

Throughout Nature Many Symbiotic Relationships have Evolved.

Symbiotic Relationships = close, prolonged associations between two or more different biological species.

- + = If a species is benefitted by the interaction
- = If a species is harmed by the interaction
- = If a species is not benefitted nor harmed by the interaction

Predation (+/-) drives evolution

- Interaction in which one species, predator, kills and eats the other, prey.
 - ◆ Eating and avoiding eating are necessary for reproductive success
 - Natural selection refines adaptations of both predator and prey over time.

- **Predators adaptations**

- ◆ Ways to locate & subdue prey
- ◆ Acute senses
- ◆ Claws, teeth, fangs, stingers, poisons, horns, speed, coloration

- **Prey adaptations**

- ◆ Ways to elude & defend
- ◆ Fast and agile
- ◆ Disguises & coloration
- ◆ Behaviors like hiding fleeing, forming herds or schools
- ◆ Alarm calls



Predation provides a strong selection pressure on both prey & predator!

Anti-predator Adaptations Include the Ability to:

- Hide from predators

- ◆ Avoid detection using camouflage (*crypsis* or *cryptic coloration*)



- Warn predators

- ◆ Advertise how undesirable you are as prey
- ◆ Fake undesirability by evolving to look like something harmful



- Defense coloration

1. Cryptic Coloration
2. Aposematic Coloration
3. Batesian Mimicry
4. Müllerian Mimicry



Cryptic coloration

■ Camouflage (crypsis)

◆ Difficult to spot prey

- Prey may survive predators better
- Prey may be able to hunt or scavenge for food more successfully



Natural Selection favors those **phenotypes** that help an organism survive and reproduce.

Types of Mimicry

Convergent evolution

Batesian mimicry

palatable or harmless species mimics a harmful model



hawkmoth larvae



green parrot snake

Hawkmoth larva puffs up to look like poisonous snake

Natural Selection selects for those phenotypes that enhance the survival and reproductive success of organisms.

- ★ Predators that have a bad experience with a harmful species or that have evolved an innate fear of a harmful species, may avoid interacting with other species that look very similar, causing those non-harmful organisms that look most similar to a harmful species to have greater survival and reproductive success.

Batesian mimicry

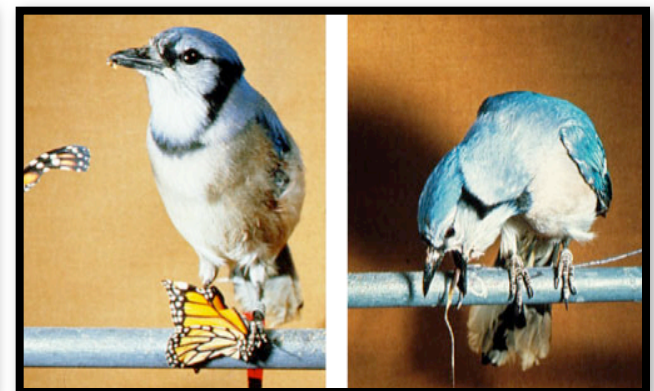
Convergent evolution



Monarch male
poisonous



Viceroy male
edible



★ the biological fitness of a non-harmful organism goes up as the population evolves to look more like a harmful species.

Which is the fly vs. the bee?



fly



bee

Which is the moth vs. the bee?



moth



bee

Types of Mimicry

Müllerian mimicry

two or more harmful, unpalatable species come to look like each other



cuckoo bee



yellow jacket

Adaptive benefit = group defense

- ★ predators may evolve innate avoidance to all animals that have a similar appearance (*those that do not innately avoid preying on dangerous organisms have decreased survival and reproduction rates so their alleles do not get passed down at equal rates to those that innately avoid harmful organisms and thus have higher reproductive success, passing down the alleles to produce this adaptation*)

Evolution of common warning colorations

- **Aposematic Coloration** = warning coloration
 - “Apo” = away & “sematic” = sign/meaning
 - ◆ Predators have evolved to be cautious in dealing with potential prey with bright color patterns
 - Aposematic species come to resemble each other since those that look alike have increased biological fitness.



black, red,
orange & yellow means:
DON'T EAT ME!



What kind of mimicry?



**Coral snake
is poisonous**



King snake is not

**Red on yellow, poison the fellow;
Red on black, safe from attack**

Batesian Mimicry

Herbivory (+/-) is a kind of predation

- Interaction in which an organism eats parts of a plant or algae
 - ◆ Predators adaptations
 - Ability to distinguish between toxic and nontoxic plants
 - Ability to distinguish between more nutritious and less nutritious plants
 - Good sense of smell to detect key chemicals
 - Specialized teeth or digestive systems
 - ◆ Prey adaptations (*plants cannot run away*)
 - Spines, thorns
 - Chemical Toxins
 - ◆ Strychnine, nicotine
 - Distasteful chemicals
 - ◆ Cinnamon, peppermint, clover



Predation adds a strong (natural) selection pressure on both prey & predator!



Parasitism (+/-)



- **Symbiotic interaction in which one organisms, the parasite, derives its nourishment from another organism, its host**
 - **Unlike predation, parasitism does not necessarily result in direct death of the parasitized organism**
 - ◆ **The host is harmed in the process though.**
 - **Endoparasites = live within the body of their host**
 - ◆ **Ex: tapeworm**
 - **Ectoparasites = live on the external surface of their host**
 - ◆ **Ex: Parasitoid insects or ticks and fleas**
 - ◆ **Parasites negatively affect the survival, reproduction, and population density of host populations directly or indirectly**
 - **May weaken host by withdrawing blood and nutrients**
 - ◆ **Could cause weakened immune function or inability to repair body, avoid predation, forage for food**
 - **May cause fur breakage deteriorating the protection against physical injury or insulation fur provides**
 - ◆ **Could cause cold stress or easier predation**
 - **Breaks in the skin or digestive track epithelium, can allow pathogens like bacteria or viruses to enter the body of the host.**



The Interesting Case of Nest Parasitism

- Brood parasitic birds lay their eggs in the nests of other bird species, sparing themselves the expense of rearing their own young.



- ◆ The cost of rearing offspring is transferred to another

- For the parasite population benefits include:

- ◆ Increased fecundity (reproductive success) due to greater allocation of resources toward mating and producing more eggs rather than defending nests, incubating eggs, and feeding young.

- Costs to the host population include:

- ◆ Diminished nestling growth rate, due to competition with larger and more competitive parasitic offspring (cowbirds, whydahs)
- ◆ Total loss of breeding by the abandonment of parasitized broods (cowbirds, cuckoos)
- ◆ The eviction (destruction) of all host eggs by the early-hatching parasites (cuckoos)
- ◆ The killing of host hatchlings by parasitic hatchlings



The Interesting Case of Nest Parasitism

- ◆ This interaction results a coevolutionary arms race including the evolution of sophisticated defenses by hosts and escalating tools of exploitation by parasites.



- Natural selection favors adaptations that protect against brood parasitism in the host birds:
 - ◆ Hosts evolving to discriminate against and reject foreign eggs or chicks based on visual, acoustic, or multimodal sensory cues
- Natural selection favors adaptations that make brood parasites more successful:
 - ◆ The eggs of many brood parasites, for example, mimic those of their hosts (to deceive hosts to accept)
 - ◆ Eggs may evolve harder shells (to impede rejection by puncture)
 - ◆ Eggs may evolve to require slightly shorter incubation times (causing a size advantage for parasitic nestlings which will be bigger than the host nestlings)



Mutualism (+/+)

- **Symbiotic relationship in which the inter-specific interaction benefits both species**



- ◆ **Ex: digestion of cellulose by microorganisms in the digestive systems of termites and ruminant mammals like cows**

- Cow obtains some glucose from actions of bacteria and bacteria get a place to live and access to amino acids, ions, water etc consumed by the cow

- ◆ **Ex: Acacia trees with hollow thorns house stinging ants**

- Ants feed on nectar produced by the tree and the protein-rich swellings
- Tree benefits because ants attach anything that touches it, remove fungal spores, small herbivores, debris, clip other vegetation surrounding tree



- ◆ **Obligate mutualism**

- One species lost ability to survive without its partner species

- ◆ **Facultative mutualism**

- Species can still survive without each other



Commensalism (+/0)



- Interaction between species that benefits one of the species, but neither harms nor helps the other species
 - ◆ Ex: “hitchhiking” species like algae on turtle shells, barnacles on whales, epiphytes growing on taller trees, or a bird building a nest in a tree get a substrate to grow on, better access to sunlight for photosynthesis, access to nutrients in the water passing by as the animal swims along, or space to raise their young.
 - These “hitchhikers” do not remove resources from, cause physical harm, or donate resources to the turtle, whale, or tree.
 - ◆ One species provides the other species a place to grow and inadvertently exposes the other species to a valuable resource



Amensalism (-/0)



- **Biological interaction where one species causes harm to another organism without any cost or benefits to itself.**
 - ◆ A larger, physically stronger organism deprives a smaller, weaker organism from food or space.
 - ◆ An organism is either damaged or killed by a chemical secretion produced by the normal metabolic processes of another organism.
- **Ex: When cattle trample on grass, the grass is crushed. However, the cattle do not benefit from this action nor is harmed in the process.**
- **Ex: Humans waste seeps into the river harming the fish populations**
- **Ex: When one plant grows and shades out a smaller plant below**
- **Ex: When a proportionally very large organism like a goat feeds on the same type of shrub as a tiny organism like a beetle. The goat is unharmed when the tiny beetle eats some of the shrub, but the beetle loses significant quantities of food due to the goat and may accidentally even be eaten by the goat.**
 - ◆ **Note: If the beetle population becomes large though then this interactions may be seen as competition (not amensalism) since the goats are obtaining significant fewer resources with the beetle population present and the beetle obtain fewer resources with the goat population present.**



Symbiosis

Epiphytes are plants that live on trees, but are NOT parasites feeding on the tree's sugar

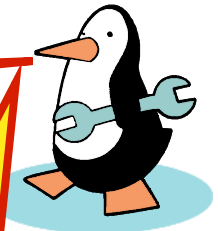
commensalism

+ / 0

mutualism

+ / +

No funny business for a clown fish



predation

+ / -

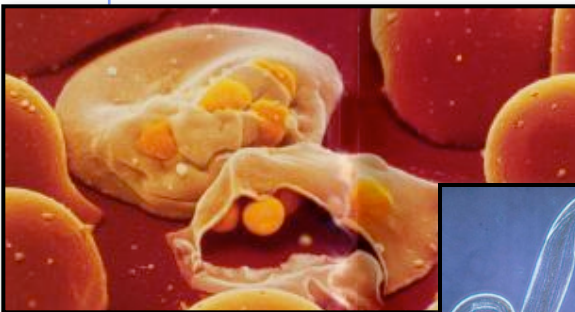
Parasitism

+ / -



Coevolution in Community

- two (or more) species may reciprocally affect each other's evolution.
 - ◆ Predator-prey relationships
 - ◆ Parasite-host relationships
 - ◆ Flowers & pollinator relationships



Long term evolutionary adjustments between species