Predation

Similar to both herbivory and parasitism
Interaction with very strong fitness consequences, especially for the prey
Thus, lots of strong selective forces and extreme adaptations

There can be 3 responses in the prey population:
(graph: Prey# vs time)

1. No effect: if the prey successfully evade, or they reproduce quickly enough that the predators keep them at carrying capacity.
2. Extinction: Prey can't escape, they all get eaten. Predators may follow, if no other food.
3. Cycling (we'll talk more about that)

Famous example: hares and lynxes
The data set is very good—collected by trappers since the 1850's
Observed: both populations cycle every 10 years, the lynxes behind the hares (ppt)

What would cause that? (student ideas)
Early hypothesis: sun spots affected the vegetation, which affected the hares. A charming idea, but the timing never lined up.

Overpopulation: the hares would increase their population rapidly, and then disease, parasitism, and food shortages would start to drive their numbers down.

Predation: the lynxes would increase until they were killing more hares than were born, then would decrease in turn.

The hares:
Food supply: they live in boreal forests, eat understory plants (roses, willows), buds and twigs. They eat a lot of biomass.
Food shortages have been demonstrated in winters, where they just run out of food.
Food quality also diminishes: feeding induces defenses (secondary compounds) for up to 2 years. Terpenes and phenolics.

Predators:
Many species prey on them: lynx (specialize on hares), coyotes, owls, goshawks, foxes, weasels.
More of these may also cycle, we just don't have the long term data to see.
At high densities, predators have been shown to cause 60-90% of the hare mortalities.

Activity: Draw the cycle, have students tape up the events at the point where they're true.

Testing some of these hypotheses:

A really impressive field experiment
9 blocks: 1 km each
Treatments:
 Control
 Supplementary food for the hares
 Fertilizer: not direct supplemental food, but improve plant quality
 Exclude mammalian predators
 Exclude predators and also supplemental food
Ran this for 8 years (!), tracked the hare populations
In all blocks, saw the hare population increase and then decrease
But the numbers depended on the treatment:
 Supplementary food: 3x the hare population
 No predators: 2x the control population
 Both: 11x the control population
Conclusion: Both predators and food supply reduce the hare population in the cycle

These cycles were formalized by Lotka and Volterra
Nh= population size of prey
Np = population size of predators
rh = birthrate of prey
p = rate of predation
c = conversion factor—a constant rate at which prey are converted into prey
dp = death rates of predator

dNh/dt = rh*Nh – pNhNp
The change in the prey population depends on the exponential population growth minus the deaths caused by predators

dNp/dt = cpNhNp – dpNp
Change in predator population depends on the rate at which they destroy prey and turn them into offspring, minus the predator deaths

If you chart this, you get the classic cycle, with predators following about a quarter cycle after the prey. Stable oscillations.

Experimental evidence:
People have tried to recreate LV cycles in the lab
In most cases, the predators just drive the prey to extinction (second response from beginning)
In order to survive, the prey need a "refuge"
Activity: hand out examples of refuges, have students work in groups to come up with classification of types of refuges, discuss as a class
Approximate classifications: hiding, speed, unpalatability, saturation, size, crypsis

Crypsis—coloration that makes you hard to see (generally by matching the substrate)

Famous crypsis story: Peppered moths
In England, before 1811, all collected moths were light grey
By the 1850's, in some places, almost all dark grey/black
Caused by pollution—caused the trees in some forests to be darkened
After clean air acts were passed, the light morphs increased in frequency again

Hypothesis: Evading predation by birds exerted selection on the coloration
Experiments: several over time (some quite recently)
Pinned dead moths to trees, counted the number of strikes. Contrasting moths were more attacked.
Release-recapture experiments: The contrasting moth had lower survival
Recent, similar experiments have validated these results.

The selective differential was 0.1-0.2: meaning, light moths in light forests (no dark ones left) had a 10-20% fitness increase over dark moths—strong selection

Genetics of melanism in moths
Had previously tested candidate genes—none of them were it
Linkage mapping let them identify a region
Just this year, a study identified the gene and mutation

carbonaria is the gene; it affects expression of *cortex*, which is important in patterning in *Heliconious*
Insertion of a large tandemly-repeated transposable element into the first intron of the gene caused the change
It was a single mutation, just one origin, which originated ~1815
Strong signatures of selection around the gene

Another classic system for crypsis: mice (Hoekstra lab)
Pigmentation in mammals is controlled by two main pigments:

1. Eumelanin (black-brown)
2. Pheomelanin (red-yellow)

The pathway is well characterized, which has been a major advantage for studies.
2 genes that are often important (in mammals and other species):

Mc1R: signals for high levels of a molecule cAMP, which triggers production of eumelanin
Agouti: agonist of MC1R: binds to it and inhibits it, which leads to a reduction in cAMP, and the production of pheomelanin

Mice: selection to match substrate studied since the 1920's.
New Mexico: black lava flows and white sand dunes: morphs match
Florida: light on beaches, dark inland
Multiple traits are involved:

Color (which pigment, how much)
The dorsal-ventral boundary
Tail stripe width
Facial stripes

Examples of convergece: black on all lava flows, even if there's no migration between them (independent evolution; in contrast to the moths)

Because they have strong candidate genes to start with, they can do really good, detailed work (some of which we will be reading)

Ongoing debate in evolution: relative importance of coding mutations vs. regulatory mutations
Pigmentation has been really interesting here
Mc1R: one of the only genes where almost all known mutants are coding changes
Agouti: generally, regulatory changes
Examples of both:
Oldfield mice in Florida
Between environments, see differences in both Mc1R (lighter overall color caused by a coding mutation) and Agouti (changes in color pattern caused by a regulatory change)

> Also epistasis going on—the variation in Mc1R is only visible in the variant Agouti background

Another question: how to actually measure selection directly on animals?
An ongoing question: here, they use plasticine models
Actually measuring selection on a specific mutation is a big deal, they were some of the first to do it.