers, moving fingers in the direction of fur or feathers, et cetera. Handle fresh flowers with one or two cupped hands, gently turning the flowers to see different sides or structures.
- Make students aware of their options for exploration of the station materials. Point out specimens, flowers, videos, photographs, models, paper, et cetera and make clear that students may observe with their hands, eyes and noses.
- If necessary, start students exploring by posing a beginning question: *can you find a pollinator that you have seen before?*
- As students explore, ask them to share their observations and ask guiding questions. You may consider asking:
    - *What do you notice about these pollinators?*
    - *How can you describe the pollinators' bodies?*
    - *How can you describe the flowers?* (Color, shape, size)
    - *How do these fresh flowers look/feel/smell?*
    - *Can you find the pollen?*

STOP AND SMELL THE FLOWERS

- Before distributing materials, ask the students in the group about smell. *What are some smells that you like? What do you do when you smell that smell? Students may provide examples of food smells they like.*
- *Connect these smells to an action. For example: I love the smell of chocolate chip cookies baking in the oven. When I smell that smell, I know to go into the kitchen and wait for the cookies to be ready*!

- Help students select a scent container, helping students share if there are more students than scents.
- Demonstrate opening the container and smelling the scent: encourage students not to remove the cotton balls if it is safe for them to put the containers to their noses.
- Ask students to describe what they smell. You may consider asking:
    - *Does this smell remind you of anything you have smelled before?*
    - *Does this scent remind you of something you eat?*
    - *Can you describe this smell?*
- Help students open containers to try and find the scent matching the one they selected. Ask them the same questions as above, and ask them how they know that the pair they have identified is a true match.
- Students may repeat this process as many times as they choose.

POLLINATION IMAGINATION

- Distribute the pollinator cutouts, and ask students to predict what kind of flower they will be searching for.
- Send students to search around the space for their chosen flower. They may choose to visit all flowers in the room.
- When students return or when you call them to their center, ask them to point out which flower was the best match for their pollinator. Ask them to describe it: *what color was it? What shape was it? Why do you think it was the best match? Were there other flowers your pollinator could visit? Could any other pollinator visit the same flower?*
- As time allows, give students the opportunity to "fly" additional species.

CONCLUSION

When all students have explored each center, bring the group together as they were for the introduction. Ask students to share about their experience: *which center was your favorite? Can you tell me about something that you learned? Can you tell me about something that was surprising?* Encourage students to reflect on their time at each of the centers: *what did you notice about the fresh flowers? What did you see in the photographs or on the video? How did you use your nose to find matching scents? When you "flew" a pollinator around the room, did you find a flower that it would match? Which one?*

Connect students' experiences to the content of the lesson. If you choose, use materials from stations to ask students to name "matches" aloud: for example, holding up one flower and several cutouts from *Pollination Imagination* station, and asking students to choose which pollinator(s) might visit that plant. Pose the question: *how do plants and pollinators help each other?* Take a few responses, and encourage students to remember that plants provide pollinators with nectar meals, and pollinators carry pollen from blossom to blossom.

EXTENSION ACTIVITIES

Educators may wish to pair this lesson plan with other activities about pollination or further exploration of the relationships between plants and pollinators. Below are extension activities that may be relevant or useful in combination with *the Blossoms, the Birds and the Bees.*

NATURE WALK

The purpose of this activity is to encourage students to make observations of live plants and pollinators in the natural environment and to create or deepen students' emotional connections with familiar plant and pollinator species.

If available in your area and seasonally appropriate, take students outdoors to observe plants and pollinators at work. Encourage students to explore an area individually, in pairs or in small groups and notice the plant and animal life. Ask for their observations on the types of plants and animals present: *do all the plants in this area have flowers? Do flowers only grow on small plants, or can we find them other places? Do we see more than one kind of animal here?* If multiple species of pollinator are present or one pollinator can be observed visiting many different types of flowers, ask students to notice similarities and differences: *what color/shape/size of flowers are the bees visiting? What color/shape/size of flowers are hummingbirds visiting? Do they visit any of the same flowers? How can we describe the many different flowers the bees are visiting?* Students may choose to draw or write about their observations.

Prior to going outdoors, be sure to remind students to be respectful of animal and plant life. Some students may be fearful of bees or of other flying insects: model safe and respectful observation and encourage these students to observe as they feel comfortable.

POLLINATION RELAY

The purpose of this activity is to connect kids to the importance of pollination to flowering plants and the mechanics of pollen transfer through a fun and physical game.

Outdoors or in a suitably large indoor space, divide the group into equally sized teams. Line up half the students in each team behind a starting line or marker, and line up the other half of the team behind another line across the space. The first half of the team represents the "pollinators": give each pollinator a cotton ball, yellow pompom, tennis ball or other object to represent pollen. The second half of the team represents the "plants": this half of the team will pick one spot and stand still, with their hands outstretched to represent a blossom.

This game will run like a relay race: the first pollinator will run to one of the plants on their team, and deposit their pollen in that plant's "blossom". When they receive the pollen, the plant will sit down, becoming a "seed". The pollinator may then "fly" back to their team, tag the next pollinator, who will repeat these steps. The game ends when one team has turned all its blossoms into seeds.

You may extend the game by having team members switch roles as soon as all the plants have become seeds. As soon as all original pollinators on a given team have returned to their starting line, they will freeze and become plants. With the pollen grains they now possess, the former plants can become pollinators. The game will end when all teams have managed to switch roles and turn all plants into seeds a second time.

GARDEN MURAL

The purpose of this activity is to use art to connect students to the diversity of flower species and traits that they might see in gardens, park and yards in their area and to the relationship between floral traits and pollinator preference.

Using whatever supplies you have available and that you choose, have students draw, paint or put together flower species of a variety of colors, shapes and sizes. Cut stems and leaves from green paper or draw these parts using markers, cut flowers out of their paper, and attach the flowers and stems to a large piece of butcher paper or bulletin board in the classroom. You may choose to use books, photographs, Internet media or cuttings of real flowers as reference for students.

If you choose, have students draw or color and cut out pre-drawn pollinators or cut out printed (to scale) images of pollinators. Using students' learnings about which shapes and colors of flower each species prefers, have students add pollinators to the appropriate flowers on the mural.

Modification for the Informal Education Setting

Though the above lesson plan is written specifically for use in a formal classroom or otherwise with a specific, captive audience, the activities included are adaptable to the informal education setting or otherwise non-specific, changing audiences.

Make the Introduction a Conversation

If your audience is likely to be change throughout the day, facilitators likely will not have time to greet each guest or audience member with a formal introduction to the subject of pollination, plants and pollinators. Rather, facilitators should greet guests with a quick hello and an invitation to explore the activities together. Introduction to the subject, including the lines of questioning suggested in *Suggested Introduction* and other basic content should be part of the introduction to the activities at a particular center.

Let Participants' Curiosity Be Your Guide

An open-ended lesson structure allows facilitators and participants a great deal of freedom. A lack of time constraints, structured rotations and other limits present in the classroom give the chance for participants to engage with materials that excite them for long periods of time and follow their curiosity. As participants engage with materials, ask questions and add your own observations to spur conversation, and follow the conversations that naturally evolve to create an experience that is unique to each participant. As these conversations evolve, invite guests to explore new and different centers relevant to their interests or to the conversation.

Shorten and Lengthen as Needed

The amount of time each participant or group spends engaged with each activity and with the lesson as a whole may vary significantly from person to person. As such, facilitators may need to adjust the timeline of the facilitation to accommodate short and long stays alike. Facilitators may not know from the beginning of the conversation what each participant's timeline is, and should be prepared to make each conversation or each center a standalone experience. The addition of some general content to each interaction with a participant and the connection of each interaction to the larger themes of the facilitation (see *Key Concepts* and *Learning Outcomes*) will help ensure that each participant gains new knowledge or experience, regardless of dwell time. Conversely, guests may have additional questions or be excited to delve deeply into one portion of the lesson. Facilitators should be prepared to explore alongside guests as they do so, adding additional observations and points of content or asking additional questions.

INSTRUCTIONAL BACKGROUND

Flowering plants (*angiosperms*) bloom in a brilliant array of colors, shapes, sizes, and scents. Human beings benefit from this diversity as we grow colorful gardens and sow wide varieties of crops, but the reasons for this diversity are not solely due to human activity. Between 67 and 95 percent of flowering plants rely on animal pollination to some degree (Ollerton et al., 2011), and floral traits like color, scent, shape and "nectar guide" patterns on petals serve to attract these *pollinator species* and facilitate the transfer of pollen between blossoms via pollinators' bodies (Shimizu et al. 2014; Johnson & Steiner, 2000; Raguso et al., 2004). From these traits, plants gain help spreading their genetic material over longer distances-- a sure advantage. Pollinator species likewise benefit from animal pollination, gaining a meal of nectar from the flowers they visit (Anderson & Johnson, 2008; Ollerton et al., 2011). The mutual benefit of this relationship--known as a *mutualism* (Anderson & Johnson, 2008)--underlies the diversity of pollination syndromes we can observe in the natural world.

The floral traits attracting the most common pollinators--including bees, butterflies and moths, bats, and hummingbirds (Rader et al., 2016)--may differ widely (Raguso, 2004). Some combinations of floral traits predictably attract certain pollinator species or groups: for example, red or orange flowers with plentiful nectar and a long, narrow shape are typically preferred by hummingbirds and may be visited less frequently by other pollinators (Castellanos et al., 2004). Such associations of floral traits with groups of pollinators are known as *pollination syndromes* (Rosas-Guerrero et al., 2014). *Table 1* details the preferences of several common pollinator species in terms of petal color, scent, shape, nectar availability and other variables. These preferences may be the result of physiology, like the ability of some but not all pollinators to detect nectar guides in ultraviolet light (Chittka & Wells, 2004) or morphology, like the shape of the proboscis (long tongue) of butterflies and moths.

Pollination syndromes exhibit varying degrees of specificity. Many species of plants display traits that are attractive to many species and thus are visited by several pollinators (Rosas-Guerrero, et al. 2014; Johnson & Steiner 2000), and some flowering plants display traits that are compatible with only a very small number of species (Arditti et al., 2012; Wasserthal, 2013). Similarly, some pollinator species visit flowers displaying many different traits, while some visit only a small number of flower types (Rosas-Guerrero et al., 2014; Johnson & Steiner, 2000; Arditti et al., 2012; Wasserthal, 2013). The level of specificity of a pollination syndrome depends largely on the environment of the species involved. High specificity is more frequent in tropical and subtropical regions, perhaps because these regions have a stable climate that is more likely to support stable pollinator populations year round. Because pollinators are likely to be active through much of the year, plants need not rely on multiple species that may be active at different times of the year (Myers, et al. 2000; Rosas-Guerrero, et al. 2014). Therefore, plants in these climates may have more extreme traits that are only

compatible with a small number of pollinators (Arditti et al., 2012; Wasserthal, 2013).

Environmental conditions make specificity more or less advantageous for animal pollinators as well as plants. Pollinators in environments with a large number of species may face tougher competition for a nectar meal from other pollinators, making specialization beneficial: if only one species can access the nectar of a particular plant, that species will thrive with little competition (Castellanos et al., 2004; Wasserthal, 2013). Conversely, harsher environments mean than a single plant species will likely only bloom when conditions are right, not year-round, making the ability to forage nectar from many species beneficial. Because these climates typically have fewer pollinator species, competition is less of a risk (Rosas-Guerrero et al., 2014; Johnson & Steiner, 2000).

Finally, environments in which pollinator populations are extremely unstable or altogether absent favor alternate pollination systems, including wind pollination and self-pollination. Adaptations for these alternate systems are more prevalent in harsh habitats where high exposure to the elements may prevent pollinator populations from becoming established (Eckert & Schaefer, 1998; Culley et al., 2002; Yamasaki & Sakai, 2013). Flowers of some wind or self-pollinated species (like grasses, wheat) are not colorful or fragrant and lack nectar and specialized structures for pollen transfer to animal bodies (Culley, et al. 2002). Self-pollination essentially assures reproduction in the absence of pollinator species, a certain advantage.

The complementary traits of flowering plants and pollinators are an observable example of diversity and biological relationships in the natural world. Continued studies of and fascination with pollination syndromes of the past, present and of the uncertain future are essential to our growing understanding of how to best protect these special. Understanding pollination syndromes can help gardeners make decisions about which plants to grow to provide habitat and resources for these species, is important for farmers growing crops that rely on animal pollination, and is valuable for everyone who benefits from these services.

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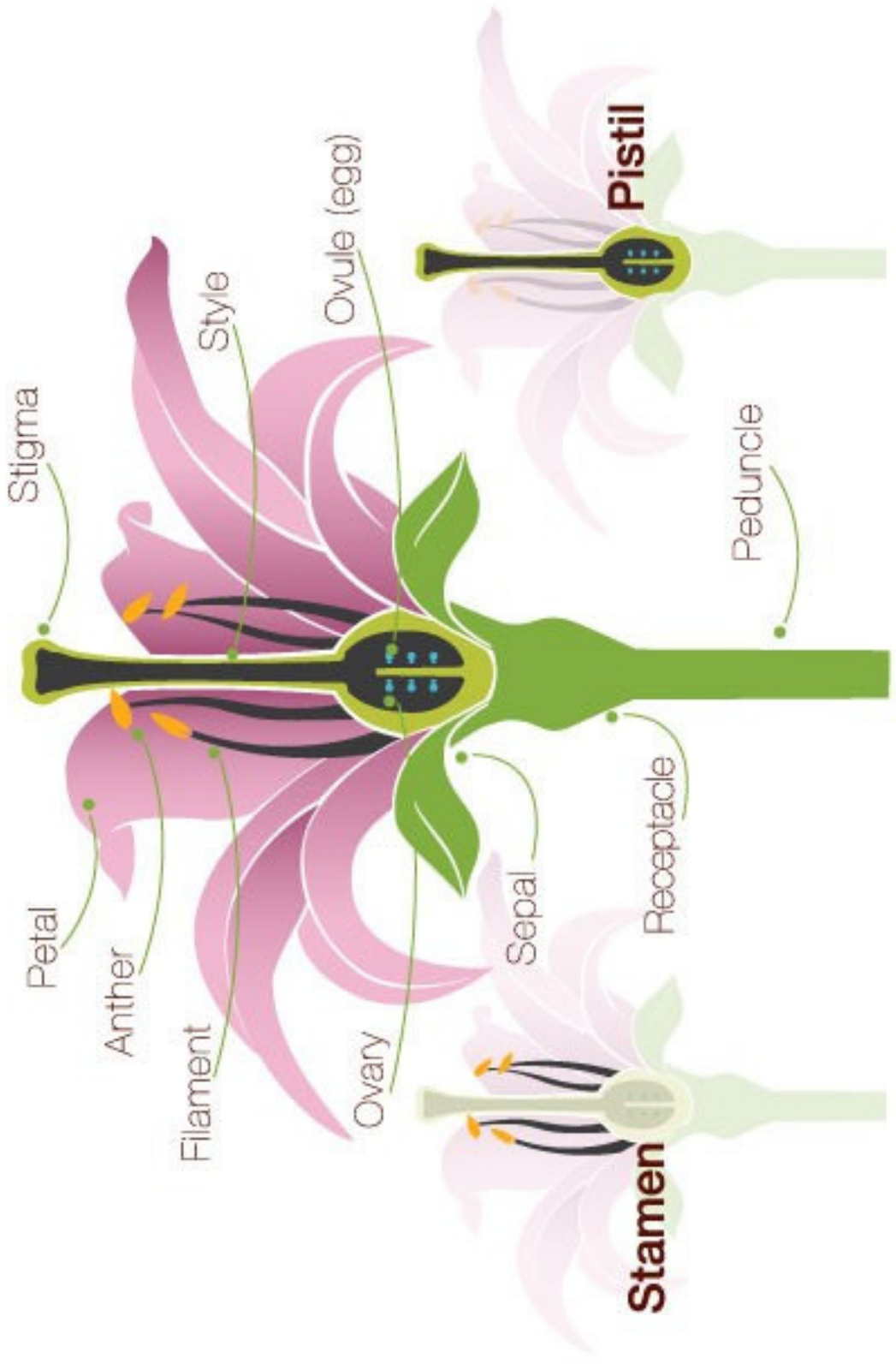
APPENDIX 1

APPENDIX 2: DIAGRAM OF FLORAL ANATOMY (PROFLOWERS, 2014)



APPENDIX 3: POLLINATOR CUTOUTS TEMPLATE

TABLE 1: FLORAL TRAITS AND POLLINATORS IN COMMON POLLINATION SYNDROMES
MODIFIED FROM UNITED STATES FOREST SERVICE (NO DATE).

	POLLINATOR							
TRAIT	BATS	BEES	BEETLES	BIRDS	BUTERFLIES	FLIES	MOTHS	WIND
COLOR	White, green, purple	White, yellow, blue, ultraviolet	White or green	Orange, red, white	Brightly colored, red, purple	Dull colored, dark brown, purple, flecked pattern	Red, purple, pink, white	Dull, brown, colorless, absent or reduced petals
SHAPE	Bowl-shaped, closed in daytime	Shallow or tubular	Large and bowl-shaped	Large and funnel-shaped or cup-shaped	Narrow, deep and tubular	Shallow and funnel-shaped or complex	Regular, tubular	Small, pollen structures extended
ODOR	Strong and musty	Fresh, mild, pleasant	No odor or rotten-smelling	None	Fresh, faint	Putrid, rotten	Strong and sweet	None
NECTAR GUIDES	Absent	Present	Absent	Absent	Present	Absent	Absent	Absent

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