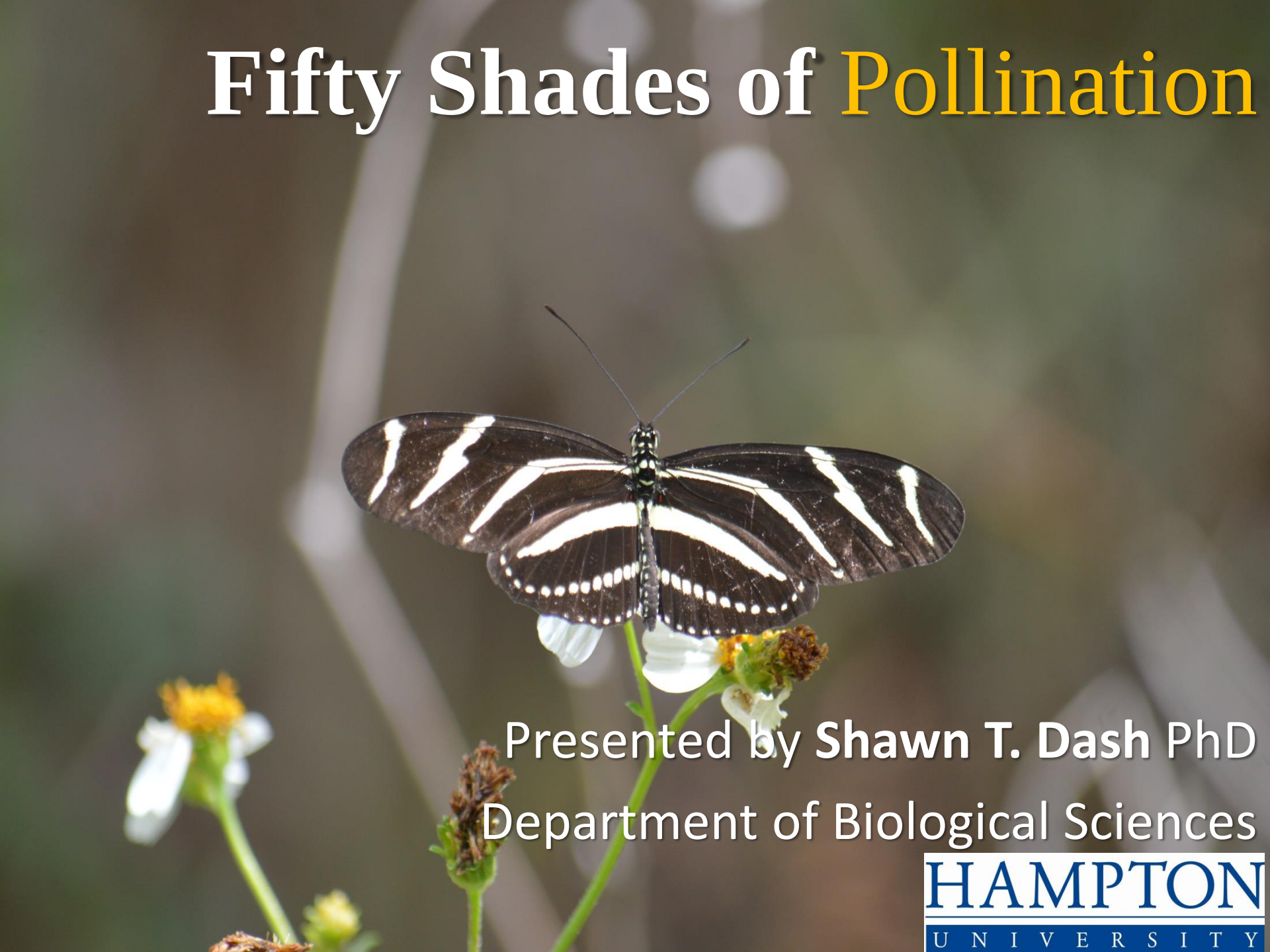
Fifty Shades of Pollination



Presented by **Shawn T. Dash** PhD

Department of Biological Sciences

HAMPTON UNIVERSITY

Why is there a need for pollination?

Why do plants need a pollination agent?

Why trick another organism to carry around your sperm


CAREFULLY!
RIPE

"Thank a pollinator for 1 out of every 3 bites of food you eat."

"Insect pollination is essential for 35% of global food production."

Lecture Map

1) Context
2) Interactions
3) Plant-side
4) Pollinator-side

Major Players in Communities

Plants Roles in Communities

- Energy transformation
- Nutrient movement
- Erosion
- Carbon cycle
- Nitrogen cycle
- Soil formation
- Food

Species interactions

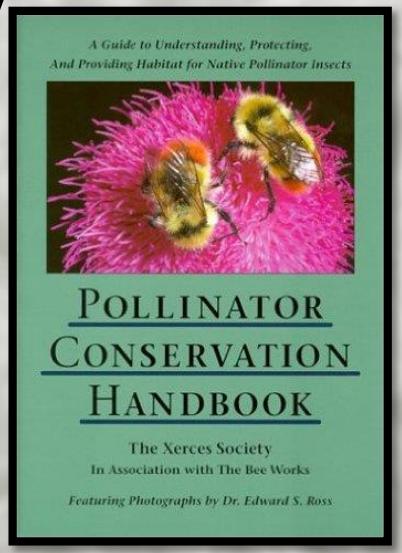
Insects Roles in Communities

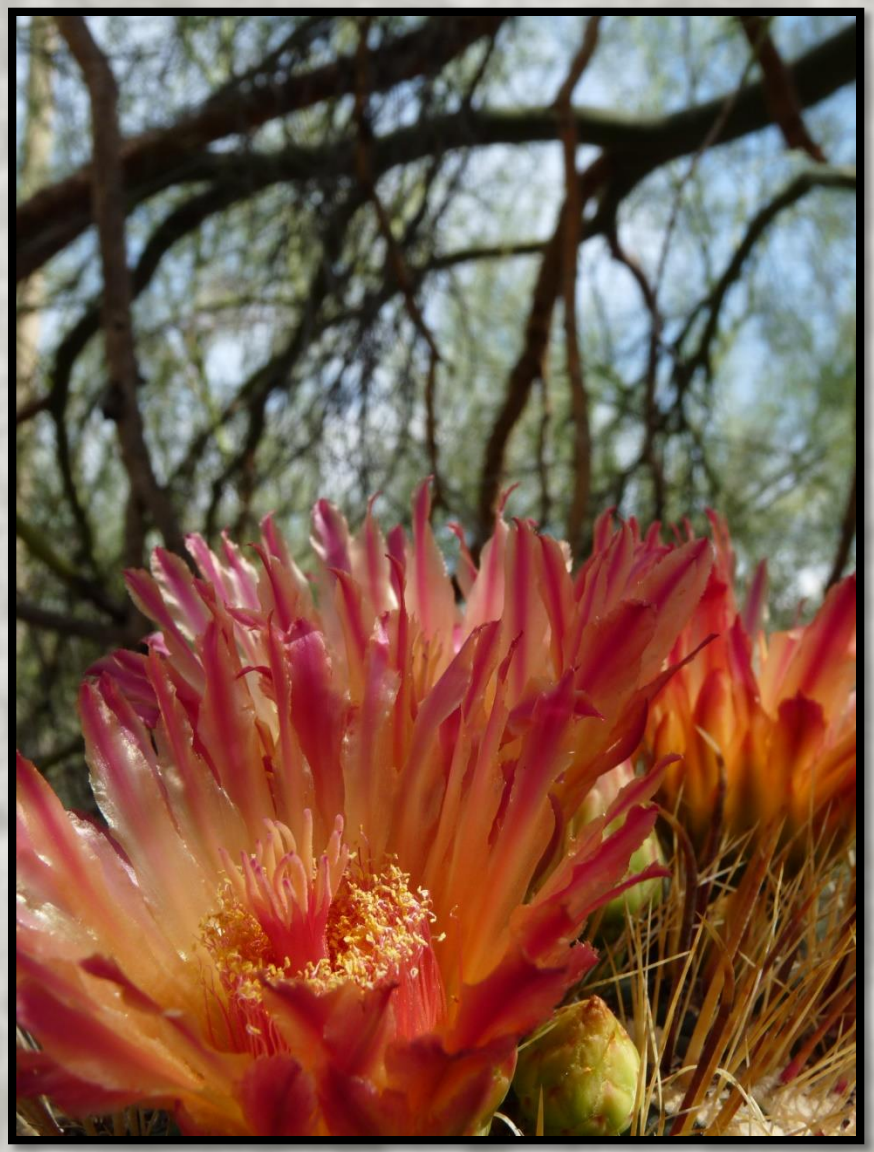
- Pollination
- Decomposers
- Disease vectors
- Population control (herbivore, parasitoids)
- Soil formation
- Food for wildlife

Introduction

A biological **community** consists of interacting species, usually living within a defined area.

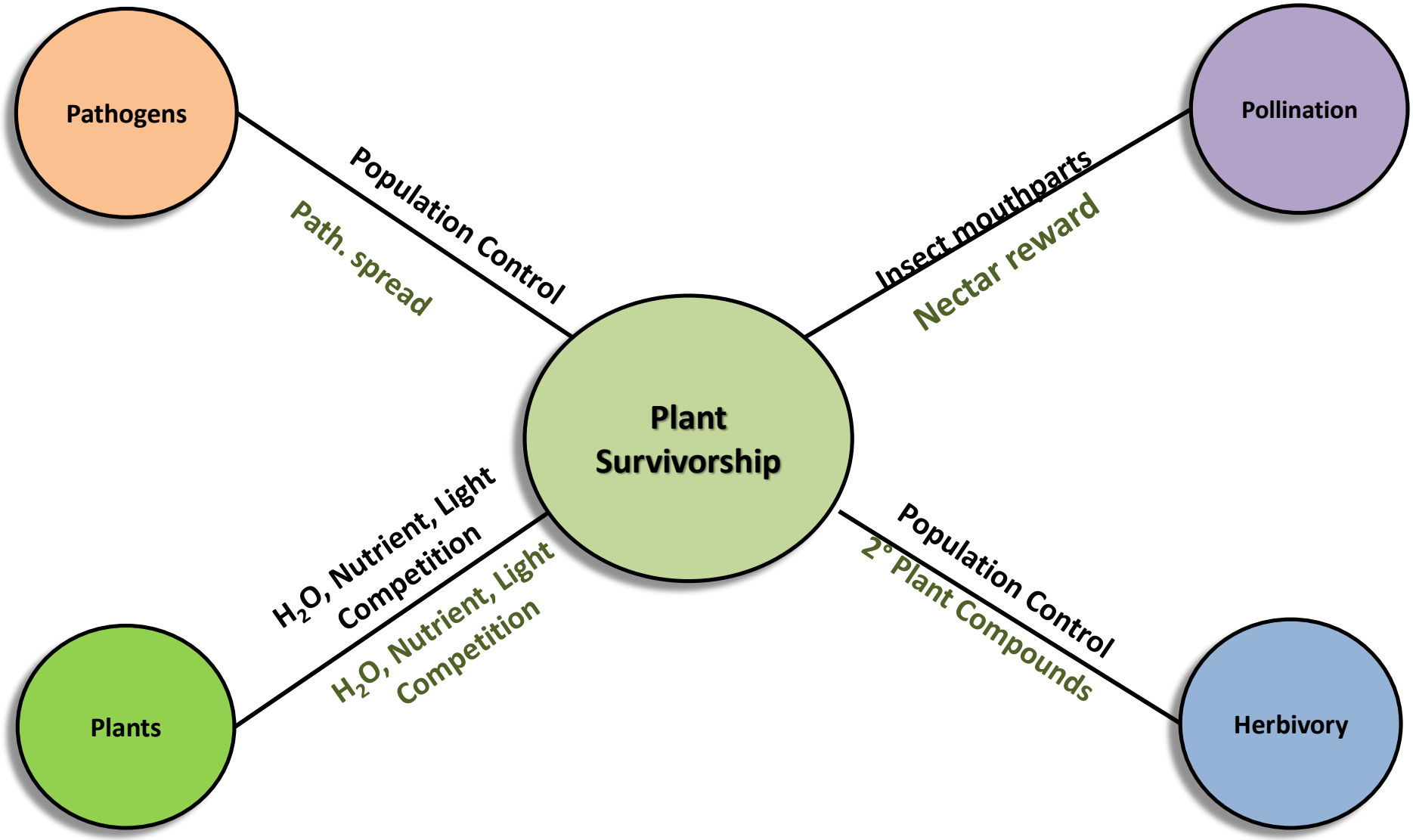
Biologists want to know how communities work, thereby knowing how to manage them in a way that will preserve species and maintain healthy ecosystems.





Interacting Components

Ecological interactions relationship between two species that influence the survivorship of each.



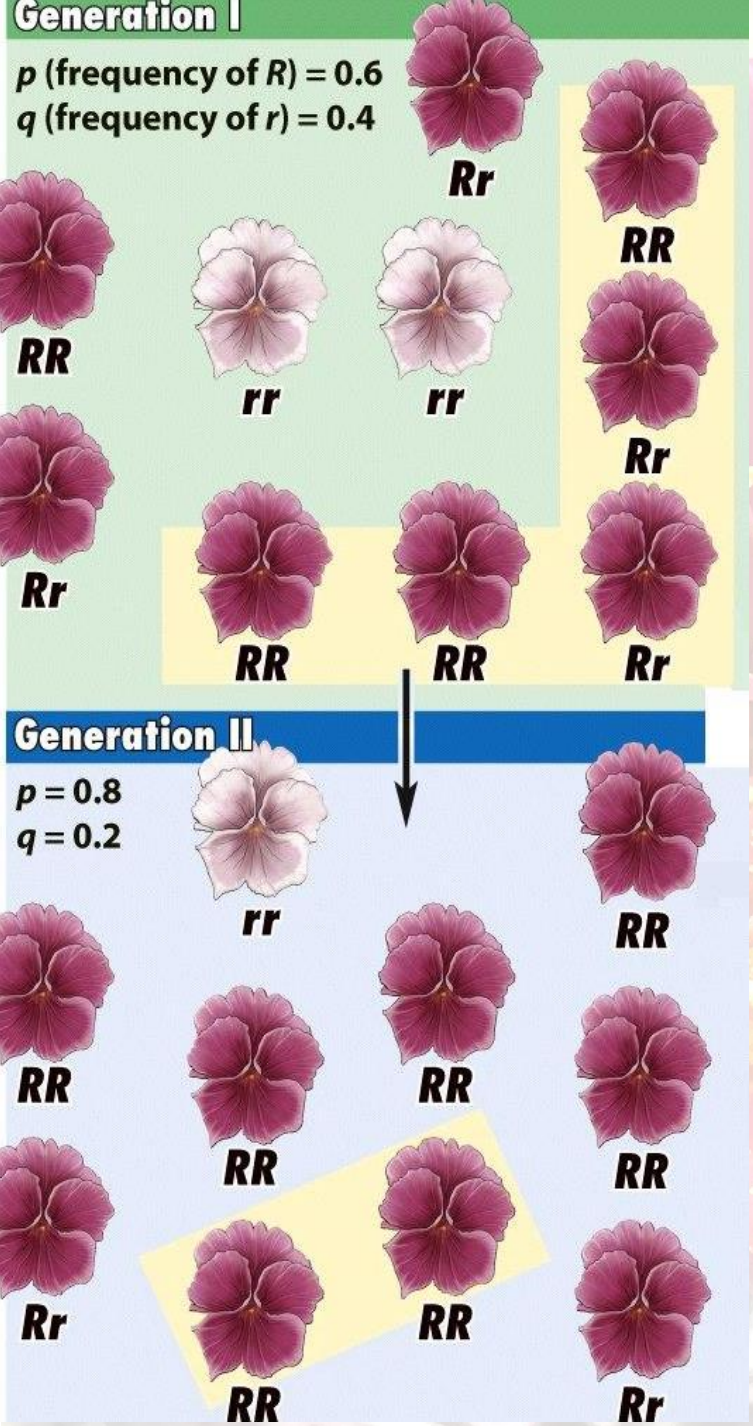
Species Interactions

Because the species in a community interact almost constantly, the fate of a particular population may be tightly linked to the other species that share its habitat

The Process of Relationships

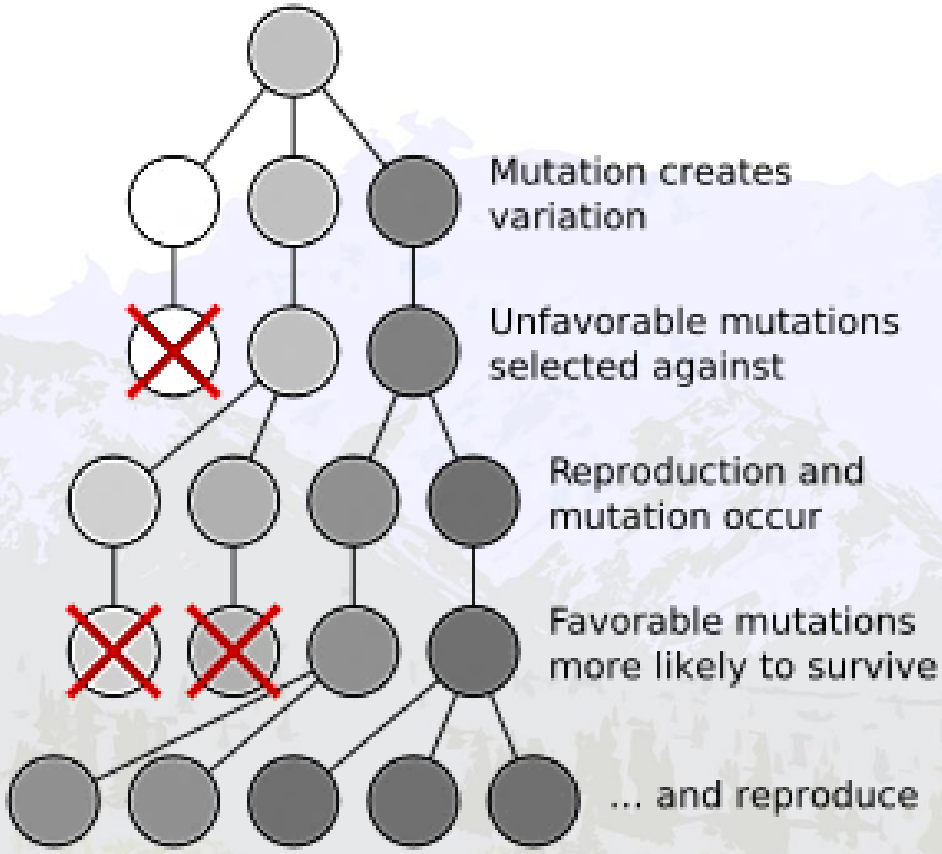
- Changes in the characteristics of a population of organisms that occur over the course of generations, that increase survivorship will be selected for and increase.
- These changes must have a genetic basis.

Take Home: Change of allele frequency over time =change populations.



Change of allele frequency over time = basic idea of biological evolution.

The population's characteristics will change over time as the individuals with the favorable traits increase in frequency.



I have called this principle, by which each slight variation, if useful, is preserved, by the term Natural Selection.

—Charles Darwin from "The Origin of Species"

Biological interactions = Symbiosis

Relationships between organisms occur in a continuum from antagonistic to cooperation to dependency (symbioses)

Parasitism **Commensalism** **Mutualism**

Antagonism **Cooperation**

(+/-)

(+/0)

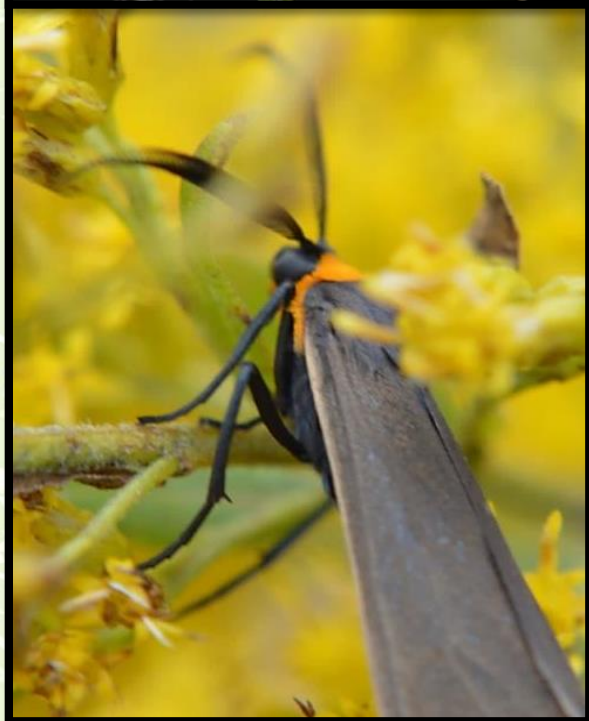
(+/+)

Animal-Plant Interactions

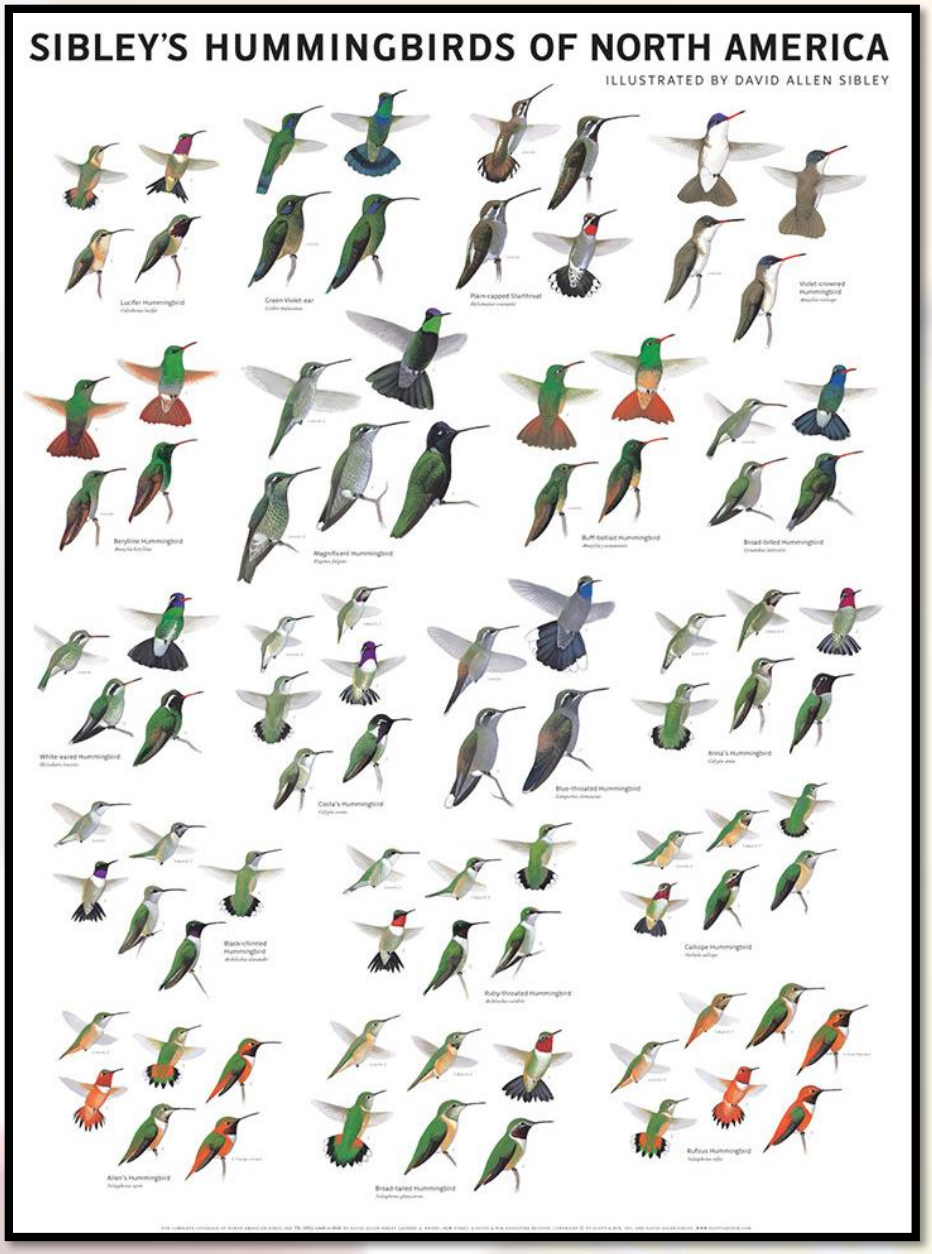
Two General Groups of Behaviors.

1. Phytophagy-Herbivory
2. Mutualisms

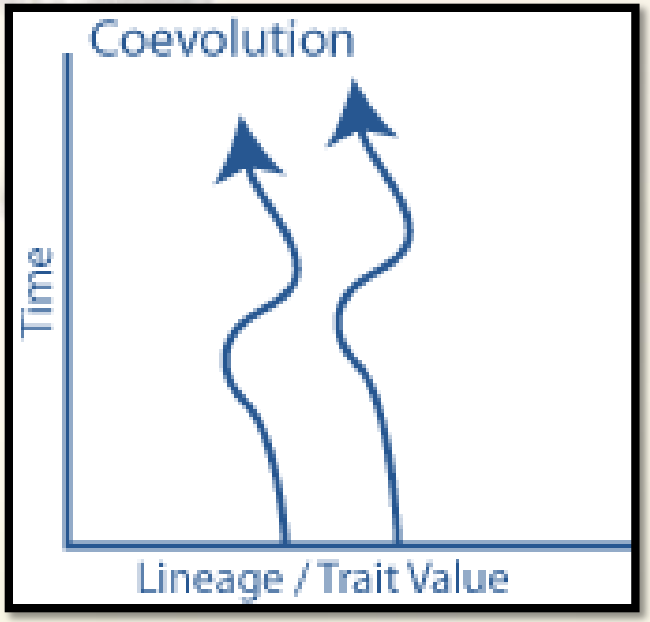
It all comes right down to exploitation symmetry.



Building a Community



Coevolution is the change of a biological object triggered by the change of a related object.




© Ardea.com

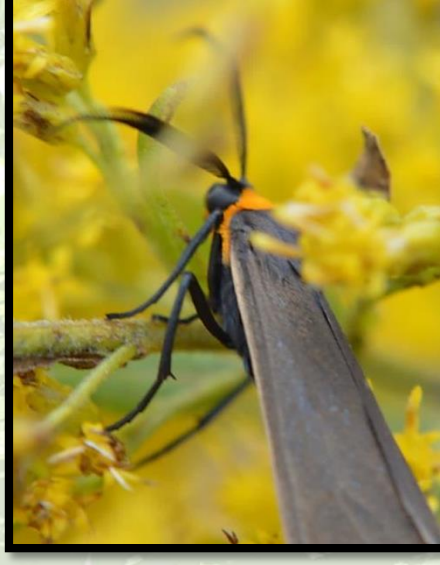
Apis millifera

Anthophora affabilis

Geodiscelis longiceps

Photography by Sam Droege, USGS

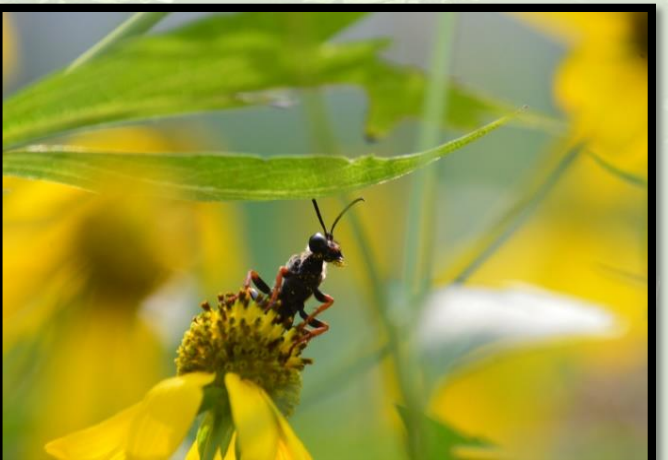
Animal-Plant Interactions

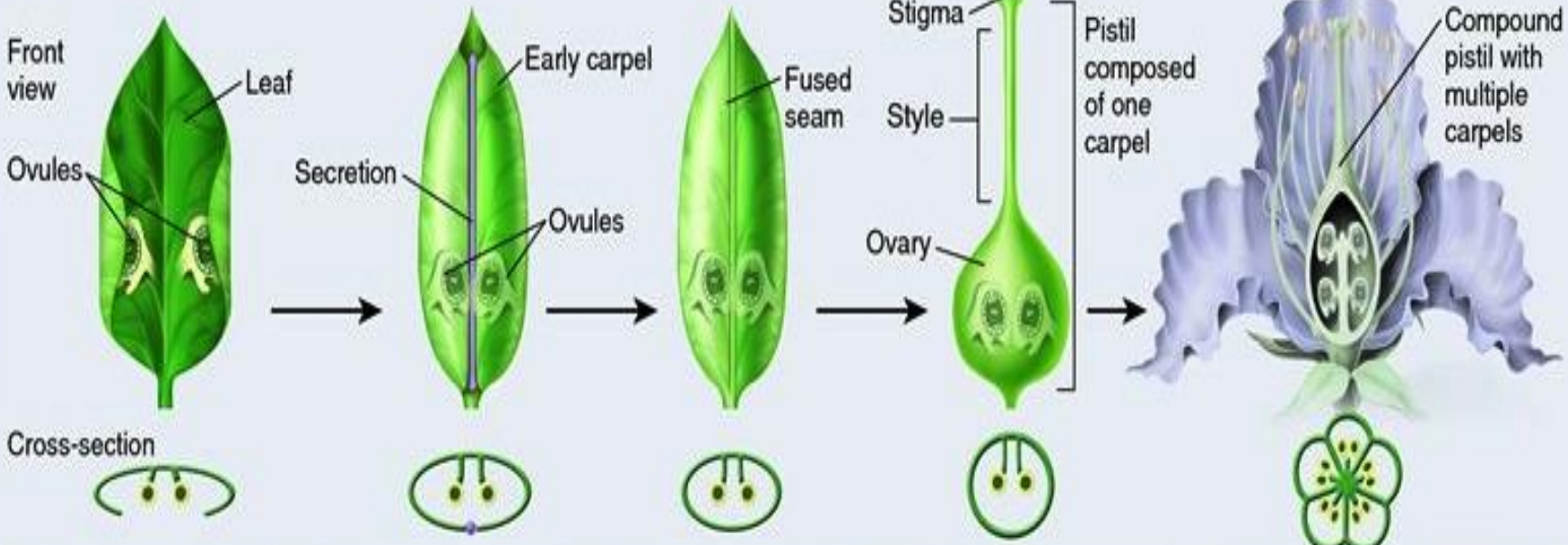


Two General Groups of Behaviors.

1. Phytophagy-Herbivory
2. Mutualisms *as well as commensalism*

	# of US spp.	# of pollinators	% contributing to pollination
Insects:	91,000	3,500	4%
Birds:	914	20	2%
Bats:	40	2	5%



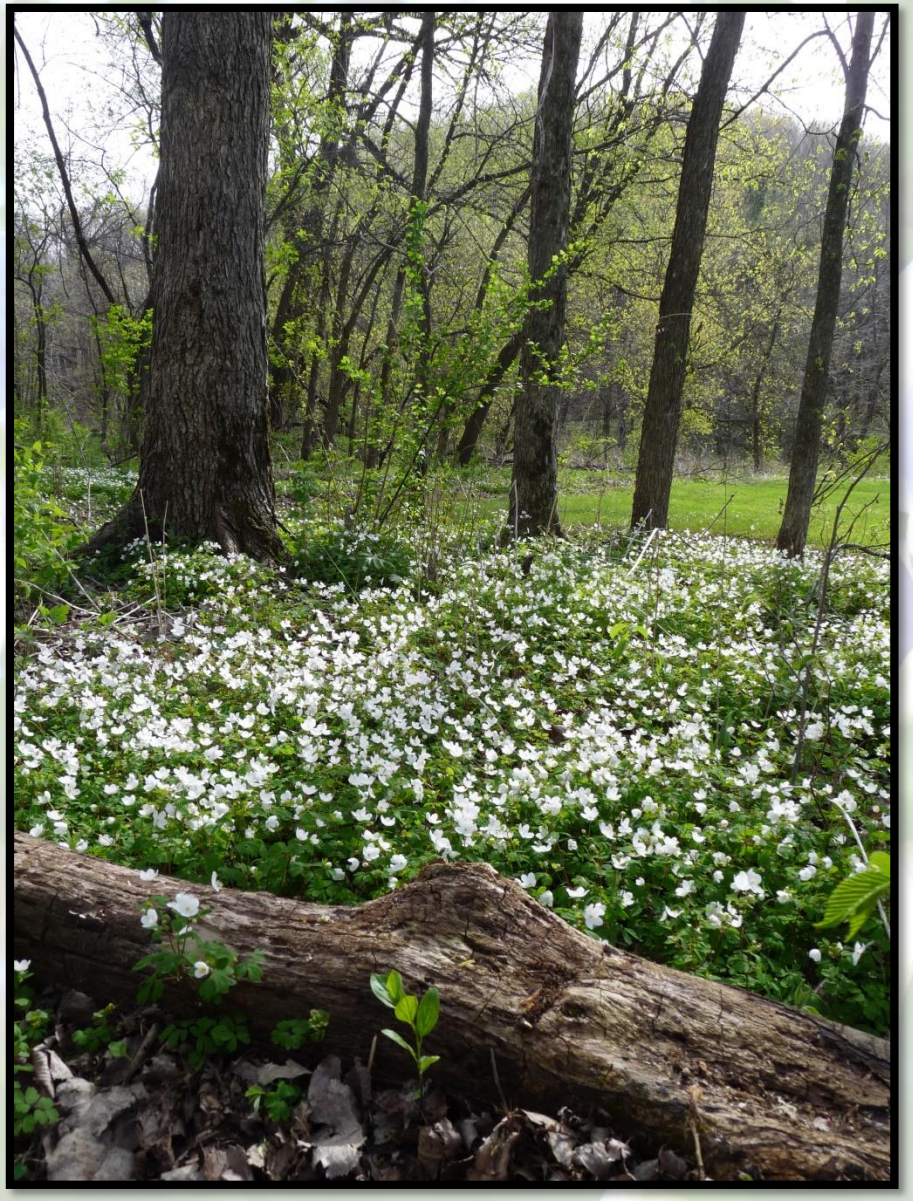


1. Carpels evolved from leaflike structures whose edges folded over ovules, protecting them.
2. Early carpels folded over ovules, with the seam closed by sticky secretions.
3. Later carpels were completely closed into a tube, by fusion of tissue.
4. Carpels developed specialized regions (stigma, style, and ovary) to form a pistil.
5. In many modern flowers, several to many carpels are fused to form a compound pistil.

- No longer in liquid media- terrestrial; life presents challenges to gamete transport.
- Plants are stationary and depend on external forces to bring gametes together.
  - 10-20% of plants use wind or water (rarely)
  - 80-90% pollination is animal assisted

  <u>Plants are</u>:
    - Specialist-attract one pollinator
    - Generalist-attract wide range of pollinators

Agents of Pollination

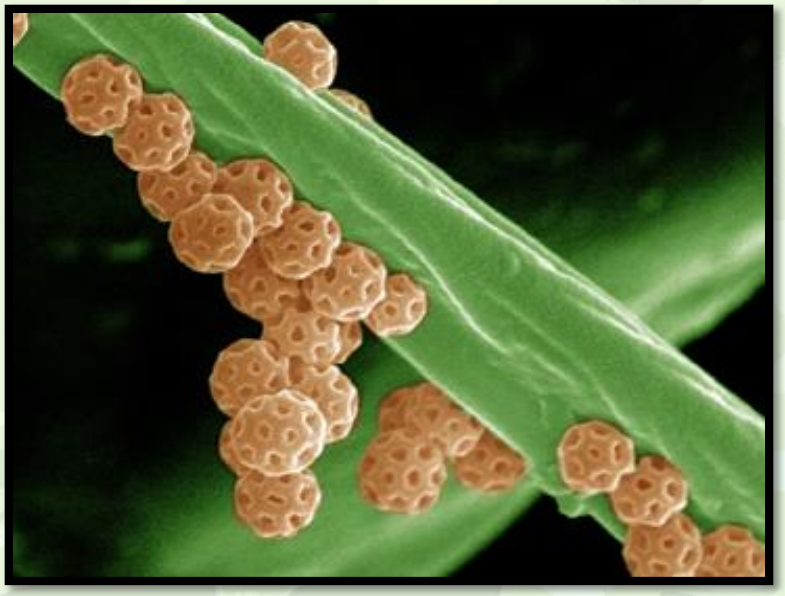


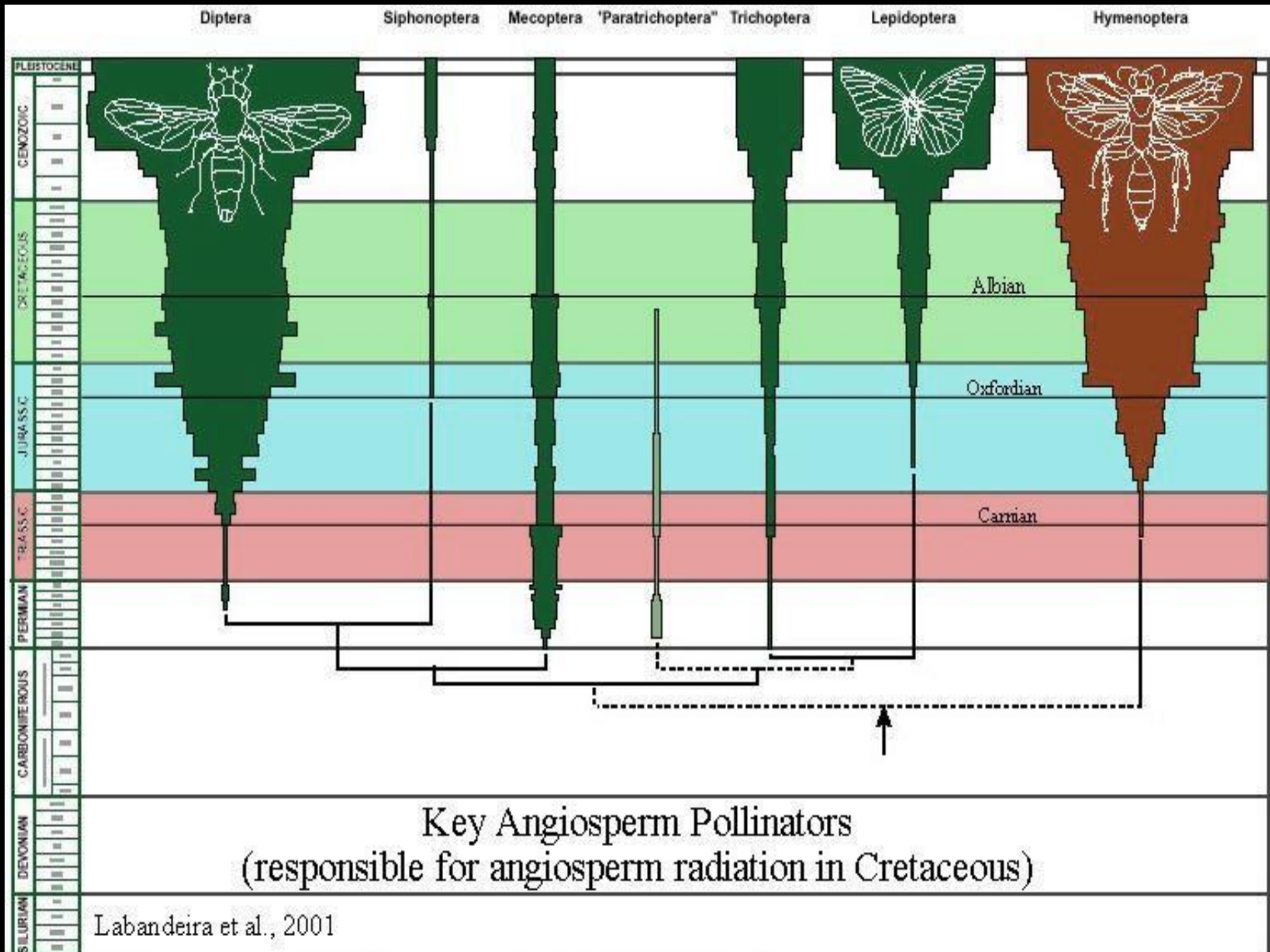
- Pollination depends on pollinators visiting flowers of the same species in sequence.
- To help ensure that this happens, the plants have various characteristics that aid pollinators including: color, size, shape, scent, as well as a food reward.

Animals as Pollinators

The majority of flowering plants rely on animals for pollination:

- **Insects** – bees, wasps, flies, butterflies, moths, and beetles
- **Birds** – hummingbirds and honey creepers
- **Mammals** – bats, mice, and even monkeys





Key Angiosperm Pollinators
(responsible for angiosperm radiation in Cretaceous)

Labandeira et al., 2001

For Pollinator

COMPETITION

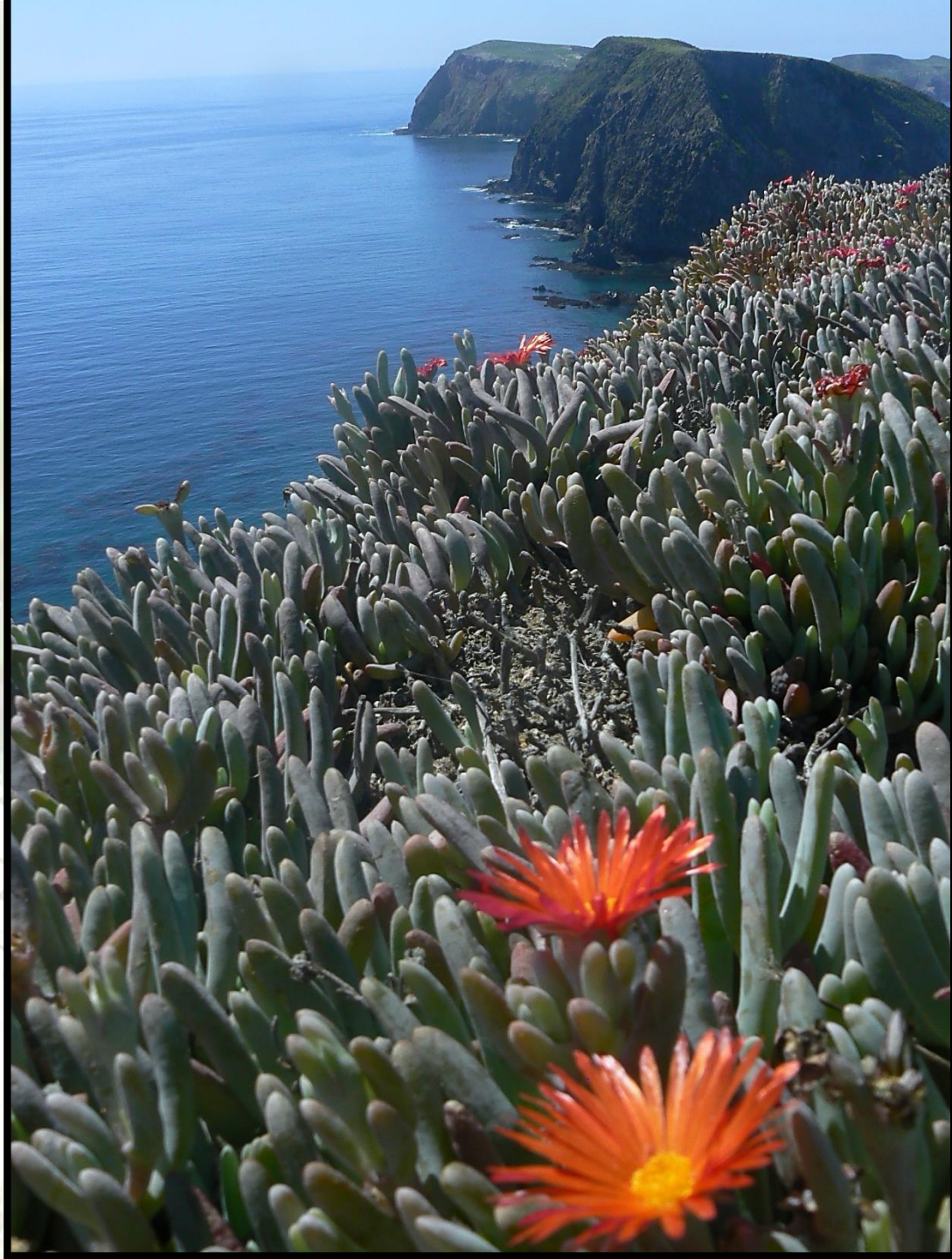
For Nectar

Pollinator Syndrome

Pollen Distribution

MUTUALISM

High energy sugars and amino acids



Pollinator Syndromes

Flower characteristics, or traits, that may appeal to a particular type of pollinator.

Characteristics can be used to predict the type of pollinator that will visit flower.

Characters: combination of color, odor, quantity of nectar, location and type of pollen, and flower structure

Affect a potential pollinator's ability to locate a flower and its food resources.

Bees-Apiophily

Flower Shape. Shallow; with landing platform; tubular

Opening.

Color. Bright white, yellow, blue, or UV

Nectar guides. Present

Odor. Fresh, mild, pleasant

Nectar. Usually present

Pollen. Limited; often sticky, scented

Butterflies-Psychophily

Flower Shape. Narrow tube with spur; wide landing pad

Opening. Day

Color. Bright red and purple

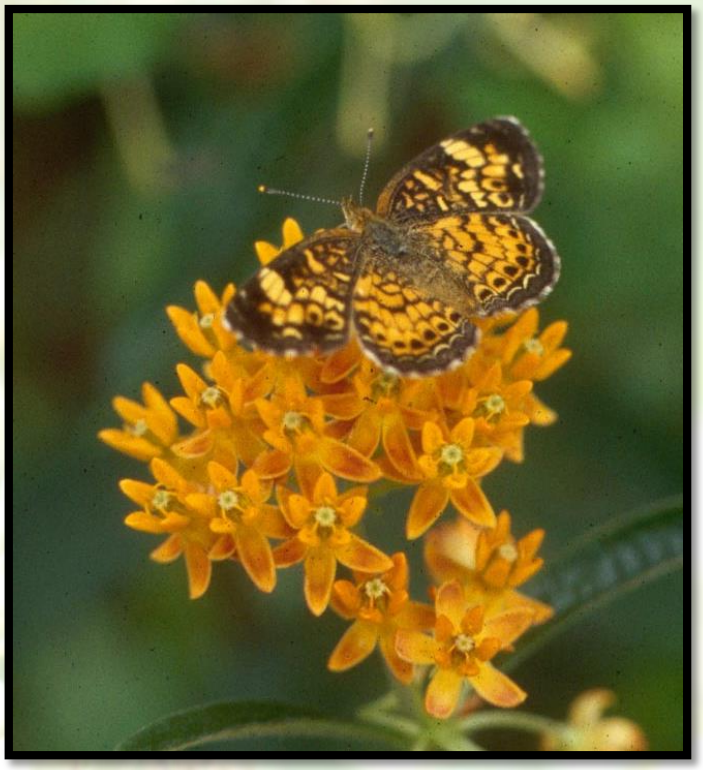
Nectar guides. Present

Odor. Faint but fresh

Nectar. Ample; deeply hidden

Nectar Comp. Sucrose-rich

Pollen. Limited



Moth-Phalaenophily

Flower Shape. Regular; tubular without a lip

Opening. Night

Color. Pale red, purple, pink or white

Nectar guides. None

Odor. Strong sweet; emitted at night

Nectar. Ample; deeply hidden

Nectar Comp. Sucrose-rich

Pollen. Limited

Fly-Myophily

Flower Shape. Shallow; funnel-like or complex with trap

Opening. Day/night

Color. Pale, or dark brown, purple

Nectar guides. None

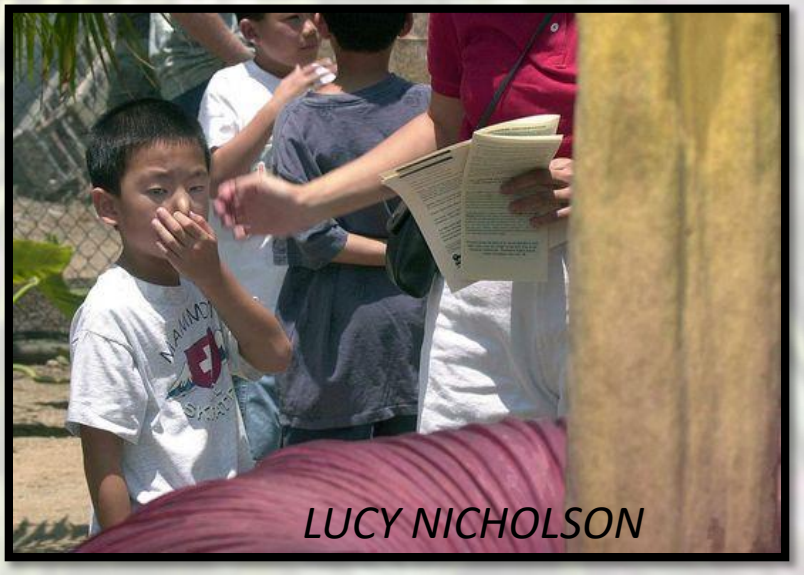
Odor. Putrid

Nectar. Usually absent

Nectar Comp. Amino acid-rich

Pollen. Limited

Amorphophallus titanum



Spadix releases chemicals

- **Benzyl alcohol-** sweet floral scent
- **Dimethyl disulfide** - limburger cheese-like
- **Trimethylamine** - rotting fish
- **Isovaleric acid** sweaty socks
- Thermogenic heat of 98-100°F

Beetle-Cantharophily

Flower Shape. Large and bowl-shaped

Opening. Day/night

Color. White or green

Nectar guides. None

Odor. None to strongly fruity or foul

Nectar. Sometimes present

Pollen. Ample

Bird-Ornithophily

Flower Shape. Large, funnel - like; strong perch support

Opening. Day

Color. Scarlet, orange, red or white

Nectar guides. None

Odor. None

Nectar. Ample; deeply hidden

Nectar Comp. Sucrose-rich

Pollen. Limited

Bats-Chiropterophily

Flower Shape. Bowl shaped; closed during day

Opening. Night

Color. White, green or purple

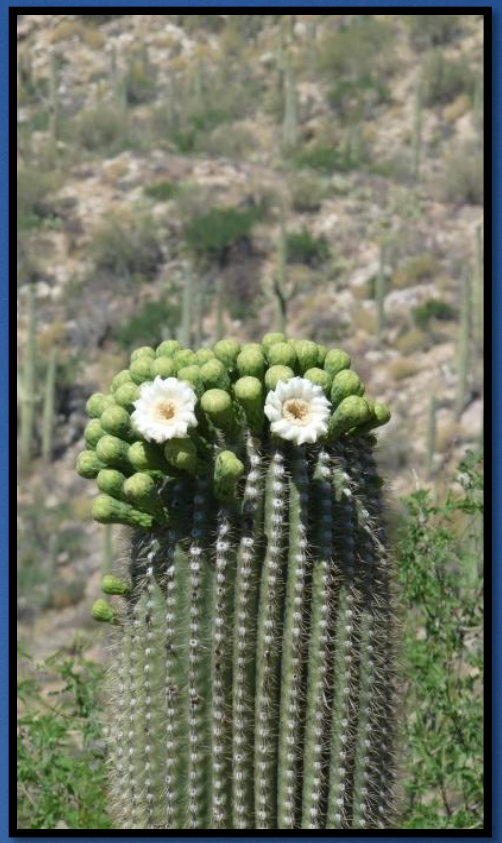
Nectar guides. None

Odor. Strong and musty, emitted at night

Nectar. Abundant; somewhat hidden

Nectar Comp. Sucrose Rich

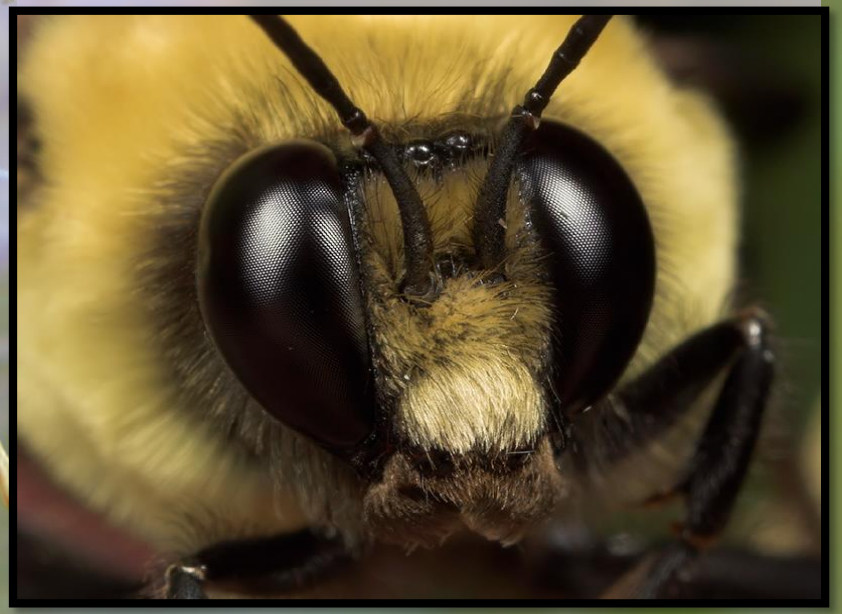
Pollen. Ample



A Pollinator's View

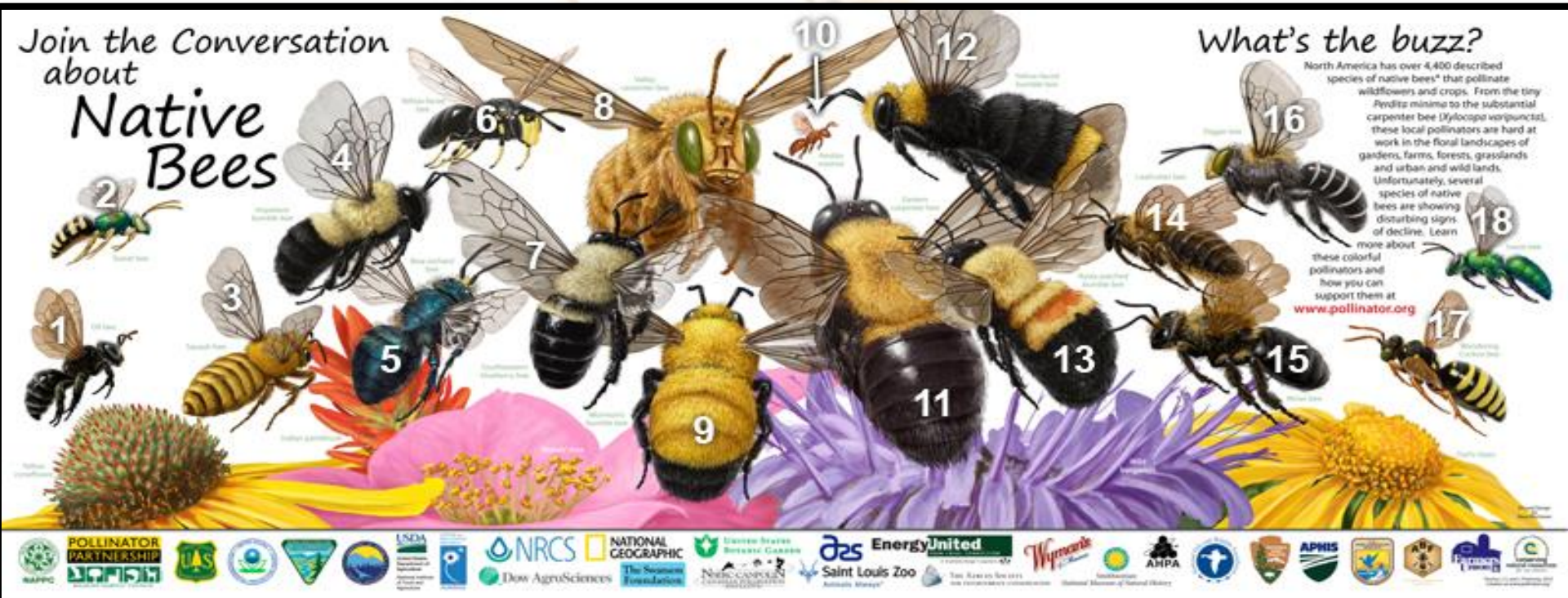
- Nectar-Energy
- Pollen-Nutrients
- Petals-Nesting Material (*Megachile*)

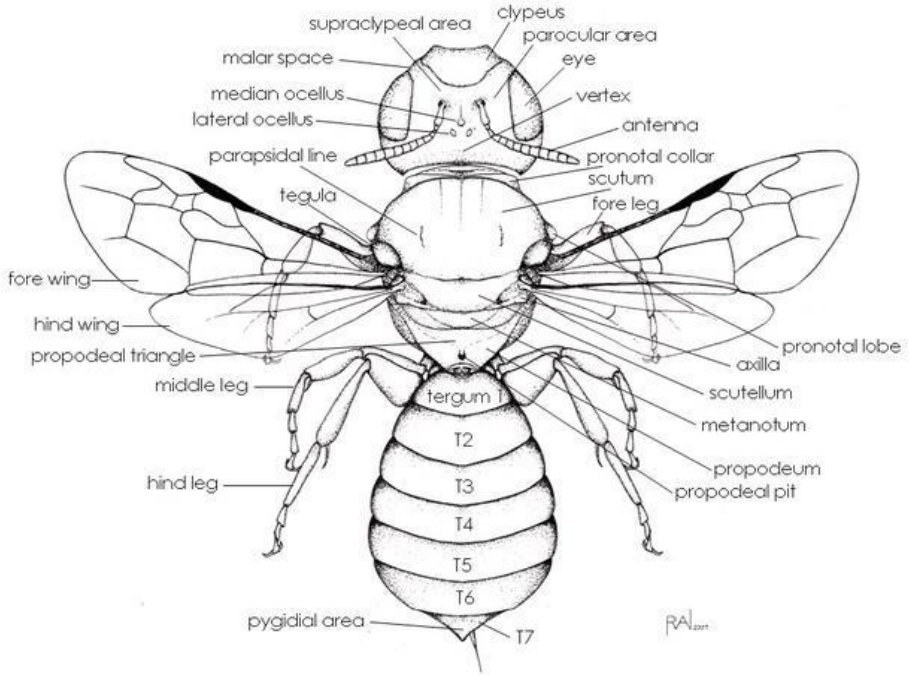
"What?! I am player in the not-so secret sex-lives of plants"

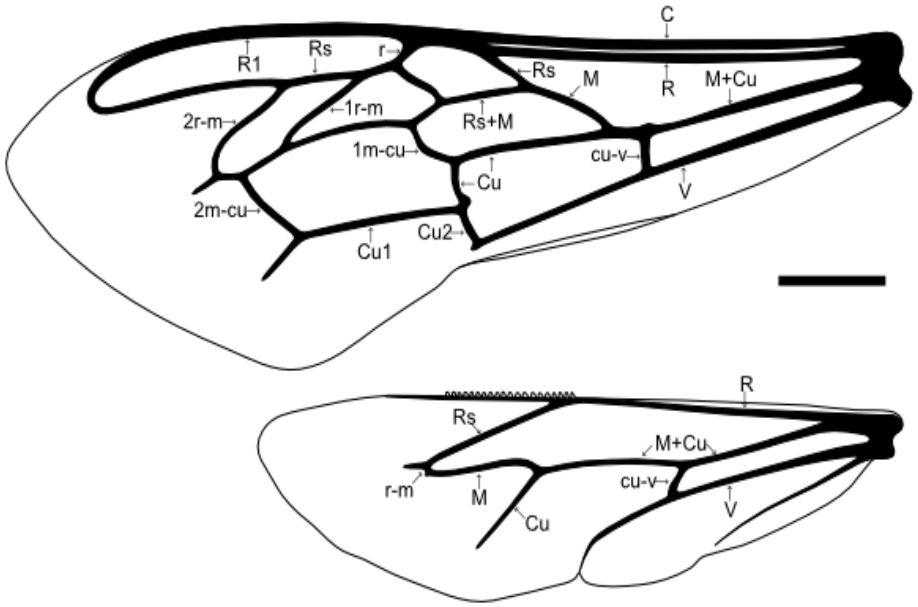


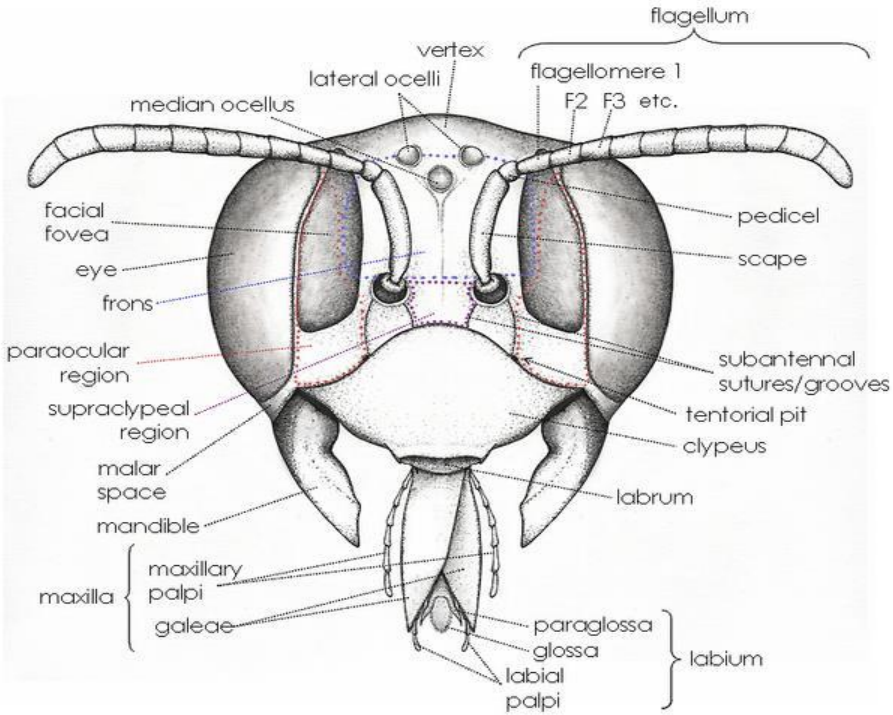
Major Groups of Bees.

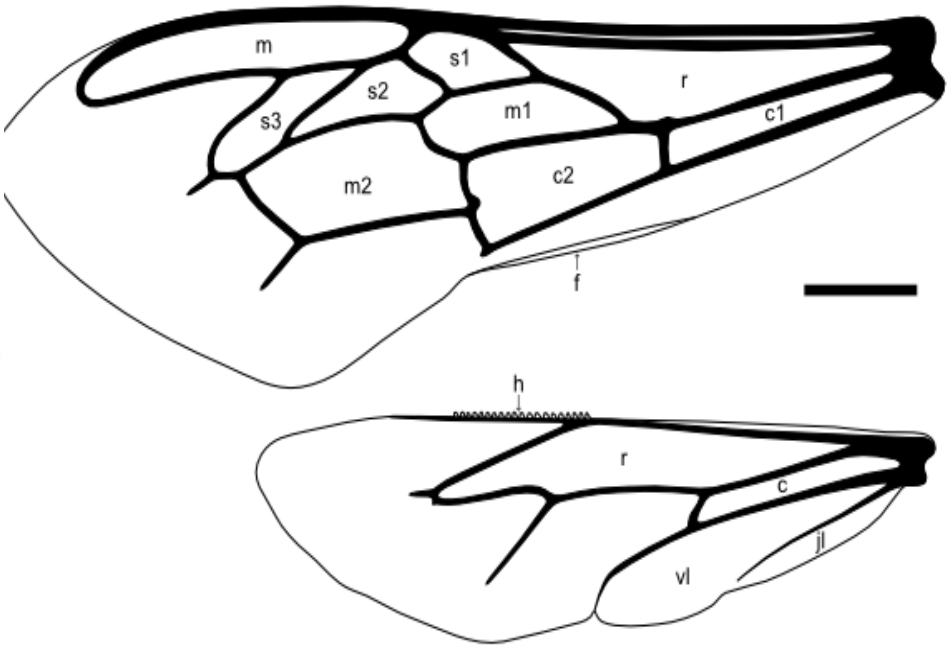
In North America there are a little over 4,000 species of bees. The majority of these occur in five common families: Andrenidae, Apidae, Colletidae, Halictidae, and Megachilidae.







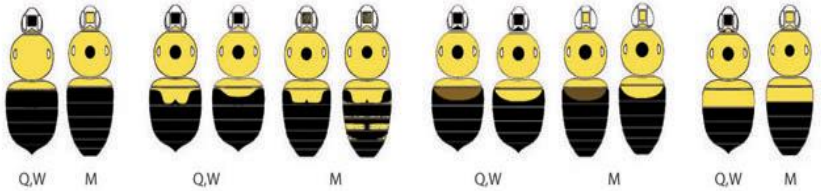





2007 © J. McGavin

Bumble bees of Illinois

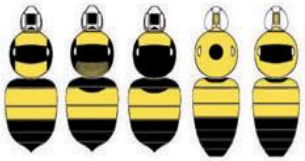
Color Group 1



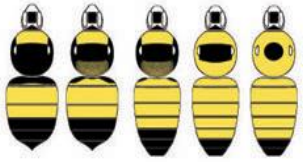
B. impatiens *B. bimaculatus* *B. griseocollis* *B. vagans*

B. affinis *B. fraternus*

Color Group 2



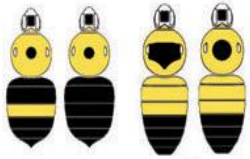
B. auricomus



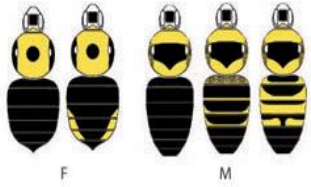
B. pensylvanicus

B. fervidus

Cuckoo Bumble bees



B. citrinus



B. variabilis

Bumble Bees of the Eastern United States

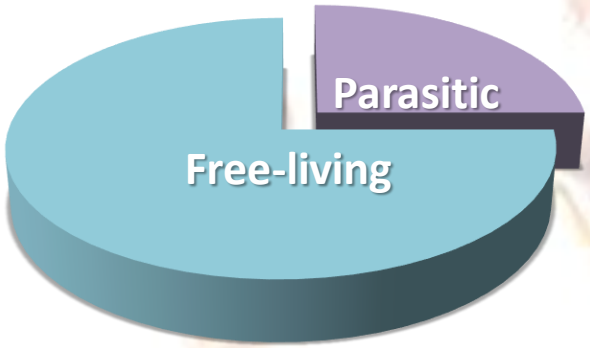
Twenty-one species of bumble bees (*Bombus* spp.) occur east of the 100th meridian. Within the genus *Bombus*, individuals vary dramatically within a species in color patterns, extent and intensity of colors on the head, thorax and abdomen. A representative color pattern is shown for each species. Facial shape is not pictured, but is a key component to accurate identification. Please refer to the depictions of color pattern and face shape in our published field guide, *Bumble Bees of the Eastern United States*, available at www.pollinator.org/bookstore and at www.fs.fed.us/wildflowers/pollinators/documents/BumbleBeeGuide.

To complicate matters further, bumble bees often mimic one another in color patterns, so they can be difficult to distinguish from one another especially on the wing as they go from flower to flower in your garden. The sizes of the bees on the poster are relative. The size of adult bumble bees is entirely dependent upon the amount of food they ate as larvae. Thus, even within the same colony of a species you can find one to very large workers, some of them approaching the size of the colony's queen.

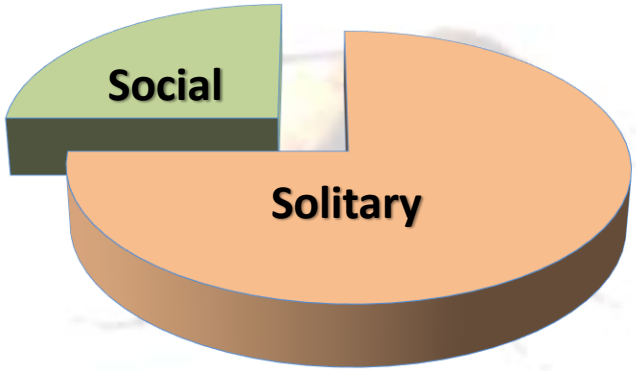
There are 47 bumble bee species in the entire United States and they are among our most important pollinators. These charismatic bees visit flowers with long corollas and abundant nectar. Bumble bees are important as commercial pollinators of tomatoes, along with certain wildflowers, which they buzz pollinate, causing themselves and living mating forks to harvest their pollen grains. At least 6 species in the U.S. are in trouble. Visit www.pollinator.org for more information and to see how you can help.

Major Groups of Bees.

Besides systematics organization, bees can be organized by ecology.



Cleptoparasitic (**Cuckoo Bees**) lays eggs w/in nest related bee species



Free-living Bees

A continuum of solitary nest-building bees to eusocial nesting-bees

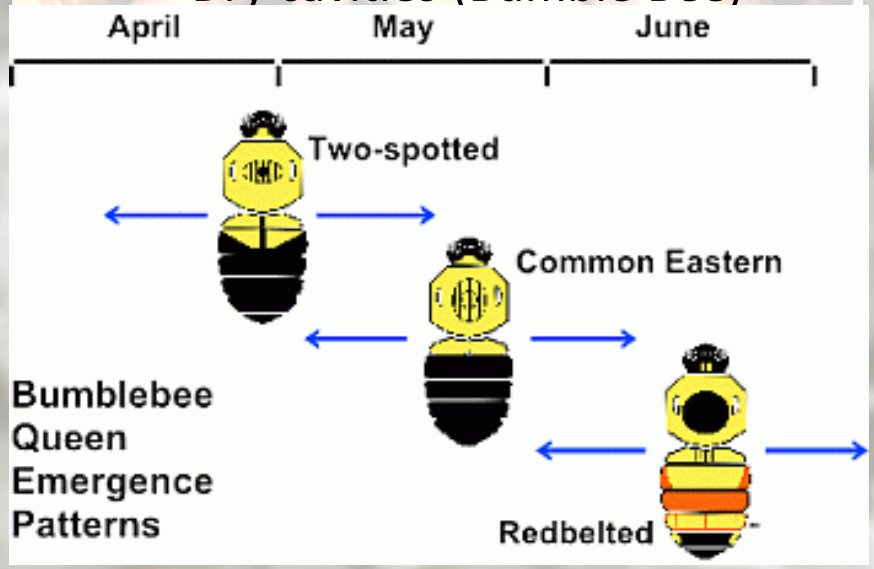
Nesting

Solitary Nest-Building

- Nesting is soil 2/3 Nest plant material
- Provisioned cells with pollen & nectar
  - **Leaf-cutting Bee-** Flower-lined cell
  - **Mason Bee-** Cell walls mud leaf pulp
  - **Carpenter Bees-** Wood fibers cell walls
  - **Masked Bees-** Cellophane-like material: secreted

Social Nest-Building

- 50 US spp.
- Provisioned cells with pollen & nectar, in collaboration with daughters and sisters
- Soil:
  - Underground Tunnels
  - Dry cavities (Bumble Bee)



Flower Selection

Polylectic

Oligolectic

Monolectic

Classified by Range of Plants

generalist, gathering pollen from **multiple genera** in one family

gather pollen from two to **several species** in one family

a **single species**

Vulnerability to Change

Wide range of plants-**most stable**

Various plants but focus-**semi-stable**

Specialist- **very vulnerable**

Aster Family (Asteraceae, 28 dependent bee species): One leaf-cutter bee, *Megachile apicalis*, specifically benefits from *Centaurea*, while the long-horned bee *Melissodes desponsa* specifically benefits from *Cirsium*. The other 26 bee species seem to have relatively broad tastes within the Aster Family.

Cabbage Family (Brassicaceae, 1 dependent bee species): The miner bee *Andrena arabis* is also very rare and has not been observed for several decades.

Dogwood Family (Cornaceae, 3 dependent bee species): Plants in the genus *Cornus*, in particular, are preferred by three rare species of miner bee (genus *Andrena*).

Heath Family (Ericaceae, 4 dependent bee species): Plants in the genus *Vaccinium (blueberries)* are primarily used by the miner bee *Andrena carolina* and the Southeastern Blueberry Bee *Habropoda laboriosa*.*Rhododendron* is utilized by *Andrena cornelli*.

Geranium Family (Geraniaceae, 1 dependent bee species): This miner bee, *Andrena distans*, is very rare.

Mallow Family (Malvaceae, 1 dependent bee species): As its common name suggests, *Ptilothrix bombiformis*, the Hibiscus Bee, specifically prefers *Hibiscus*.

Water-lily Family (**Nymphaceae, 1 dependent bee species)**: The small sweat bee *Lasioglossum nelumbonis*depends on flowers from water-lilies.

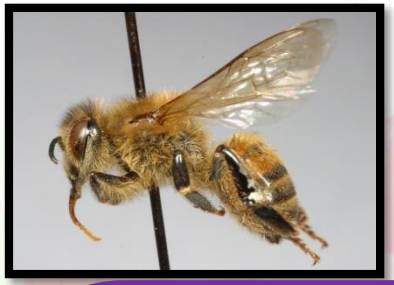
Evening Primrose Family (Onagraceae, 1 dependent bee species): *Lasioglossum oenotherae*, a small sweat bee, is dependent on evening primrose and other flowers in the genus *Oenothera*.

Rose Family (Rosaceae, 1 dependent bee species): The one dependent species is a

Flower Selection

Classified by Range of Plants

Polylectic



generalist, gathering pollen from **multiple genera** in one family

Oligolectic

gather pollen from two to **several species** in one family

Monolectic

a **single species**

Flower Constancy- bees attend to a particular plant species on any given foraging trip.

Plants want efficient pollen transport (Monolectic & Oligolectic)

Numerous Ant-Plant Interactions but…

Poor Pollinator!

Ants feed on nectar however,

- Not so hairy
- Chemical factories
- High morality

But still important for plants-a whole other story.

Poor Pollinators too!

Wasps feed on nectar and pollen however,

- Not hairy, hairs not plumose
- Opportunistic
- Little Flower Constancy

Beetles

- 30,000 US spp. Many considered pollinators
- 1st insect pollinators?
- Little flower-adaptation in beetles
- Important pollinators “primative-flowers” Magnolias
- Families include Solider (**Cantharidae**), Long-horned (**Cerambycidae**), Scarab (**Scarabaeidae**), Flower (**Melyridae**), and Pollen Beetles (**Nitidulidae**)
- Larval tunnels in wood create nesting sites for solitary bees.

Tetraopes melanurus

Asclepias tuberosa

T. tetraophthalmus

A. syriaca

T. quinquemaculatus

A. amplexicaulis
A. hirtella

Flies

- A few families: Flower Fly (**Syrphidae**), Bee Fly (**Bombyliidae**), Big-headed Fly (**Acroceridae**).
- Some flies are better pollinators than others
  - Most flies are less hairy than bees, but what they lack in hair they make up for in numbers

Syrphid) and Bee Flies are parasites of insect larvae notably butterflies and ground nesting bees.

Flies


Platanthera obtusata


Stinking Benjamin *Trillium erectum*


Arisaema triphyllum

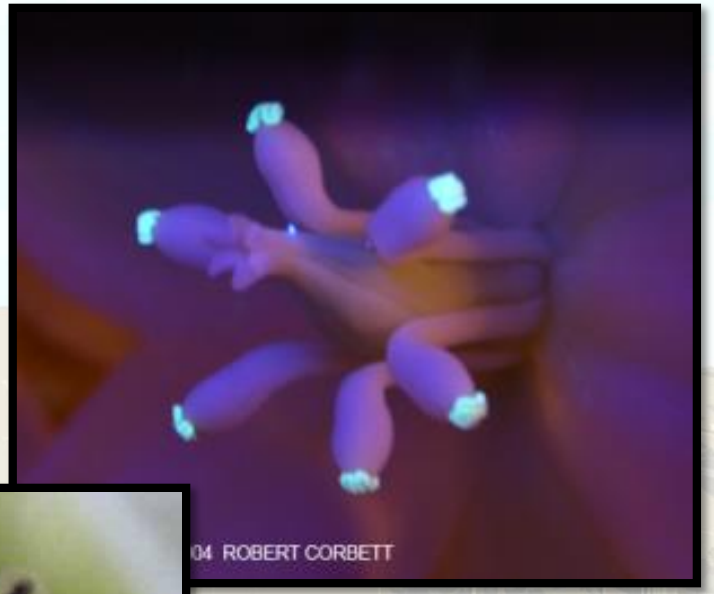
Lepidoptera-Butterflies and Moths

Butterfly ~196 spp. Moth 692 spp. Rough 861 species in the state (a lot of difference in resources vary). 20+ families

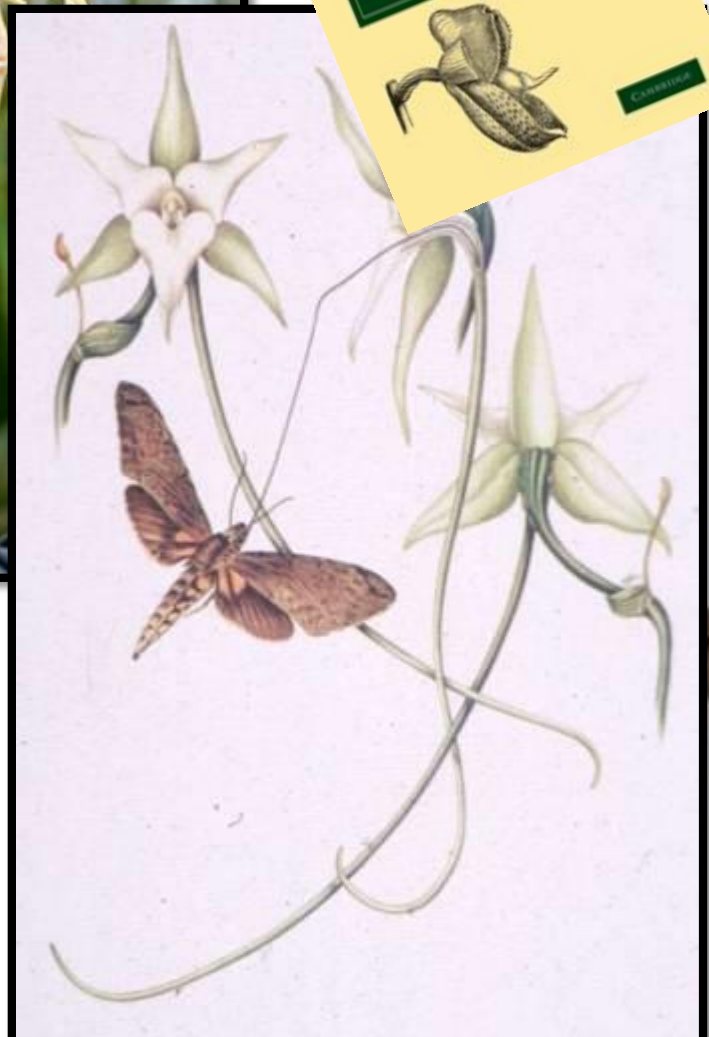
In addition to feeding on nectar and pollen this group also utilizes vegetation as host for larvae.

Yucca is a genus of perennial shrubs and trees in the family Asparagaceae a family of monocots.

Its 40-50 species are notable for their rosettes of evergreen, tough, sword-shaped leaves and large terminal panicles of white or whitish flowers.

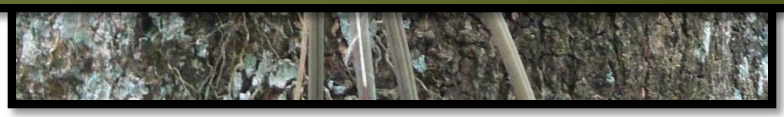



CAMBRIDGE LIBRARY COLLECTION
ON THE VARIOUS CONTRIVANCES BY WHICH BRITISH AND FOREIGN ORCHIDS ARE FERTILISED BY INSECTS
AND ON THE GOOD EFFECT OF INTERCROSSING
CHARLES DARWIN
CAMBRIDGE




NATURAL HISTORY MUSEUM LONDON

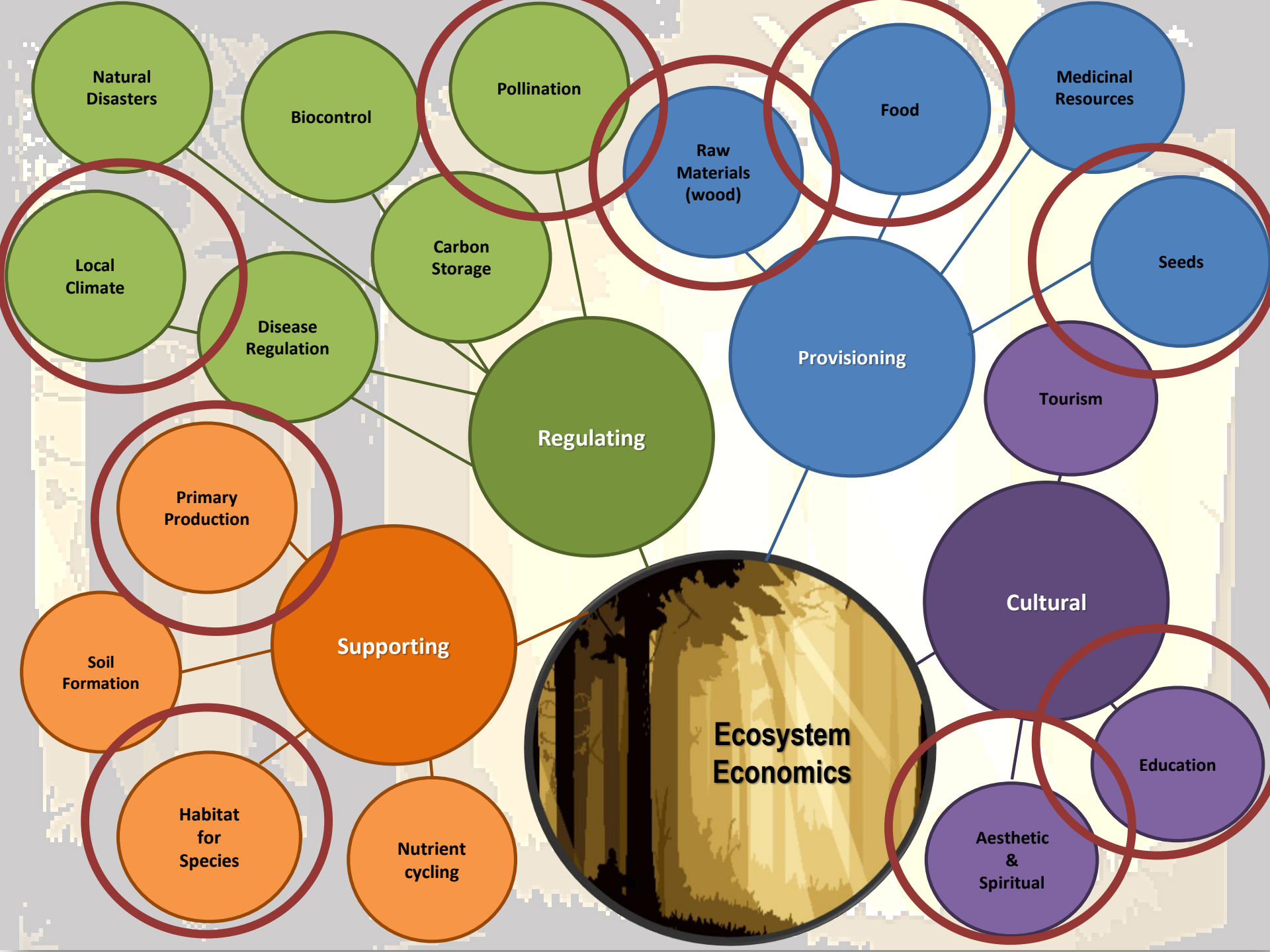
Orchids

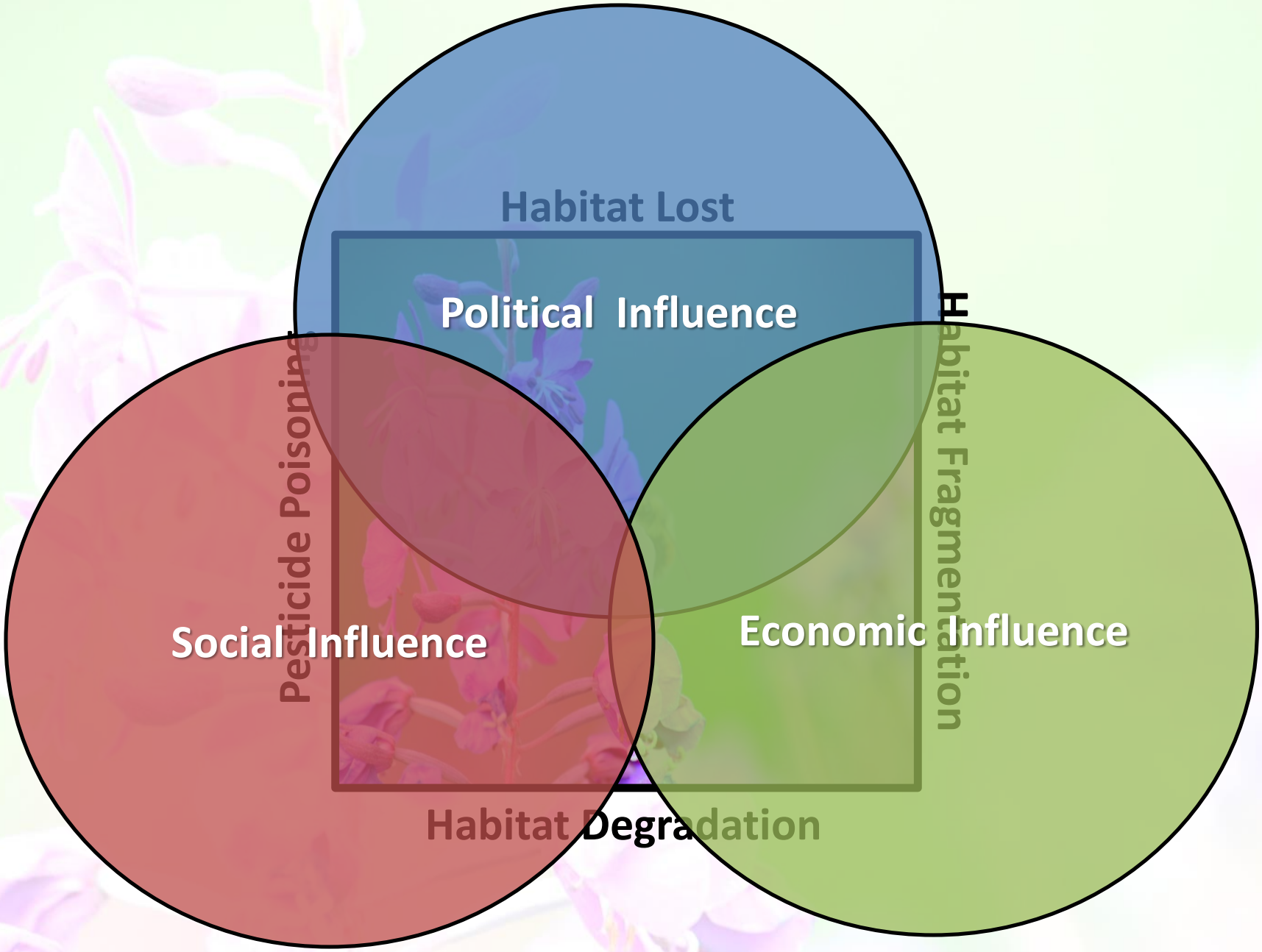


Cheating the System

- Nectar-robbing
- Nest-parasites
- Cleptoparasitism

Cheating the System


Natural Disasters
Biocontrol
Pollination
Food
Medicinal Resources
Raw Materials (wood)
Local Climate
Carbon Storage
Seeds
Disease Regulation
Provisioning
Tourism
Regulating
Primary Production
Supporting
Cultural
Soil Formation
Ecosystem Economics
Education
Habitat for Species
Nutrient cycling
Aesthetic & Spiritual


Habitat Lost
Political Influence
Pesticide Poisoning
Habitat Fragmentation
Social Influence
Economic Influence
Habitat Degradation

Scale…A Dab will Do

Small area can help with pollinators, most of us live in a pollinator desert, i.e. areas that are not suitable to support pollinator populations.

Creating small islands of resources can support limited populations.

Food resources

Water
Shrubs
Vines
Wildflowers
Ground cover
Night Garden

Nesting resources

Wood piles
Purchase bee homes
Cleared areas

Sometimes to find understanding, you need to stop looking up and start looking down.

Thank you