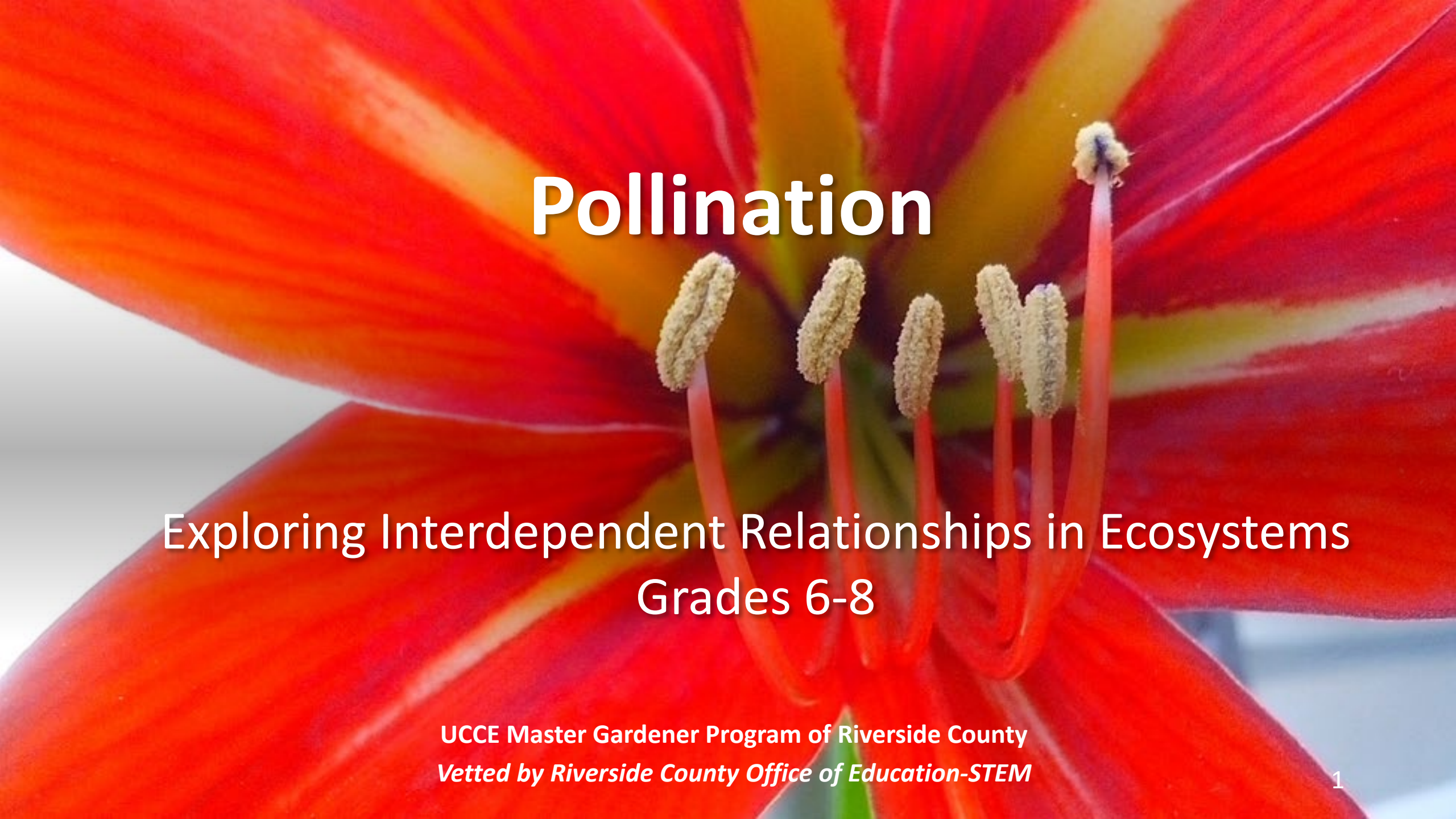


Pollination

Exploring Interdependent Relationships in Ecosystems
Grades 6-8

UCCE Master Gardener Program of Riverside County

Vetted by Riverside County Office of Education-STEM

Master Gardeners

The University of California Cooperative Extension (UCCE) Master Gardener Program (MGP) is an educational program designed to teach and effectively extend information to address home gardening and non-commercial horticulture needs in California.

UCCE is the outreach arm of UC's division of Agriculture and Natural Resources (ANR). Master Gardener volunteers (MG volunteers) promote the application of basic environmentally appropriate horticultural practices through UCCE-organized educational programs that transfer research-based knowledge and information.

University of California
Agriculture and Natural Resources
UCCE Master Gardener Program

Why Is This Important?

- Pollinators are essential to our daily life. They are responsible for bringing us one out of every three bites of food. Pollinators also sustain our ecosystems and produce our natural resources by helping plants reproduce.
- Pollinating animals travel from plant to plant carrying pollen on their bodies in a vital interaction that allows the transfer of genetic material critical to the reproductive system of most flowering plants – the very plants that:

➢ bring us countless fruits, vegetables, and nuts,

➢ produce ½ of the world's oils, fibers and raw materials;

➢ prevent soil erosion,

➢ increase carbon sequestration

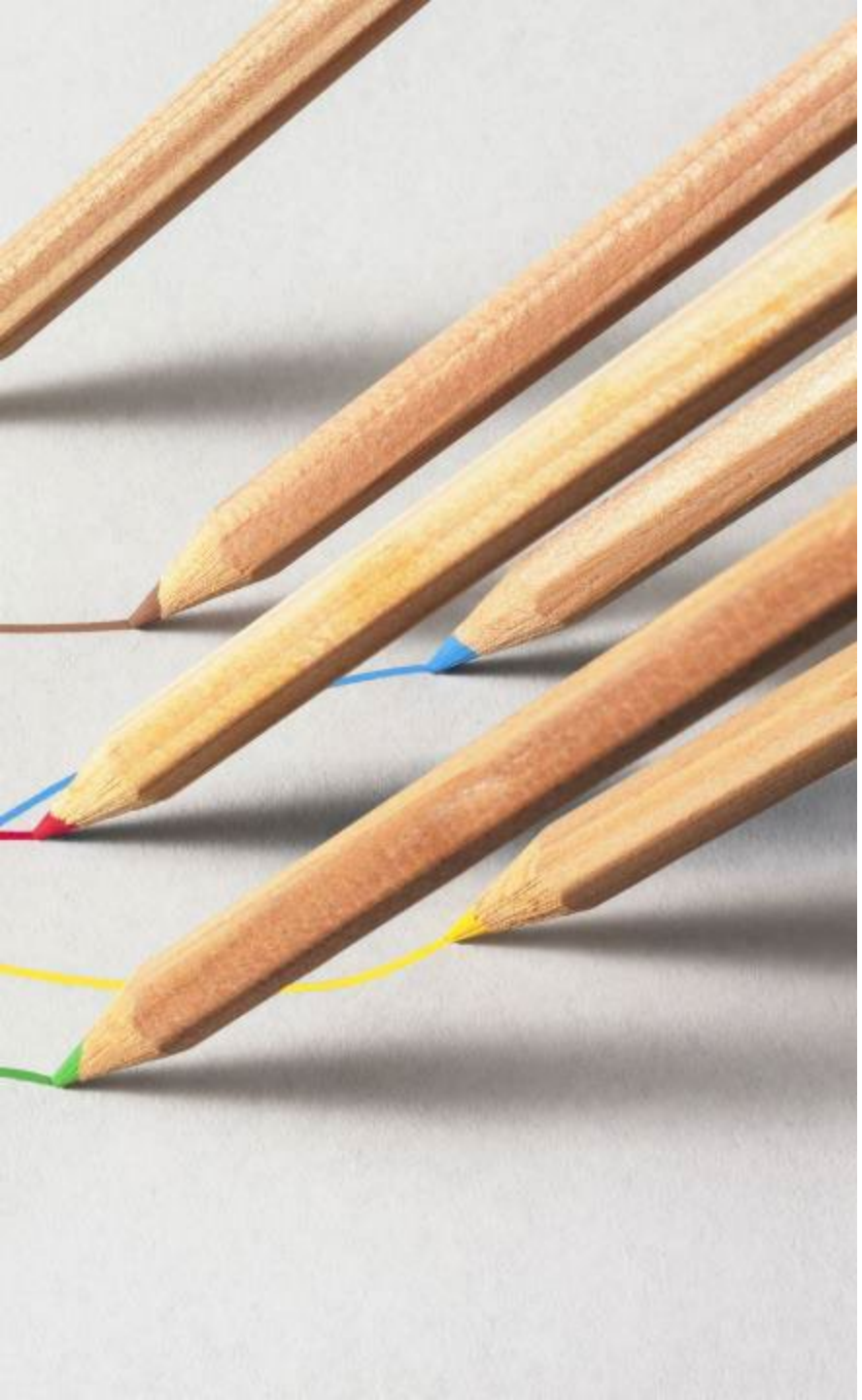
--*Riverside-Corona Conservation District*

Learning Goals

Students will learn:

- the process of plant reproduction and how it affects genetic diversity;
- the evolution of the pollinator-plant relationship;
- explore the factors impacting the pollinator population and possible solutions;
- and construct explanations using scientific information.

Anchor Phenomena: Pollination



Develop a Model To Describe the Phenomena

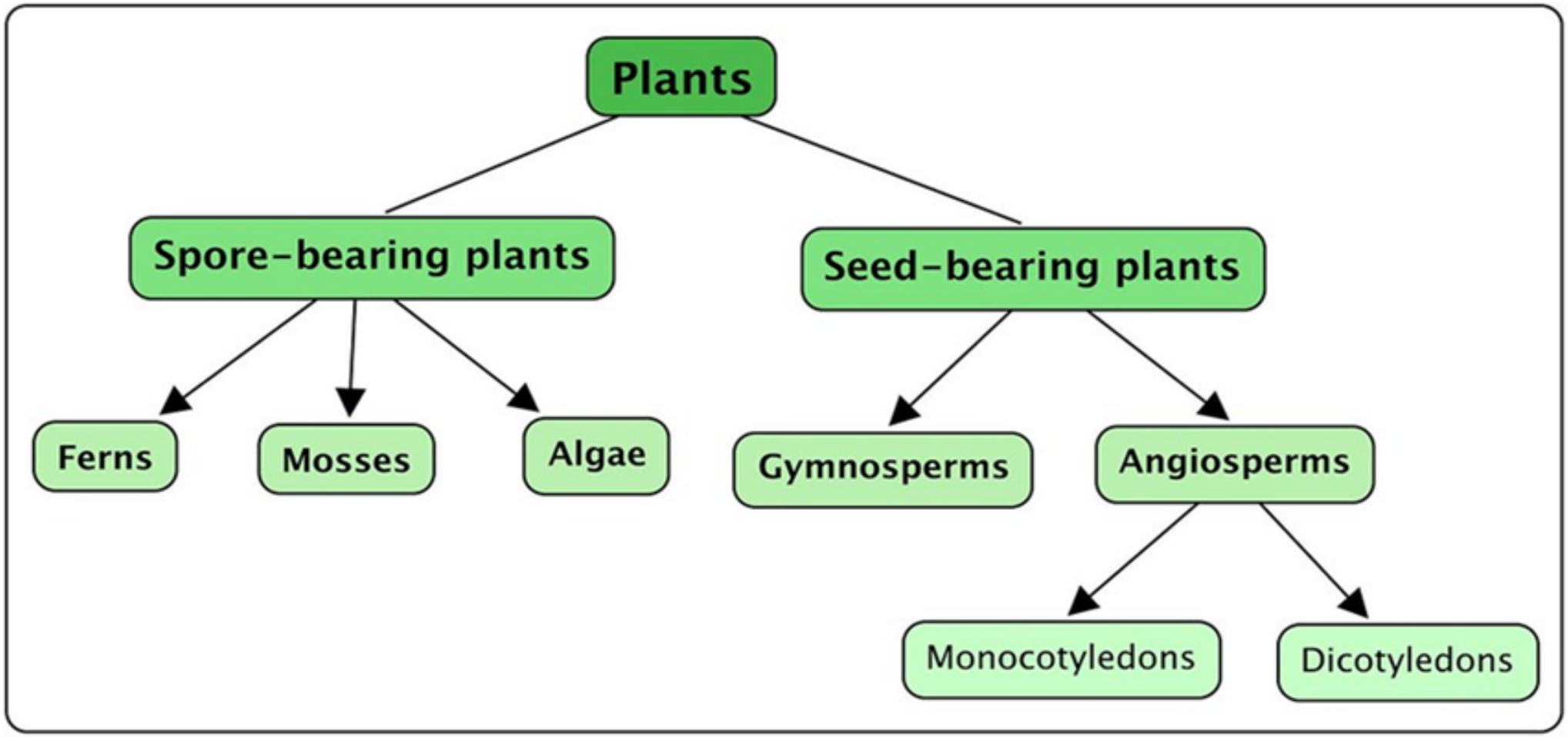
Draw a diagram demonstrating the phenomena of pollination including both observable and unobservable details.

- Label all important parts of the diagram.
- Use arrows to show how all parts interact.
- Write an explanation describing the process of pollination.

Pollen and Plant Reproduction

Lesson One

Two Plant Reproduction Categories



Spore-Bearing Plants

- Spore-bearing plants are believed to be more primitive than seed plants.
- Ferns, mosses, and algae produce spores instead of seeds and use them as a means of reproduction.
- Spores are organisms that usually contain a single cell. Because they are only made of one cell, they are *haploid*, which means they only have one set of chromosomes
- Spores are very small and light, so they are easily transported by wind or water to a growing location.

Seed-Bearing Gymnosperms

- Gymnosperm means “naked seed” They are called this because the seeds have no protective fruit covering.
- Conifers, cycads, *Ginkgo* and Gnetales have naked seeds.
- Gymnosperms were the first seed-bearing plants.
- These seeds develop either on cones or open plant structures.
- On conifers, the woody cone is the seed-producing female cone. The male cone, which produces **pollen**, is usually softer and smaller.
- Pollen is carried by the wind from the male cone. If it lands on a female cone, seeds will be produced within the scales of the cone.

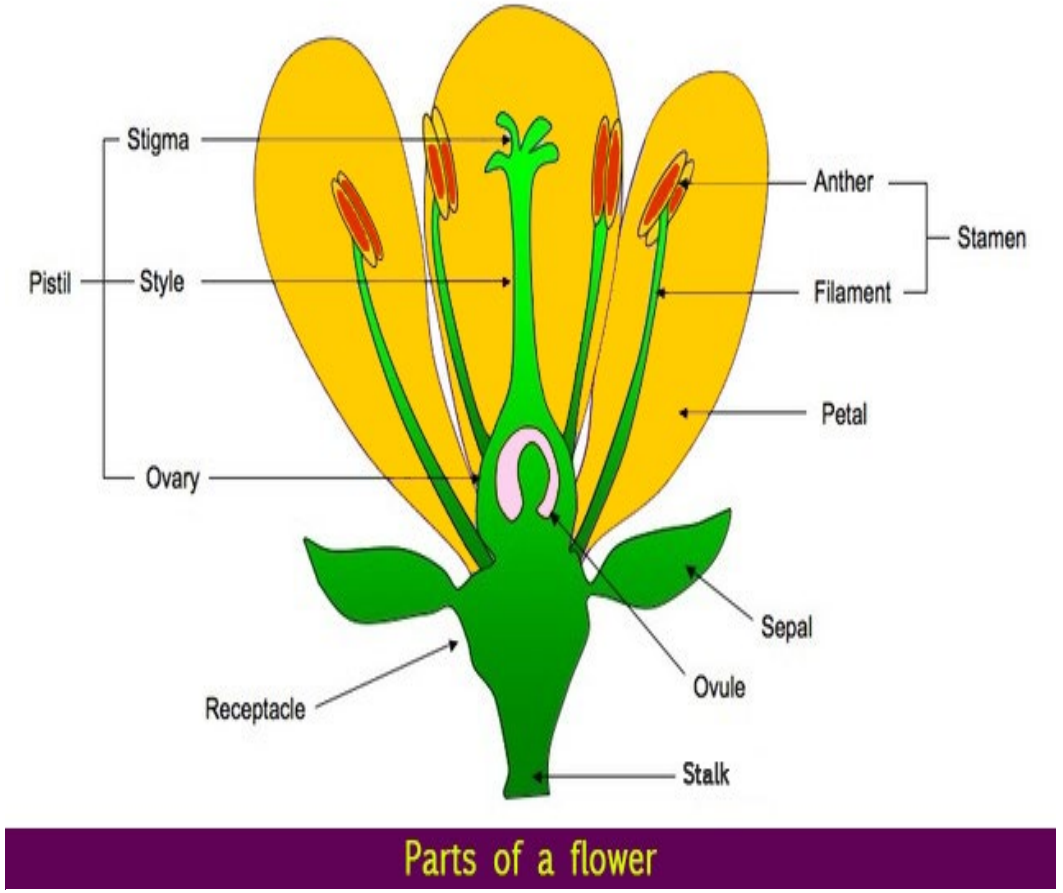
Spores Versus Pollen

- Scientists who study plant evolution have concluded that plants that make pollen and seeds developed these structures over millions of years.
- A ***pollen grain*** is a reproductive structure of a seed plant.
- Unlike spores, pollen grains are usually much larger, and they contain the male gamete of the plant.
- Pollen is carried by the wind or animals to begin the pollination process of seed-bearing plants.

Seed-Bearing Angiosperms

Angiosperms are any plant that makes a flower and some form of fruit to protect its seed.

- The name comes from the Greek words for *container* and *seed* which refers to the flower which encloses its seed within an **ovary**.
- The flower is the reproductive part of the plant.
- In most plants, flowers contain both female (pistil) and male (stamen) parts. These flowers are classified as “perfect” flowers.
- However, some angiosperms have evolved to produce flowers with only male or female parts; these flowers are classified as “imperfect.”

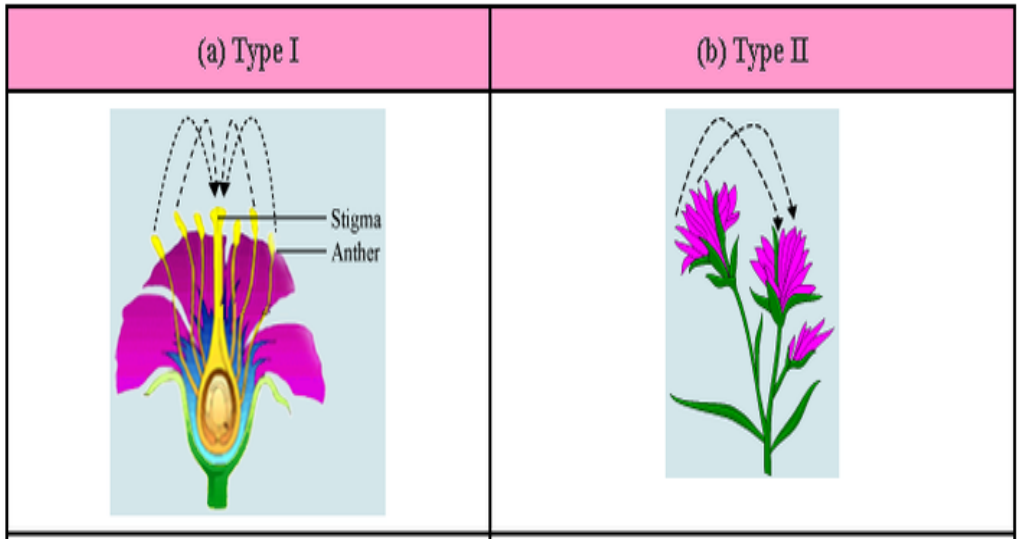


There Are Two Main Types of Pollination

Self-Pollination

Pollen from a stamen sticks to the pistil of the same flower or flowers within one plant.

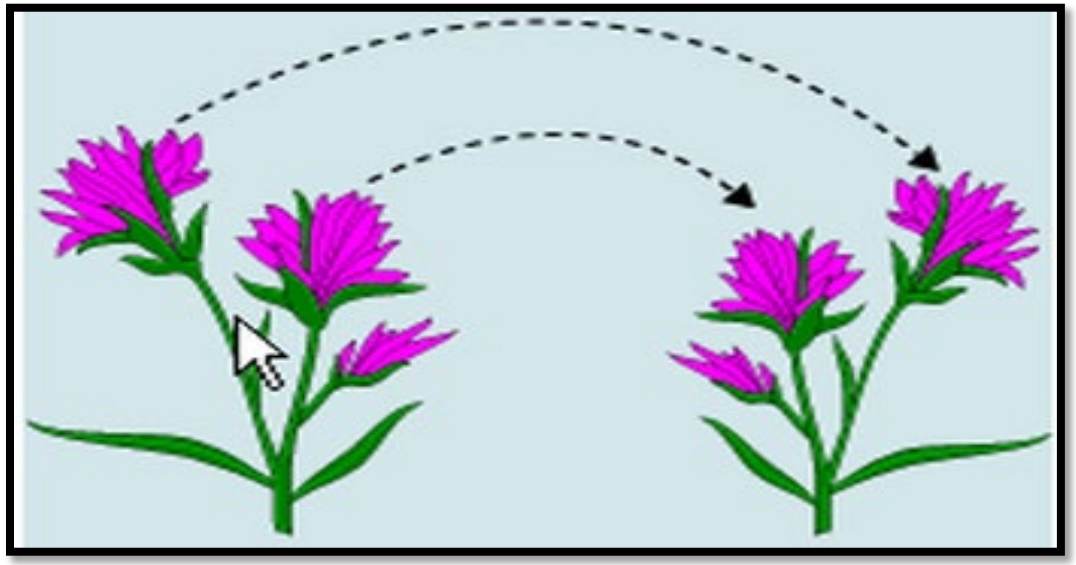
Self-pollination **reduces** genetic diversity.



Cross-Pollination

Pollen from one plant travels to the pistil of another plant. Most plants use this kind of pollination.

Cross-pollination **increases** genetic diversity.



The Dominate Form of Plant Life

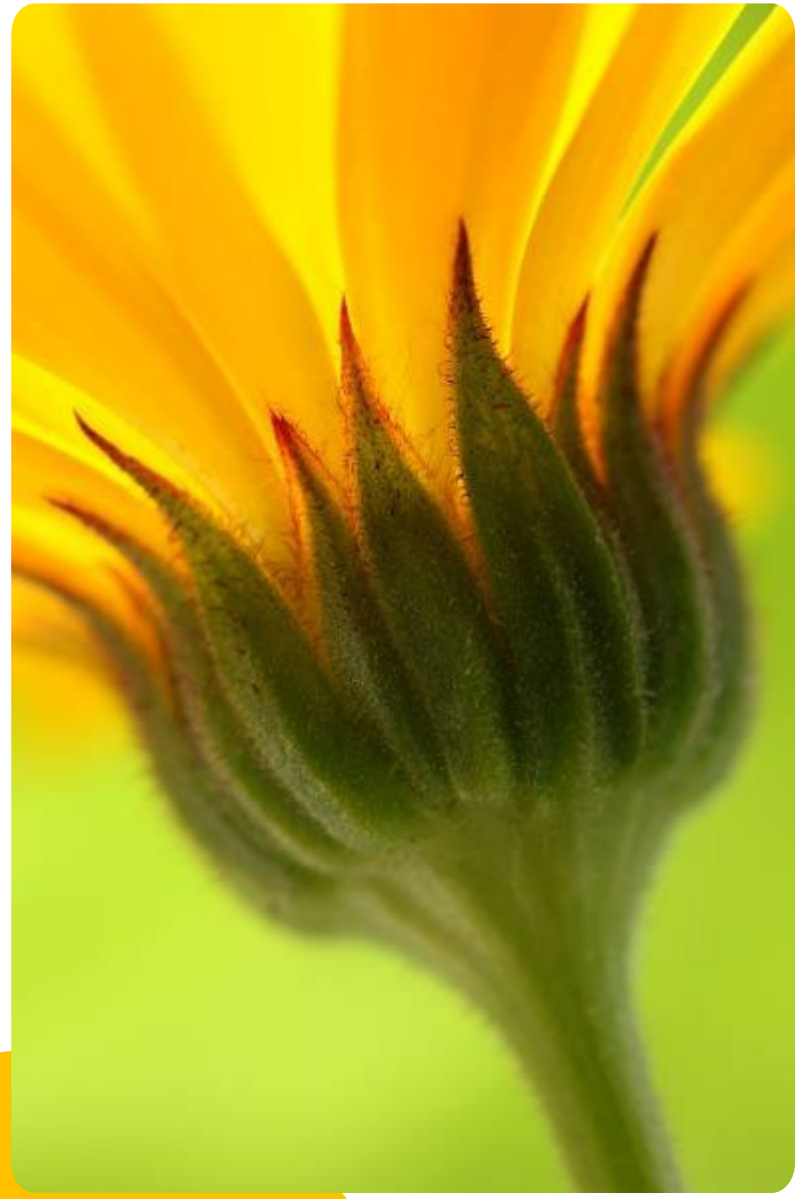
- Angiosperms comprise 80 percent of all green plant life with over 250,000 species and are 90 percent of all food crops.
- The success of angiosperms is due to their unique reproductive structures: flowers and fruit.

✓The function of the flower which ensures pollination.

✓The function of the fruit which is seed dispersal.

Check For Understanding

- As seed-bearing plants, what do both gymnosperms and angiosperms produce in order to reproduce?
- How are angiosperms different from gymnosperms?
- What is the purpose of a flower?
- What is the female part of a flower?
- What is the male part?
- Which form of flower pollination increases the genetic diversity of flowering plants?
- Which type of flower ensures genetic diversity- a perfect or imperfect flower? Explain.
- Why are angiosperms an essential part of an ecosystem?



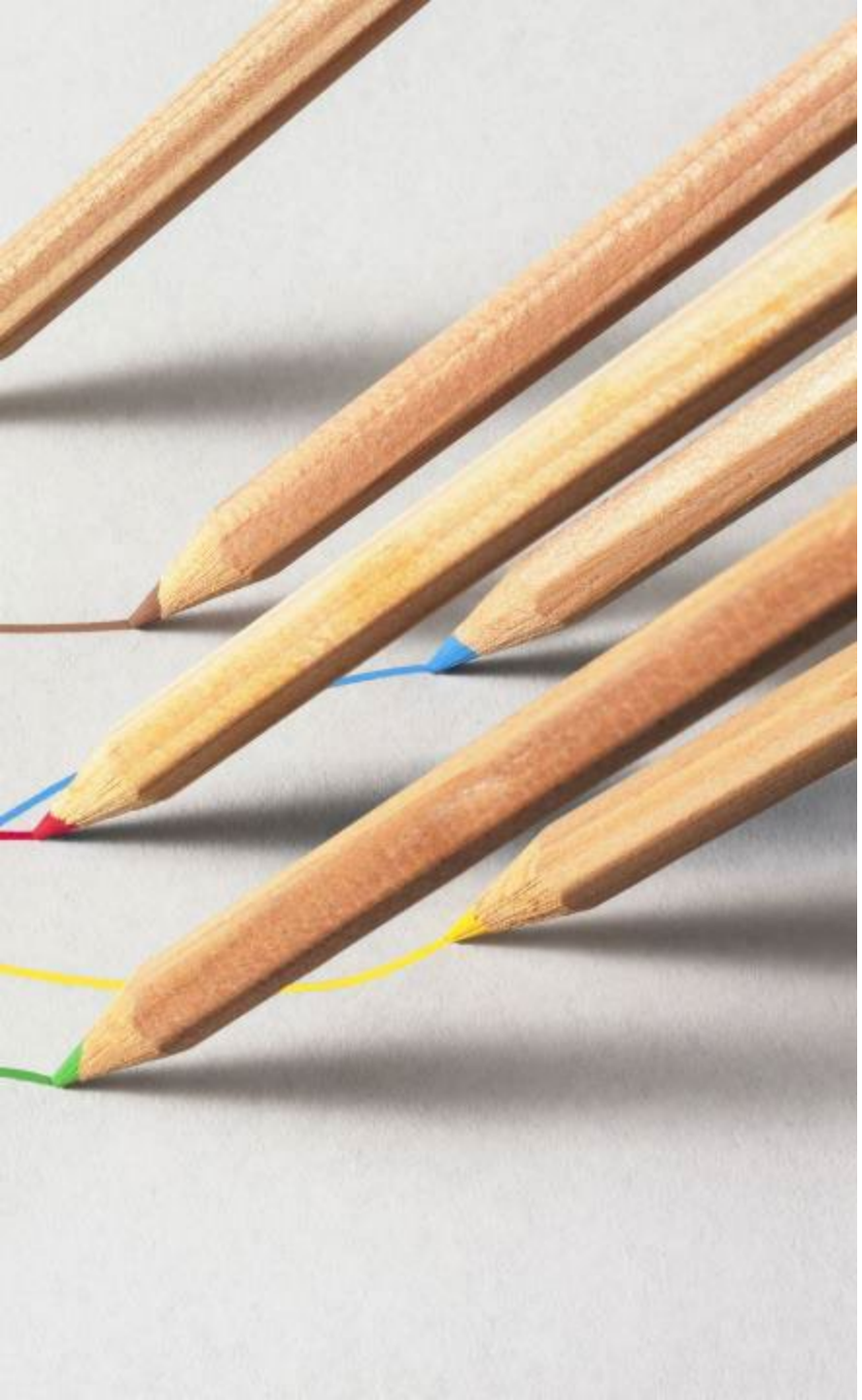
Phenomena in the Garden Application Activity:

Examine the Inside of a Flower

- Visit your school garden for a selection of flowers or provide students with flowers. (Daylilies are large and easy to examine.)
- Use the diagram at the link below to guide your identification of the reproductive parts of the flower :

297_flower_diagram.pdf (calacademy.org

- Based on your observations is this flower perfect or imperfect?
- What could happen if cross-pollination occurs between two of the same kind flowers?



Develop a Model To Describe the Phenomena

Revise or draw a new model of pollination to reflect what you have learned about this phenomena.

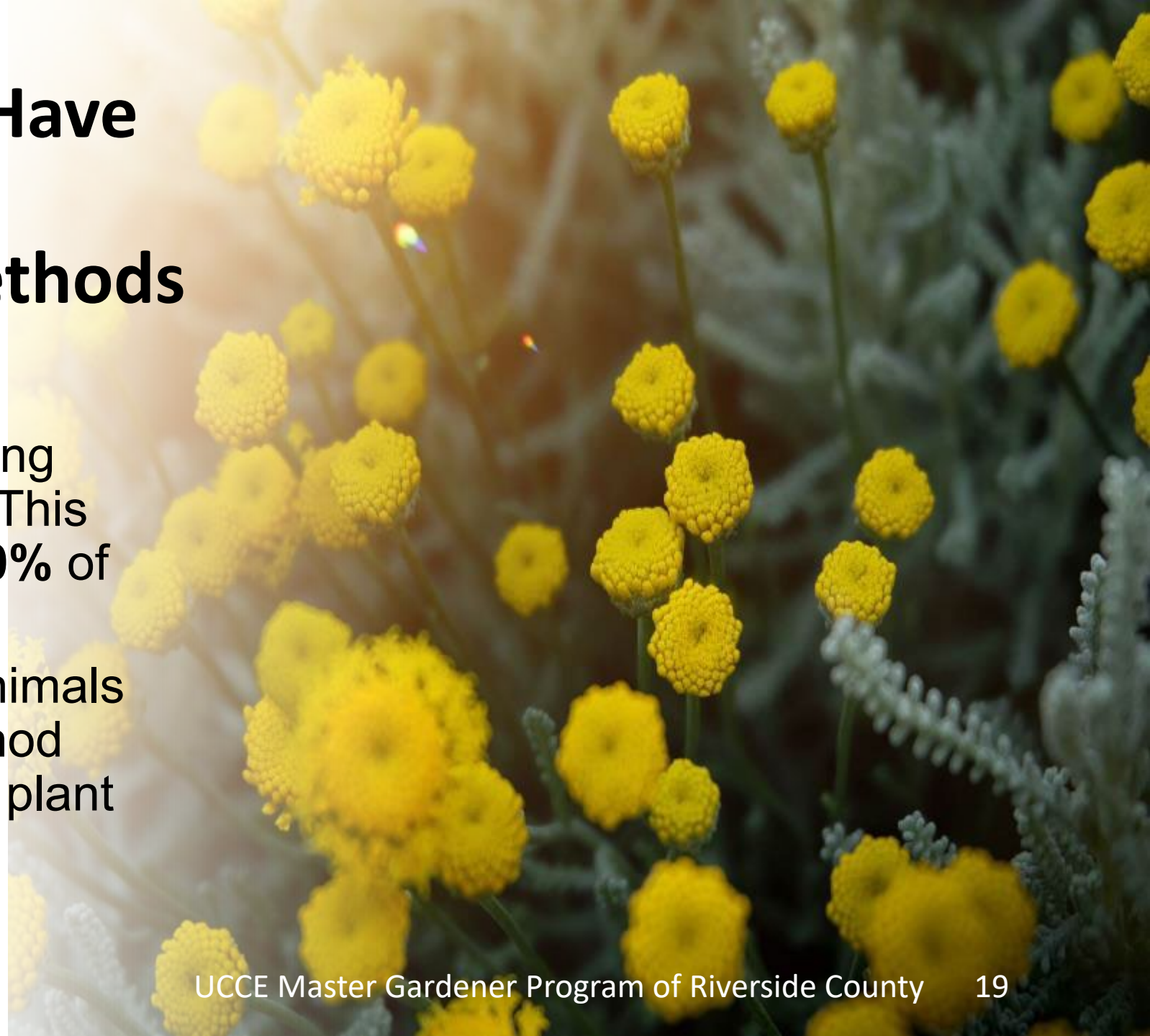
- Label all important parts of the diagram.
- Use arrows to show how all parts interact.
- Write an explanation describing the process of pollination.

Pollinator-Plant Relationship

Lesson Two

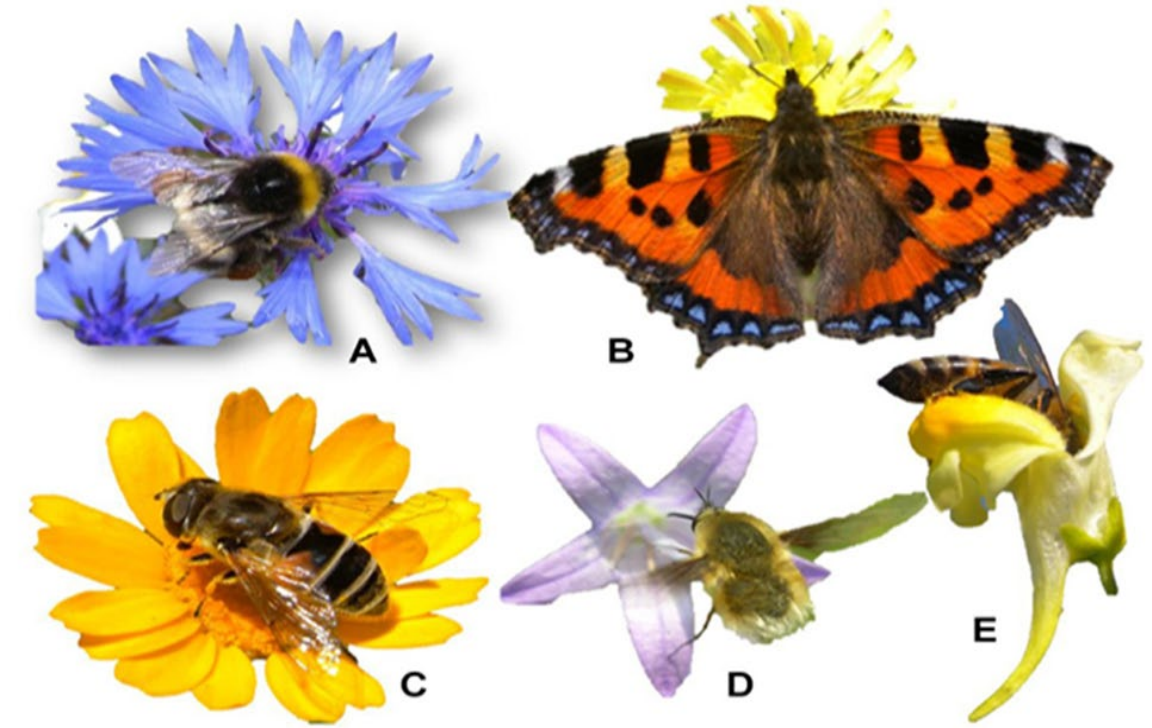
Flowering Plants Have Evolved Two Pollination Methods

- **Abiotic** pollination: Spreading pollen using wind or water. This method comprises about **20%** of all plant pollination.
- **Biotic** pollination: Using animals to spread pollen. This method comprises about **80%** of all plant pollination.



The Plant-Pollinator Relationship

- Insect and other animal pollinators obtain food in the form of energy-rich nectar and/or protein-rich pollen from the flowers they visit.
- In return, flowers receive cross-pollination from the pollinators who carry the pollen from one flower to another.



Flowering Plants Have Coevolved With Their Pollinator Partners

- Plants developed a wide range of strategies to attract pollinators.
- Pollinators developed adaptations to increase their ability to access nectar and pollen.

Attracting Pollinators

Plant strategies include variations to the following characteristics of a flower:

- ✓color
- ✓shape
- ✓scent

While food is often enough to lure pollinators, flowering plants also attract pollinators using one of more of these strategies.

Pollinator Syndrome

- The strategies used to attract pollinators are called pollinator syndromes.
- Tables have been developed describing characteristics of these strategies and the pollinators each characteristic (syndrome) will attract.

Flower Trait	Pollinator							
	Bats	Bees	Beetles	Birds	Butterflies	Flies	Moths	Wind
Color	Dull white, green or purple	Bright white, yellow, blue, or UV	Dull white or green	Scarlet, orange, red or white	Bright, including red and purple	Pale or dark brown or purple; flecked with light spots	Pale and dull red, purple, pink or white	Dull green, brown, or colorless; petals absent or reduced
Nectar guides (patterns on petals guiding pollinators to the nectar)	Absent	Present	Absent	Absent	Present	Absent	Absent	Absent
Odor	Strong musty; emitted at night	Fresh, mild, pleasant	None to strongly fruity or fetid	None	Faint but fresh	Putrid	Strong sweet; emitted at night	None
Nectar	Abundant; somewhat hidden	Usually present	Sometimes present; not hidden	Ample; deeply hidden	Ample; deeply hidden	Usually absent	Ample; deeply hidden	None
Pollen	Ample	Limited; often sticky and scented	Ample	Modest	Limited	Modest in amount	Limited	Abundant; small, smooth, and not sticky
Flower Shape	Regular; bowl shaped – closed during day	Shallow; have landing platform; tubular	Large bowl-like, Magnolia	Large funnel like; cups, strong perch support	Narrow tube with spur; wide landing pad	Shallow; funnel like or complex and trap-like	Regular; tubular without a lip	Regular: small and stigmas exerted

One Example of a Pollinator Syndrome

- The visible light spectrum for bees and some other insects is not the same as for humans. Humans can see violet to red, while these creatures cannot.
- Instead, they can see ultraviolet light, which humans cannot. Many flowers, have an ultraviolet bull's-eye pattern that signals to pollinators that this flower is a good place to land for a snack.

Interdependent Relationship

Plants and pollinators have adapted over a long period of time, developing interdependent relationships across all ecosystems.

"The secret bond of the partnership is that neither plant nor pollinator populations can exist in isolation – should one disappear, the other is one generation away from disaster."

- U.S. Forest Service

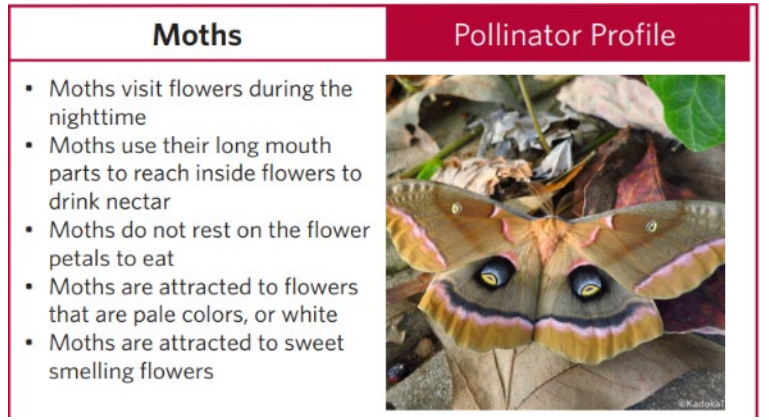
Trading Food For Fertilization: Video

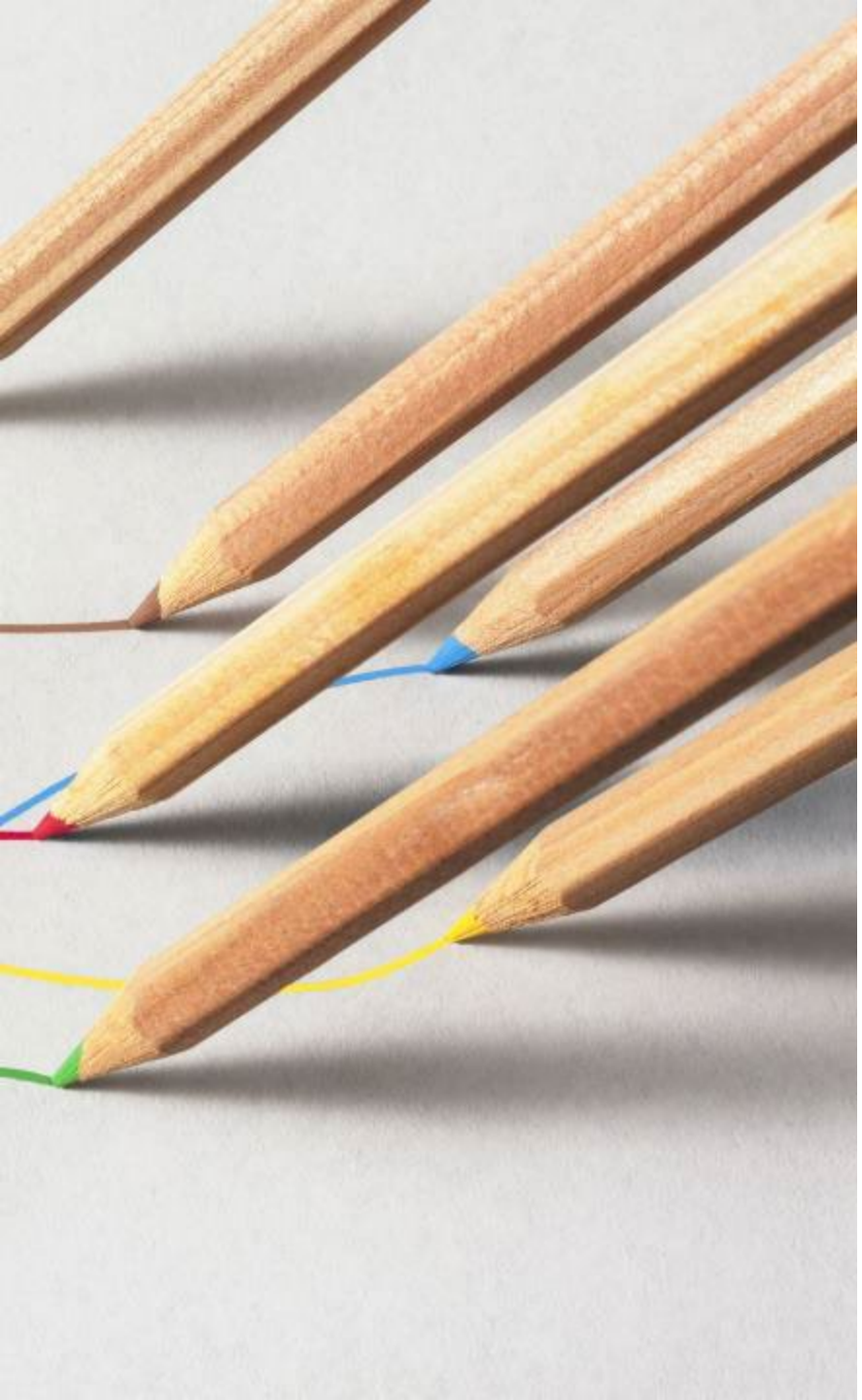
Check For Understanding

- Based on the descriptions of the abiotic and biotic methods of pollination, which method do you think is most likely to contribute to allergies?
- What do insects and other animals receive from plants?
- Identify a strategy plants use to attract insects and other animals.
- What term do scientists use to describe these strategies?
- Do you think plants and their pollinators can adapt quickly to changes in their ecosystem? Justify your answer.

Phenomena in the Garden
Application Activity:
Observe the Plant-Pollinator Relationship

- Select a pollinator from the Pollinator Profiles and review the characteristics of the pollinator. Also review the Pollination Syndromes Table .
- Using the information provided, *hypothesize* what a flower might look like to attract your pollinator. Show your hypothesis by making a sketch of a flower.
- Label your sketch with the characteristics your pollinator would be seeking.
- Use your drawing and the pollinator profile to survey your home or school garden area for plants meeting this pollinator's needs.
- Tally how many plants you find available for this pollinator.
- Compile results onto a class-wide chart.
- Develop conclusions from this data.





Develop a Model To Describe the Phenomena

Revise or draw a new model of pollination to reflect what you have learned about this phenomena.

- Label all important parts of the diagram.
- Use arrows to show how all parts interact.
- Write an explanation describing the process of pollination.

Impacts on the Plant-Pollinator Relationship

Lesson Three

Pollinators and Climate: Video

Globally There Are Signs of Pollinator Decline

Contributing to this decline are a variety of factors:

- Climate change
- Loss of habitat
- Non-native species
- Pesticides
- Parasites and Disease

Climate Change

Plants may begin to flower earlier.

Over time plants may also grow farther north or at higher elevations as a response to warming temperatures.

- The result could be that their blooming period becomes out of sync with their pollinators.

➢The types and distributions of pollinators may change. Pollinators adapted to warmer temperatures may expand their northward range seeking flowers and displace other pollinators.

Habitat Loss

Pollinators require natural spaces with vegetation and flowering plants in which to live and forage for their food.

The primary causes for pollinator habitat loss are agriculture, mining and human development.

- These land uses do not provide the native plants, overwintering areas, and foraging and nesting sites for pollinators.

➢ Developed urban areas replace vegetated areas and limit habitat for flowering native plants and pollinators.

➢ Fragmented habitat (small areas of nature) may be too small to meet pollinator survival needs.

Non-Native Species

Pollinators require specific plants which provide nutrition and habitat to both larvae and adult pollinators.

- Native plants and wildflowers needed by pollinators are being replaced by non-native species.

➢ Non-native plants may attract pollinators away from native species that are more nutritious and are a better food source.

➢ Non-native species of pollinators may compete with native pollinators for pollen and nectar.

Pesticides

Pesticides are tools used to kill weeds, insects, and fungi. They include herbicides, insecticides and fungicides.

- Pesticides can be harmful to pollinators.
- Some pesticides may remain in the environment for an extended time and affect many generations of pollinators.

➢ **Insecticides** applied to plant seeds may, when the plant is mature, contaminate pollen grains that are food sources for pollinators.

➢ I**nsecticides** that don't directly kill may affect the ability of pollinators to navigate or forage.

➢ **Herbicides** may kill important forage plants for pollinators.

Parasites and Disease

A parasite is an organism that lives and feeds in or on a larger animal called the host.

- Insects that parasitize other invertebrates are parasitic only in their immature stages and kill their host just as they reach maturity.

Insects can get sick, too. They suffer from diseases caused by everything from bacteria and viruses to parasites which carry infectious diseases.

- There is an increase in the transfer of parasites and diseases due to rapid travel by planes, trains, trucks and cars.

➢ Non-native parasites and diseases can also infect native species.

Why Protect Pollinators and How Do We Do It? Video

Why Protect Pollinators? | California Academy of Sciences

Check For Understanding

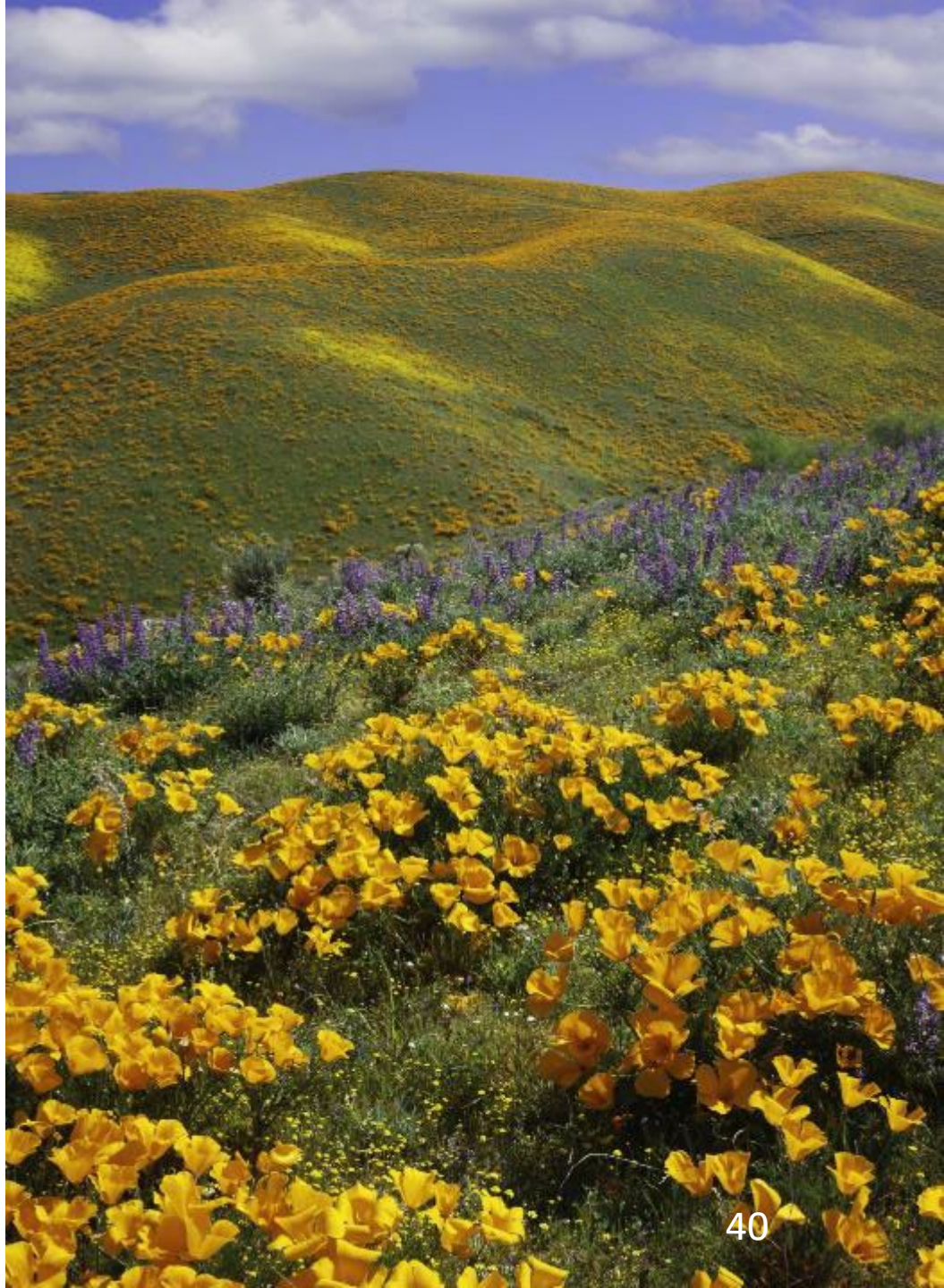
- Describe a possible impact to pollinators from climate change.
- How does agriculture contribute to pollinator decline?
- Why are native plants so important to pollinators?
- Why are pesticides used?
- Hypothesize how vehicles might be contributing to insects catching diseases.
- What percentage of plants need pollinators?
- Why is the biting fly an important pollinator?

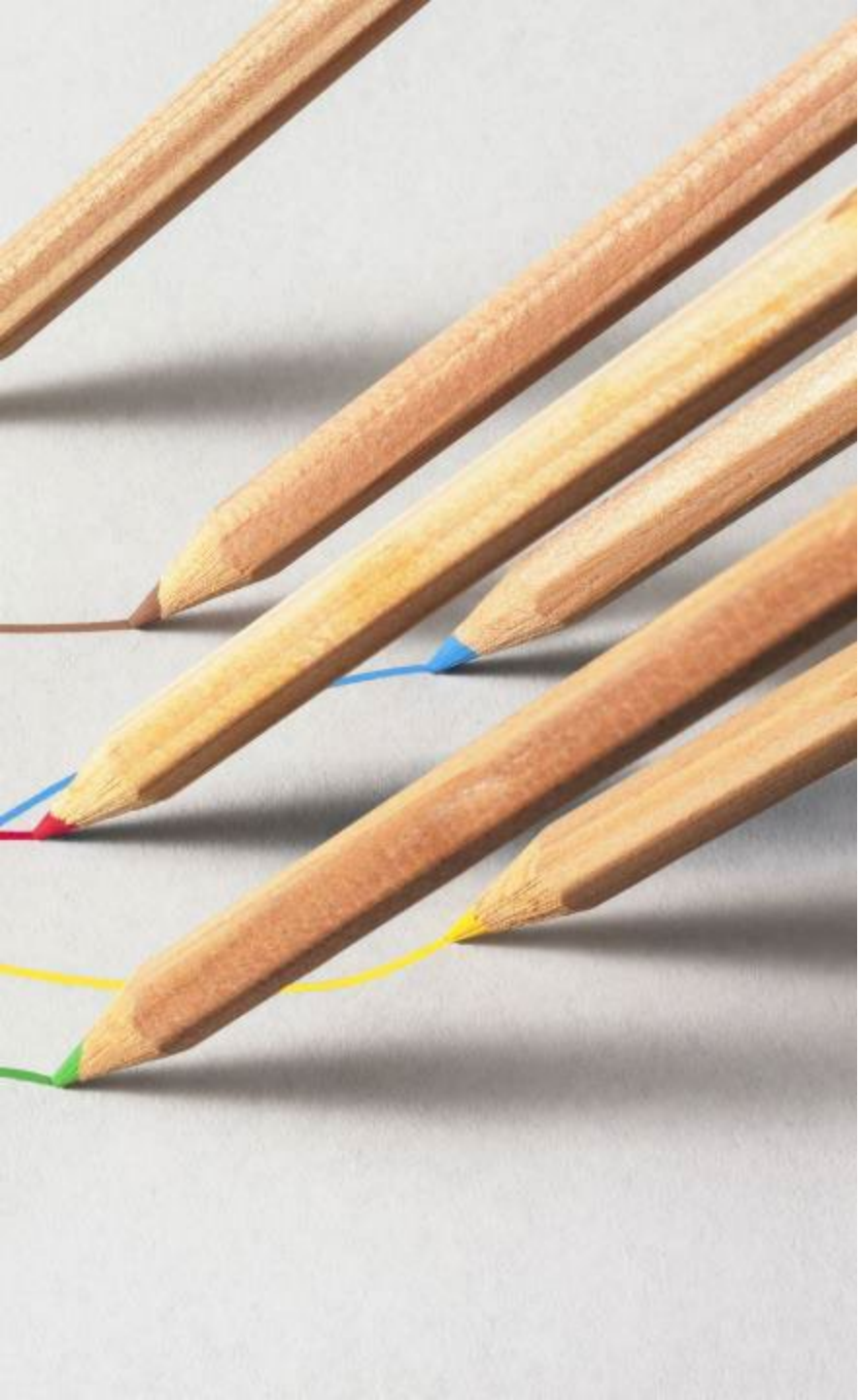
Phenomena in the Garden Application Activity:

Does Your Environment Protect Pollinators?

Survey your campus or the outdoor area of your home using the following checklist:

- ❑ Large areas of flowering plants
- ❑ Native plants
- ❑ Minimal lawn
- ❑ Undisturbed areas of leaves and plant debris for groundcover
- ❑ Water source
- ❑ Little or no evidence of pesticide use





Create a Final Model To Describe the Phenomena

Draw a new model of pollination to reflect what you have learned about this phenomena.

- Label all important parts of the diagram.
- Use arrows to show how all parts interact.
- Write an explanation describing the process of pollination.

Extend Activity

Certification For a Wildlife Habitat

For a home, school or community garden

- Research the guidance for developing a wildlife habitat.
- Follow the checklist provided and develop a landscape plan.
- Be sure to include native plants. Use resources including the Audubon Society's Native Plant Database and the California Native Plant Society *Calscape* website to locate plants suitable for your area. Just type in your zip code.

Next Generation Science Standards

- **LS1.A: Structure and Function** ▪ Plants reproduce in a variety of ways, sometimes depending on animal behavior and specialized features for reproduction. (MS-LS1-4)
- **LS2.A: Interdependent Relationships in Ecosystems** ▪ Organisms, and populations of organisms, are dependent on their environmental interactions both with other living things and with nonliving factors. (MS-LS2-1)
- **LS2.C: Ecosystem Dynamics, Functioning, and Resilience** ▪ Ecosystems are dynamic in nature; their characteristics can vary over time. Disruptions to any physical or biological component of an ecosystem can lead to shifts in all its populations. (MS-LS2-4)
- **LS1.B: Growth and Development of Organisms** ▪ Organisms reproduce, either sexually or asexually, and transfer their genetic information to their offspring. (secondary to MSLS2-3)

Next Generation Science Standards

Science and Engineering Practices:

- Develop a model to describe phenomena. (MS-LS2-3)
- Analyze and interpret data to provide evidence for phenomena. (MS-LS2-1)
- Construct an oral and written argument supported by empirical evidence and scientific reasoning to support or refute an explanation or a model for a phenomenon or a solution to a problem. (MS-LS2-4)

Cross-Cutting Concepts:

- Cause and effect relationships may be used to predict phenomena in natural or designed systems. (MS-LS2-1)
- Small changes in one part of a system might cause large changes in another part. (MSLS2-4),(MS-LS2-5)

Resources

- California Academy of the Sciences: Flowers Seeking Pollination Lesson Plans
- Definition of Fruit
- Food and Agriculture Organization of the UN: Global Action on Pollination Services for Agriculture
- National Park Service: Pollinators in Trouble
- National Wildlife Foundation: Wildlife Habitat Certification
- North American Pollination Protection Campaign
- Pollinator Partnership: Pollinators and Food Insecurity PPT; Vicki Wojcik, Ph.D
- Riverside-Corona Conservation District

Resources

- UC Integrated Pest Management: What Is IPM?
- US Forest Service: What is Pollination?
- WWW.Pollinator.Org: Pollinator Syndromes Table
- **Videos:** Moving Art; Cornell University-Naturalist Outreach; NASA; California Academy of the Sciences
- **Photos:** Creative Commons; Stock Images; UCANR; U.S. Forest Service

Gardening Questions?

Email the UCCE Master Gardeners of Riverside County

- Email Helpline: anrmgriverside@ucanr.edu
- School Gardens: mgschoolgardens@gmail.com

Website Resources

- Riverside Master Gardeners Website

University of California
Agriculture and Natural Resources
UCCE Master Gardener Program