


---

---

---

---

---

---


---

---


### Temperate vs. Tropical

**Ecological interactions:**  
Do they play a greater role in structuring communities and ecosystems in the tropics than in the temperate zone?

- Greater species diversity & density
- Relatively favorable climate



Temperate Willow (*Salix sp.*) is wind-pollinated



Tropical Cannonball tree (*Couroupita guianensis*) is bat-pollinated.

---

---

---

---

---

---


---

---

### Types of Ecological Interactions

Interspecific vs. intraspecific

	Affect on	
	Sp.1	Sp.2
Mutualism	+	+
Antagonism	+	-
Commensalism	+	0
Amensalism	-	0
Competition	-	-



Some days you are the bug, some days you are the windshield.

**Symbiosis** = "living together". Not synonymous with mutualism.

---

---

---

---

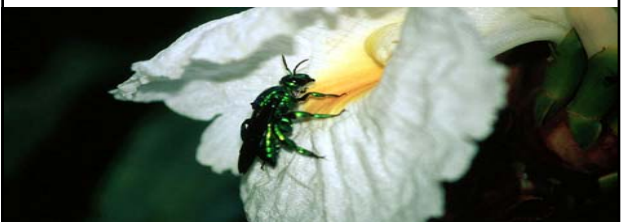
---

---

---

---

### Mutualism Examples (+,+)



- Pollination
- Seed-dispersal
- Mycorrhizae
- Reef-building
- Human digestion

---

---

---

---

---

---

---

---

### Pollination



Cecropia is wind pollinated

~95% of tropical tree species are animal-pollinated  
 80% of temperate trees are wind-pollinated

---

---

---

---

---

---

---

---

### Pollination - Insects

#### Entomophily



**Bees**  
 yellow  
 nectar guides  
 sweet smell  
 day



**Butterflies**  
 red  
 tubular  
 odorless  
 day



**Moths**  
 light color  
 nectar tube  
 open @ night



**Flies**  
 reddish  
 rotten smell

---

---

---

---

---

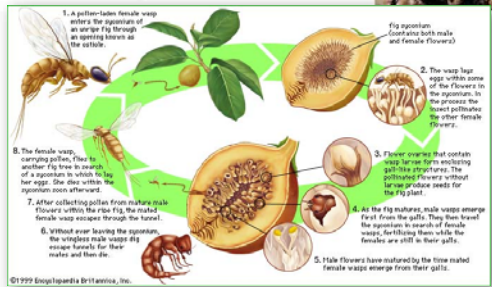
---

---

---

### Fig Pollination by Fig Wasps

- A highly specialized **obligate mutualism**
  - neither can reproduce without the other



The diagram illustrates the cycle of fig pollination by fig wasps. It shows a female wasp entering a fig through an ostiole, depositing pollen and an egg into the fig's ovary. The egg develops into a male wasp, which then emerges to find a new female wasp to pollinate. The fig's ovary contains both male and female flowers.

1. A pollen-laden female wasp enters the apertures of an unripe Fig through an opening known as the ostiole.

2. The wasp lays egg within some of the flowers in the ovary. In the process, she has just pollinated the other female flowers.

3. Flower ovaries that contain viable larvae form enclosing gall-like structures. The gall wasps are without larvae produce seeds for the fig plant.

4. As the fig matures, male wasps emerge first from the galls. They then travel the apertures in search of female wasps, fertilizing them while the females are still in their galls.

5. Male flowers have matured by the time mated female wasps emerge from their galls.

6. Without ever leaving the apertures, the wingless male wasps dig escape tunnels for their mates and then die.

7. After collecting pollen from mature male flowers within the ripe fig, the mated female wasp escapes through the tunnel.

8. The female wasp, carrying pollen, flies to another fig tree to repeat the cycle. She also enters the apertures soon afterward.

9. Fig apertures (Contains both male and female flowers)

©1999 Encyclopædia Britannica, Inc.

---

---

---

---

---

---

---

---

---


---

---

---

### Pollination - Bats

Chiropterophily



open at night  
white or light colored  
large & visibly placed  
musty odor  
sturdy construction

large eyes  
long tongues  
good olfaction  
reduced echolocation

Anoura bat pollinates *Burmeistera* flower

---

---

---

---

---

---

---

---

---

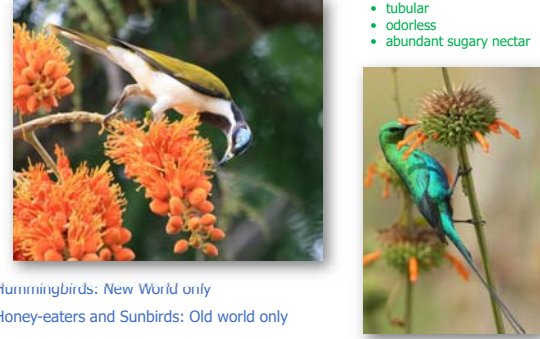
---

---

---

### Pollination - Birds

Ornithophily



- red, orange, pink
- tubular
- odorless
- abundant sugary nectar

Hummingbirds: New World only  
Honey-eaters and Sunbirds: Old world only

---

---

---

---

---

---

---

---

---

---

---

---

### Floral Rewards

**Nutritive rewards**

- Nectar
- Pollen
- Food bodies

**Non-nutritive rewards**

- Nesting materials (waxes, hairs)
- Brood places
- Heat
- Sleeping places
- Sex
  - pheromones
  - [pseudocopulation](#)



2012 © Alberto D. Tuttle  
*Eonycteris on Parkia*

**Animal pollinator provides non-random deposition of gametes**

---

---

---

---

---

---

---

---

---

---

---

---

### Beetle pollination of thermogenic flowers

*Victoria amazonica*



many beetles are phytophagous



---

---

---

---

---

---

---

---

---

---


---

---

### How do Mutualisms Come About?

**Reproductive Assurance** = Evolution always favors traits that assure reproduction.

An interaction that increases the likelihood of reproduction (fitness) of those involved is **self-reinforcing**.



*Agraecum* orchids are pollinated by long-tongued Hawkmoths.

---

---

---

---

---

---

---

---

---

---

---


---

### Frugivory & Seed Dispersal

Why is this feeding guild much more prominent in the tropics?

- year-round fruit availability
- high plant diversity
- limited wind

**Endozoochory vs. Ectozoochory**




---

---

---

---

---

---

---

---

### Figs (*Ficus*) – 800 spp.

Fruit production is costly!

Read Kricher p. 158



1274 bird and mammal spp. are known to eat figs! (Shanahan 2001)

---

---

---

---

---

---

---

---

### Benefits of Zoochory

Making fruit is **expensive!**  
But 50 - 90% of tropical plants are animal dispersed!

**Selective advantages:**

- long-distance dispersal
- non-random
- fruits deposited with fertilizer
- scarification
- genetic mixing
- expansion of range

*Where is wind or water dispersal more common?*




---

---

---

---

---

---

---

---

### Evolutionary Consequences of Zoochory

Long-distance dispersal: rare but important!

Frugivores (and seed predators) influence the survival and spacing of trees, and thus forest structure & diversity!

---

---

---

---

---

---

---

---

---

---

### Evolutionary Consequences of Frugivory

**Frugivory:** Diet >50% fruit

- Abundant, easy to “catch”
  - “free time” for courtship
  - high frugivore biomass
  - less competition
- Patchy
  - High mobility
  - Sociality – mixed-species flocks
- Low protein & fat content

Read Kricher pp.157-168  
Figs, Fruitcrows, Peccaries & Manakins

Wire-tailed manakins may spend 90% of their day courting females

---

---

---

---

---

---

---

---

---

---

### Lipid-rich fruits

**Arils** on nutmeg (*Viola*: Myristicaceae)

Avocado family: **Lauraceae**

**Elaiosomes** on ant-dispersed plants

---

---

---

---

---

---

---

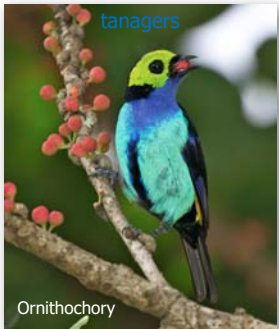
---

---

---

**Important Frugivores**

tanagers



Ornithochory

primates



Spider monkeys eat 250 species, disperse 200,000 fruits/year.  
Ave. distance ~250m, max. 500m (Dew 2011)

---

---

---

---

---

---

---

---

---

---

**Scatter-hoarding by Agoutis**




---

---

---

---

---

---

---

---

---

---

**Cauliflory & Mammal Dispersal**



A holdover from extinct large ground mammals?



*Couroupita guineensis* – Cannonball tree

---

---

---

---

---

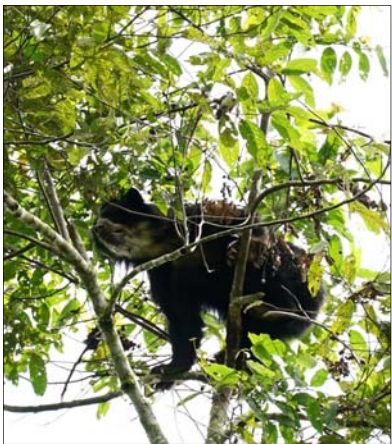
---

---

---

---

---



**Spectacled Bear**  
feeding on fat-rich Lauraceae fruits

---

---

---

---

---

---

---

---

**Frugivorous Fish**



**Ichthyochory** by Tambaqui (*Colossoma macropomum*)  
in flooded forest

Kricher p. 169

---

---

---

---


---

---

---

---

**Seed Predation Trade-off**



Agoutis Peccaries Tapir  Parrots Doves Squirrels  Bruchid beetles	<b>Plant Adaptations:</b>  hard seed coat  seed toxicity  temporal avoidance  masting
---	---

---

---

---

---

---



---

---

---

**Herbivory (+,-)**

- ~30% of plant biomass removed
- ¾ by phytophagous insects
  - Caterpillars (Lepidoptera)
  - Beetles (Coleoptera)
- Plants defend themselves!


---

---

---

---

---

---

---

---

**Leaf-cutter Ants (*Atta* spp.)**



Kricher pp. 174-177

---

---

---

---

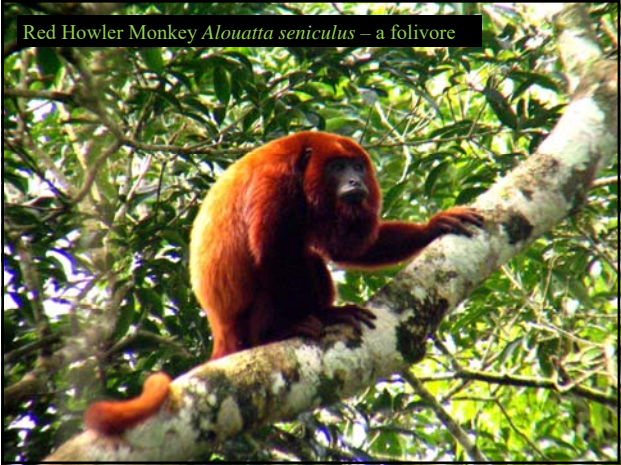
---

---

---

---

**Red Howler Monkey *Alouatta seniculus* – a folivore**




---

---

---

---

---

---

---

---

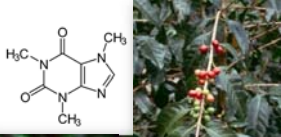

**Plant Chemical Defenses**

**"Secondary compounds"**

**Alkaloids (15% of all plants)**

- **N-containing bases**
  - nicotine, caffeine, cocaine, morphine, theobromine, strychnine
- disrupt liver & membrane function, acetylcholine transmission
- 4,000: many toxic, many medicines!

Coffee beans, and periwinkle, source of Vincristine leukemia medicine  
Read Kricher 187-192


---

---

---

---

---

---



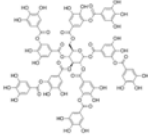
---

---

**Plant Chemical Defenses**

- **Phenolics (incl. tannins)**
  - hydroxyl group on aromatic hydrocarbon; water soluble
    - spices, capsaicin (hot chilis), menthol, aspirin
  - bind with proteins, reduce digestibility
  - antimicrobial
  - affected by leaf age, light

Tannic acid  
 $C_{76}H_{52}O_{46}$


---

---

---

---

---

---

---

---

**Plant Chemical Defenses**

- **Terpenoids**
  - 22,000 compounds
  - mimic insect growth hormones
  - antifungal
    - leaf-cutters avoid
- **Cyanogenic glycosides**
  - *Passiflora*, manioc (prussic acid)
  - blocks  $Na^+$  channels
  - muscle paralysis

Passionflowers contain cyanogenic glycosides. *Heliconius* butterflies specialize on them.

squeezing toxins out of manioc




---

---

---

---

---

---

---

---

### Mechanical Plant Defenses







thorns, spines, hairs, sticky latex, toughness, delayed greening

---

---

---

---

---

---

---

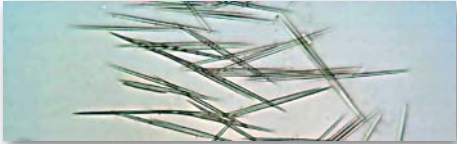
---

### Patterns of Plant Defenses

- Tropics > Temperate
- Younger tissues > Older tissues
- High sunlight > low sunlight
- Soil fertility
  - Very low fertility → "cheap" 2° compounds (tannins)
  - Low fertility → high diversity of 2° compounds
  - High fertility → few 2° compounds
- Seasonality → dry climates = more mechanical defenses

Defenses are expensive to produce  
Trade-off between defense and growth

"Raphides"  
Calcium oxalate  
crystals in Araceae



---

---

---

---

---

---

---

---

### Ant-Plant Mutualisms


**Protectionist theory**

**Myrmecophytes** provide reward for ants in exchange for protection

- extrafloral nectaries
- food bodies
- domatia

**Many Examples!**

*Cecropia* and *Azteca*  
*Inga* and various ant spp.



Read Kricher pp 192-194  
<https://www.youtube.com/watch?v=KIAEzIF2y0M>

---

---

---

---

---

---

---




---

### Predation and Herbivory as Selective Forces

Natural selection works to **reduce the NEGATIVES (-)**

**Leads to evolution of:**

- crypsis and mimicry
- escape tactics
- defensive armor & toxins
- aposematic coloration
- infochemicals?

---

---

---

---

---

---

---

---

---


---

### Warning Coloration & Mimicry

**Müllerian mimicry**

convergent colors among toxic species



- Heliconius butterflies (below)
  - bees and wasps
  - coral snake species



**Batesian mimicry**

non-toxic spp. mimic toxic ones

- non-toxic sp. must be less abundant
  - Coral snake vs. king snake
  - Viceroy vs. monarch

---

---

---

---

---

---

---

---

---

---



**Crypsis**

A Fer-de-Lance (*Bothrops asper*) hides amid dry leaf litter. A "sit-and-wait predator," its camouflage perfectly suits its hunting style.

---

---

---

---

---

---

---

---

---

---

**Parasitism**

One organism living within or on a host, from which it obtains some benefit, to the detriment of the host

Cordyceps parasitism on insects

---

---

---

---

---

---

---

---

Parasitoids

---

---

---

---

---

---

---

---

**Commensalisms - Some Examples**

Epiphytes (above) cling to a tree trunk; sea turtle shell provides a home for algae

"Hitch-hiking" seeds stick to fur or skin for transportation; a bird louse (left) hitches a ride on a fly's legs.

---

---

---

---

---

---

---

---

**Coevolution – a two-way street**

Ecological interactions exert powerful **selective pressures** on both species.

**Coevolution** = the evolution of one species in response to the evolution of another.

- e.g., long proboscis in butterflies and long tubular flowers
- e.g., toxic plant and caterpillar that eats it

**Selection works to reduce the negatives (minuses) in the interaction.**



---

---

---

---

---

---

---

---