

Angiosperm Reproduction and Coevolution

A. Introduction to Angiosperm Reproduction

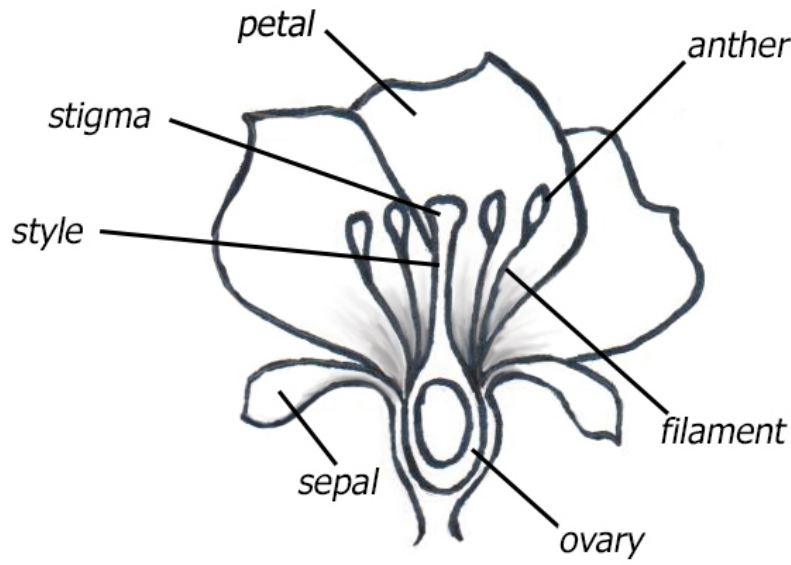
The **angiosperms** are unique compared to the rest of plants because they produce flowers and fruits as part of their sexual reproduction. Since plants are immobile, they are not able to travel in order to seek mates and reproduce. As a result, plants have evolved a number of strategies in order to accomplish these tasks. Flowers and fruits are modified in a variety of ways in order to help with **pollination** and seed dispersal, both by **biotic** and **abiotic** means.

In this lab, you will explore the variety of flower and fruit adaptations that have evolved to accomplish pollination and seed dispersal and you will investigate the **coevolution** of angiosperms and their pollinators. In addition, you will be introduced to another tool that biologists use to study life... Natural History Collections.

B. Flower Structure

A "flower" is a shoot (stem and leaves) modified for reproduction. Flowers can arise singly or in a cluster called an **inflorescence**. A stem-like structure called a **peduncle** supports an inflorescence or a solitary flower. **Pedicels** are the structures that support individual flowers of an inflorescence. The end of the peduncle is often expanded to form a **receptacle** to which the floral parts attach. Flowers can have up to 4 whorls of flower parts. From the outside working in, the parts that make up those whorls include:

- a. **Sepals** - often leaflike and green; protect the flower during the bud stage. Some sepals are modified to look nearly identical to the petals, but they are located to the outside of the actual petals. The collective whorl of sepals is referred to as a **calyx**.
- b. **Petals** - found to the inside of the calyx (if present) and are often pigmented and showy in order to visually attract pollinators. Petals may be separate or fused; together, they are collectively referred to as a **corolla**. If the calyx and corolla are both "petal-like", combined they are called the **perianth**.
- c. **Stamens** - consist of a stalk-like **filament** supporting a pollen-producing **anther**. The collective arrangement of stamens represents the male part of the plant and is referred to as the **androecium** ("house of men").
- d. **Carpels** - female floral parts; lie to the inside of the androecium. A carpel consists of 3 parts: a) **ovary** - the broadened base of the carpel which contains the ovules, b) **style** - an elongated structure extending from the top of the ovary and through which the pollen tubes will grow in order to deliver sperm to the egg, and c) **stigma** - the often sticky terminal end of the style which receives and adheres pollen grains. The carpels are referred to collectively as the **gynoecium** ("house of women").



A flower is considered "**complete**" if all four whorls are present and "**incomplete**" if one or more whorls are absent. "**Perfect**" flowers have both male and female parts present; "**imperfect**" flowers are *either* male or female.

When looking at a whole flower, if the floral parts can be arranged so that any cross section of the flower has a mirror image, it is called **radially symmetric**. If the flower only has only one cross section that produces a mirror image, the flower is described as having **bilateral symmetry**.

Is this statement true or false? "All complete flowers are perfect." Explain your answer.

You and your partner will be assigned a flower to examine and dissect. What is the name of the flowering plant you were assigned?

Examine the flower. Draw and label all flower parts including the 4 floral whorls in the space below.

Is the flower complete or incomplete?

Is the flower perfect or imperfect?

Is the flower radially or bilaterally symmetrical?

C. Pollinators and Pollination Syndromes

In angiosperms, **pollination** refers to the transfer of pollen from an anther to a stigma. Pollination is distinct from **fertilization**, which occurs when male and female gametes fuse to form a zygote. Because plants are immobile, they are unable to seek out and physically interact with a mate to carry out sexual reproduction. As a result, they must rely on other means to bring the male and female gametes together. In some cases, **abiotic** (non-living) agents such as wind and water are responsible for pollen transfer. However, many plants have **biotic** (living) pollinators, such as birds and insects, that move from flower to flower (often gathering food) and transfer pollen that has stuck to their bodies. Flowers have evolved many different ways to attract pollinators and help with pollen transfer. Some cues are visual, like flower color and pattern, flower size, and showy petals and sepals. Some flowers use scents to attract pollinators and foods like nectar and protein-rich pollen to reward them for the visit. Other flowers use pure trickery to attract pollinators under false pretenses.

The group of characters displayed by a plant that is associated with a specific pollinator is called a **Pollination Syndrome**. Often you can guess the pollinator of a plant based on its what the flower looks like.

Each of you has been given either a flowering plant or a pollinator sheet that lists the characteristics of your organism. “Pollinators”, you either need to find food or a place to lay your eggs. “Plants”, you are eager to reproduce and hoping to entice your pollinator. **Your task is to find your match.**

Rules:

1. Plants must stay in your seats and hold your flowers up; pollinators are free to move around.
2. Pollinators can only ask questions “yes or no” questions (e.g. Do you bloom at night?) and plants can only answer questions.
3. There are two of each species, so pollinators, if the correct pollinator has already visited your flower, you’ll need to find another.
4. Once you have made your match, stay with your new partner and fill out the chart below for your team’s row. Two pollinators that were not used are filled in for you as examples.
5. When all teams are matched, each team will report out on their plant/pollinator pair. Fill in the other rows of the table as the other teams report.

Pollinator	Color	Scent	Flowering time	Corolla	Reward	Examples
Beetle	Green or white	Various but often strong	Day and night	Enclosed or open	Nectar and pollen	Magnolia and Spice Bush
Fly (reward)	Light	Faint	Day	Radial symmetry; shallow flower	Nectar and pollen	Wild Radish
Bee						
Butterfly						
Moth						
Fly (carrion)						
Bird						
Bat						
Wind						

Table from Judd et al., 1999. *Plant Systematics: A Phylogenetic Approach*. Sinauer Associates, INC. Sunderland, MA

What types of adaptations do you predict that wind-pollinated flowers would have? Fill in the table above with your predictions.

Return to your original seat and look at your dissected flower again. Fill in the table below with the indicated information about your flower.

Flower Name	Color	Scent	Pollinator Reward	Predicted Pollinator

D. Coevolution Case Study [using Natural History Collection Data]

Any trait that increases the frequency of pollen transfer should increase a plant's fitness and will be favored by natural selection. Likewise, any trait that the pollinator possesses that increases its ability feed on the nectar and/or pollen can increase the pollinator's fitness. The plant and its pollinator, then, act as selection pressures on each other. This reciprocal selection is called **coevolution**. In fact, the great diversity in angiosperms is thought to be largely a result of this coevolution with biotic pollinators, such as animals, and insects in particular. About 150 million years ago there was a rapid increase in the diversity of flower-visiting insects. This correlates with a rapid increase in angiosperm diversity and is hypothesized to be the primary factor driving angiosperm evolution.

You are going to examine the coevolution of agave and their bat pollinators. You will be using data from digitized natural history collections. These are online databases that provide access to the data from natural history collections such as museums and herbaria (collections of preserved plant specimens). Natural history collections are found all over the world and contain a vast archive of valuable biodiversity information that chronicles changes in the distribution and morphology of species over time. Scientists believe we have up to 6 billion specimens archived in natural history collections. First you will learn a little about these data resources, then you will explore the biology of agave and bat pollinators, and finally, you will complete a series of exercises where you will examine real data and analyze this complex relationship.

Data Source

iDigBio Portal: www.idigbio.org/portal

The iDigBio (Integrated Digitized Biocollections) Portal is a data aggregator for digitized natural history collection data. The name iDigBio stands for Integrated Digitized Biocollections. All data in this portal are linked to a specimen in a natural history collection and can thus be independently verified. New data is being uploaded to the iDigBio Portal every day. Look at the webpage, how many specimens are in the iDigBio portal today?

Agave, Bats and Tequila!

Agave tequilana, is a large plant with a blue green coloration and spikey fleshy leaves arising in a rosette. Agave can take 5 years or more to flower. When *Agave tequilana* flowers, it produces a single flowering stalk that can be up to 15 feet high and has a large inflorescence. Once pollinated, the plant can produce thousands of seeds and then it dies. *Agave tequilana* is a very important cash crop (a clue to what the plant is used for is hidden in the scientific name) It is also an "at risk" species due to both the fragmentation of native habitat and the harvesting of young plants before they mature and set seed. Agaves are **chiropterophilous** or bat-pollinated.

Using what you already know, describe what you would predict to be the characteristics of the *Agave tequilana* flowers?

Multiple bat species pollinate the agave species. This is not surprising as the nectar is particularly rich in both sugar (~20%) and protein (~50%). The bats are not completely dependent on a specific species of plant. The bats that pollinate *Agave tequilana* can also pollinate several other species of *Agave* as well as some cactus species. All of these bat-pollinated species must attract the bats and the bats must all be able to reach the rich nectar the plants provide. Look at the images provided of flowers from these three bat pollinated plants. What characteristics do you think the bats must possess to pollinate these cacti or agave?

The Mexican long-nosed bat (*Leptonycteris nivalis*) and the lesser long-nosed bat (*Leptonycteris curasoae*) are the primary pollinators of *Agave tequilana*. Therefore, *this plant species is dependent on these two species of bats for survival*. Both bat species migrate every spring over 1000 miles moving from Mexico into the southwestern US. In this scenario, how would you predict the distribution of the pollinator species to compare to the distribution of the plant species? Pick from one of the examples below:

- ☐ Distribution of *Agave tequilana* will overlap completely with the bat pollinators
- ☐ Distribution of *Agave tequilana* will be more extensive than the bat pollinators
- ☐ Distribution of the bat pollinators would be more extensive than the *Agave tequilana*.

Explain your choice:

Online Data Activity

1. Go to the iDigBio portal and input these three species. [Your teacher will show you how to search the portal and a set of instructions is also available.] How many records can be found for each species? What do you note about their distribution (Fill in the table)?

Species	Number of records	Distribution
<i>Leptonycteris nivalis</i>		
<i>Leptonycteris curasoae</i>		
<i>Agave tequilana</i> .		

2. What did you observe for distribution of *Agave tequilana* relative to the bat pollinators?

- ☐ Distribution of *Agave tequilana* overlaps completely with the bat pollinators
- ☐ Distribution of *Agave tequilana* is be more extensive than the bat pollinators
- ☐ Distribution of the bat pollinators is more extensive than the *Agave tequilana*.

3. How would you explain the observed distributions?

4. Click on some of the individual records for *Agave tequilana*. Some records include images of the specimens. Look at some of these images. In what months were this species collected in the US? Mexico? In which month are they flowering in the US? Mexico?

5. Humans have a long history of fear associated with bats. Vampire bats have a particularly bad reputation, as they feed on blood from cattle and sheep sleeping at night and can carry disease and promote infection that can spread to other livestock and even humans. Ranchers use a variety of tactics to kill the vampire bats. The killing practices are often targeted at roosts in caves and can wipe out most of the bats in a cave. Go to the iDgBio portal and input the three species of vampire bats listed in the table below. How many records can be found for each group? What do you note about their distribution (Fill in the table)?

Group	Number of records	Distribution
<i>Desmodus rotundus</i>		

Diphylla ecaudata

7. Based on the distribution and preferred roosting sites, does the cave-wide mass extermination of vampire bats appear to pose a risk to Mexican and lesser long-nosed bats? Explain your answer.

Species

E. Conclusion – Minute Paper

1. In one sentence each, summarize three key evolutionary concepts you investigated in today's class.
2. What questions do you still have about angiosperm reproduction?
3. Is there anything you did not understand?

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