Mutualisms

• Mutualism is an association between two species that benefits both.
• Mutualisms involve the trading of resources or services between two species.
  – Resources traded include nectar, pollen, scents, honeydew, other forms of nutrients, and housing.
  – Services traded include protection against natural enemies and the transportation of adults (phoresy), their gametes (pollination) or their offspring (seed dispersal).
Types of mutualisms

- **Obligate mutualisms** occur when neither participant can survive without the other (e.g., leaf-cutter ants and their fungus, lichens).
- **Facultative mutualisms** occur when neither participant requires the presence of the other, but they both do better in their presence (ants and aphids).
The paradox of mutualisms

• Mutualisms often exhibit an inherent evolutionary tension or conflict of interest between partners.

• Given these conflicts of interest, two questions must be answered:
  – How do mutualists police the level of exploitation and prevent cheating?
  – How do mutualisms evolve in the presence of such conflicts of interest?
Cheaters do prosper sometimes (but not in this course)

• The flower of the bumblebee orchid, *Ophrys bombyliflora*, closely resembles the backside of a female bumblebee. The scent of the flower so arouses male bumblebees that they prefer to mate with the flower even in the presence of real female bees. While the male tries to copulate with the flower, it picks up and transfers pollen between flowers.

• Bumblebees in other systems bite through the petals at the base of flowers and rob the plants of their nectar without entering through the tunnel of the corolla and picking up pollen.
Fig-fig wasp pollination mutualisms are species specific, obligate mutualisms in which the wasps pollinate the figs in return for the use of some fig ovaries as food for the wasp’s offspring.

Fig and their wasps pollinators show evidence of conflict of interest in the negative relationship between seed production by figs and offspring production by wasps.
Yucca-Yucca moth pollination mutualism

- Yucca-yucca moth mutualisms are species specific, obligate mutualisms in which the moths pollinate the yuccas in return for the use of some yucca ovaries as food for the moth’s offspring.

- Moths can attain higher relative fitness by increasing egg loads within individual flowers, but this would directly reduce yucca fitness in terms of intact seeds.

- Yuccas discourage over-exploitation by its pollination partner by selectively aborting flowers that receive too many moth eggs. Abortion of flowers prevents development of moth larvae.

- Flowers receiving too few oviposition attempts are also selectively aborted because pollen quantity is positively correlation with oviposition attempts.
Protective mutualisms

- Ant acacias (*Acacia collinsii*) in Central America provide food and nesting sites for ants inside large thorns. Food include nectar from extra-floral nectaries on rachis of the leaves and protein-rich Beltian bodies on the tips of new leaflets.

- Ants (*Pseudomyrmex ferruginea*) discourage both insect and vertebrates herbivores from feeding on the acacia by stinging and/or biting them. They also trim away foliage from competing plants and vines and clear the space around the base of their tree by killing neighboring shoots.

- Ant-plant protection mutualisms are extremely common and typically less obligate than ant-acacia mutualisms.
Some species are involved in a complex web of mutualisms—Fungus-growing ants

- Fungus-growing ants cultivate specialized fungi that are their primary source of food. Ants are obligately dependent on the fungi for food and the fungi are obligately dependent on the ants for growth and reproduction.

- Ants and their fungi have a long history of coevolution and cospeciation.

- A parasitic fungus, *Escovopsis*, can infest the ant gardens and destroy the fungi growing inside. Ants obsessively prune their gardens to remove the parasites. *Escovopsis* has also evolved in response to the mutualism between the ants and their fungi.
Mutualistic interaction webs

• Fungus-growing ants also have a mutualistic partnership with a streptomycyes bacteria that produces antibiotics that help keep the *Escovopsis* in check.

• The ants have evolved a variety of specialized structures on their bodies that house the bacteria and allow them to grow and reproduce. The ants collect the antibiotics and apply it to their fungus garden.

• Such complex mutualistic interaction webs are probably more common that we suspect. For example, it is likely that endophytes in leaves help protect plants from herbivory from fungus-growing ants.
Evolution of mutualisms

- Mutualisms probably initially arose from commensalisms or antagonistic interactions (predator-prey, host-parasite, competition).

- Mutualism between species is favored when there are repeated interactions and when cooperation is conditional on the other partner’s behavior or when interactions occur over a small spatial scale.

- Mutualism is further favored by three forms of feedback between partners
  - Cooperator association occurs when cooperation with one species (white) provide large benefits and compensates for the cost of cooperation in the other species (grey).
  - Partner-fidelity feedback occurs when cooperation by one species (white) has positive phenotypic effect on the other species (grey).
  - Partner choice occurs when an active behavioral response in one species (grey) favors cooperation in the other (white).
Mutualisms occur when both species benefit from an interaction. Mutualistic partners trade resources and services and range from obligate to facultative in their intensity. Evolutionary stable mutualisms require mechanisms that allow the partners to police one another to prevent cheating or overexploitation of one partner by the other. Mutualisms have multiple, underappreciated effects in ecological communities. Our understanding of the evolution of mutualisms is very incomplete and will require much future work.