Hypothesis development: Physiological Ecology (Spring 2013)

The challenge: We present you with two ecological puzzles that may fall within the domain of physiological ecology. For each puzzle, your challenge is to come up with a plausible hypothesis to explain the puzzle and design a study that will efficiently and convincingly support or refute the hypothesis.

Your mission
1. Develop a plausible hypothesis to explain one of the two phenomena described below. Provide a concise statement of the hypothesis and one or more alternative hypotheses.
2. Suggest an experiment or protocol of data collection that will test your hypothesis. Provide a brief description of the test(s).
3. Graph at least two possible results of your experiment: one that would falsify the hypothesis (Result A) and one that would support your hypothesis (Result B). Be certain the graphs are fully labeled and include measurement units on the x and y axes. Be prepared to state the important broad conclusions that would follow logically from result A and result B.
4. Summarize your proposal (including hypothesis, alternative hypothesis, test, possible results) on an overhead transparency. Be prepared to present a 5-10 minute summary at the end of class. Next week in lab, turn in a one page summary of your proposal to resolve the puzzle.
5. Be creative and thoughtful.

Puzzle 1: Growth and distribution of paper birch (**Betula papyrifera** and **B. cordifolia**; **Betulaceae**)

**Background**
Global climate change may affect plants through increased carbon dioxide, increased temperature, and changes in cloud cover, precipitation, and nutrient availability. Although much work has been done on the effects of carbon dioxide, relatively little is known about plant responses to different temperatures. Jonathan Ruel (94) studied the effects of temperature on growth of paper birch. If temperatures increase as predicted, changes may occur in the distribution of local paper birch populations with respect to altitude and latitude.

Paper birch seeds were collected from two populations representing different temperature regimes: 120-180 m above sea level in Hanover and 1200-1350 m asl on Mt. Moosilauke. Seedlings from each of population were grown in pots using a common soil at a valley site (200 m asl on Trescott Road in Etna, NH and a mountain site (800 m asl near Mt. Moosilauke. Mean daily temperature at the valley site was 2.1° C warmer than at the mountain site. Soil moisture and sunlight were very similar. At each site, 5 seedlings from each of 5 mother trees from each populations were grown and measured.

**Results**
In both environments, birch growth was lower in high elevation vs. low elevation populations (see figure). The valley genotype grew equally well in either environment, while the mountain genotype grew significantly more in the mountain environment than in the valley environment.

**The Puzzle**
Why have mountain populations not evolved to grow at faster rates and why are mountain populations not outcompeted and replaced by faster growing genotypes from valley populations?
Puzzle 2: Geographic variation in the population dynamics of gypsy moths
Lymantria dispar; Lepidoptera: Lymantriidae)

Life Cycle
Gypsy moths are univoltine and undergo complete metamorphosis. Eggs overwinter. Larvae hatch shortly after budbreak (mid-May in Hanover in 1994) and grow through 5-6 instars. Larvae pupated in mid-July in Hanover in 1994; pupation lasts ~2 weeks. Adults eclose, mate, and die in <10 days. Females are flightless and emit pheromones; males fly to females and mate. Females lay eggs in large masses.

Gypsy moths are poikilotherms.

Feeding Ecology
Larvae feed mostly at night; other life stages, including adults, do not feed. Gypsy moth caterpillars feed on many tree species (see supplemental materials). In NH and ME, suitable host species include Quercus rubra, Betula spp., and Populus spp.

Oaks (Quercus species) exhibit long-term resistance: i.e., trees defoliated in one year produce foliage that is of lower nutritional quality in the next year.

Leaf nutritional quality generally declines with leaf maturation.

In some tree species, leaf nutritional suitability changes in response to water regime, cloud cover, nutrient availability, etc..

Natural Enemies
Natural enemies include >35 species of parasitoids, primarily parasitic wasps and tachinid flies, which parasitize the eggs, larvae, and pupae. Peromyscus (mice) prey on pupae near or on the forest floor; birds prey on the larvae. Larval pathogens include nuclear polyhedral viruses (NPV) and Entomophaga (a fungal pathogen).

Population Dynamics
Gypsy moths were introduced in Boston ~1870 from Europe. Since then, they have spread south and west to Wisconsin, Arkansas, and South Carolina. They have spread north through New England and adjacent Canada.

In western Europe, many gypsy moth populations never show outbreaks; in eastern Europe, populations tend to cycle (i.e. exhibit outbreaks of roughly regular intervals).

In North America, many populations illustrate dramatic fluctuations in population size (e.g., x10^3). These outbreaks tend to be cyclical and result in dramatic defoliation that impacts many other organisms in the forest community.

Although gypsy moths occur throughout New England and into Canada, outbreaks have never been observed in northern NH or ME (Fig. 2).

The Puzzle
Why do the population dynamics of gypsy moths differ in northern and southern New Hampshire?