LAB #1: Natural Selection and Ecomorphs

BEFORE LAB
- **Read the Introduction and skim the lab exercises below.**
- **Read Sadava et al., chapter 20.2-20.3 (pp. 427-436)**

BRING TO LAB
Pencil and paper, calculator may help but app is available on laptops

OBJECTIVES
1. Understand how predator-prey interactions and crypsis can lead to changes in frequency of different traits
2. Learn how similar habitats can shape evolutionary patterns (ecomorphs)

INTRODUCTION

As (hopefully) a review from high school remember that natural selection as envisioned by Darwin has 4 components, and if all four are present, we expect traits to evolve over time.

1. There must be variation among individuals in a population. Darwin was much more focused on variation within species, rather than among. This was new
2. That variation must be heritable – passed on in some way. Note that Darwin didn't understand genetics, and had his own theory of inheritance (gemmules) that wasn't that different from Lamark.
3. There must be overproduction – more offspring produced than can possibly survive and reproduce, and what affects reproductive success?
4. Some of the heritable variation leads to different average reproductive success (fitness).

So now we have the building blocks of an evolutionary definition of **fitness** – the average reproductive success of individuals having a given trait. Note that fitness isn't something that individuals have. Individuals have reproductive success, but not fitness. Traits have fitness; an average effect of that trait on reproductive success of individuals.

We will play a short game to see how strong natural selection can be, then another to look at another evolutionary mechanism that can change gene frequencies, most powerful in small populations like this class. Finally we will see how similar ecological challenges and the availability of niches can repeatedly favor similar adaptations, using the natural laboratory of large and small islands in the Caribbean.

Foraging behavior of predators and the evolution of crypsis. A classic example of evolution in action is the spread of **industrial melanism** in the peppered moth, *Biston betularia.* Industrial melanism is an increase in frequency of dark forms that more closely match the darker trunks of trees when lichens die and coal soot accumulates, as it did following the industrial revolution in the 19th century. The frequency of the dark form of peppered moths, earlier shown to be a genetic polymorphism in the species, increased in frequency in the 20th century. HBD Kettlewell (1955, 1956) wanted to show that it was the foraging behavior of birds that led to the evolved change in frequency of the different morphs. He did this by placing light and dark moths on lichen and soot covered surfaces in captivity and observing the capture rates of each form by birds in those cages. Then he placed light and dark forms in first a polluted wood and attempted to recapture them later using UV lamps and traps, and then a year later he replicated the experiment in an unpolluted wood. In each case the recapture rate of the morph matching that habitat was higher. Interestingly right after Kettlewell's experiments pollution controls and the larger change from coal to oil as the primary fossil fuel led to an increase in lichens on tree trunks and less soot deposition, and a recovery in the frequency of lighter morph moths.

Above: On the left is a light form of the peppered moth matching a light colored background (Photo by Andy Phillips). To the right are a pair of moths mating, one light '*typica*' and one dark '*carbonaria*' (*Ilik Saccheri/Science/AAAS*).

SELECTION BY SIMULATED PREDATORS

1. Work in groups of 4. Position yourselves around a tree background laid flat on the benchtop.

2. Locate the first data sheet at the end of this handout. It will be used for the first simulation. Fill in your group names, the habitat board number, and describe the habitat.

3. Obtain two Ziploc sacs of dark and light butterflies (can't actually buy a moth-shaped stamp

4. Designate two group members as 'predators' and two as 'helpers.'

5. Predators: move out of sight of the table

6. Helpers distribute the moths evenly on the board.

7. Predators will have 90 seconds to catch up to 30 prey each. They do this by using their fingertips moistened on the wet sponge to pick up butterflies, and then drop them in the

counting bowl. Make sure to watch the butterfly until you've dropped it in the bowl, don't look for the next until you've done so, this is similar to 'handling time' in prey choice models.

8. Helpers: keep track of your predator's capture total as they drop in the bowl, remember we don't want to catch more or less than 60 total. If it's easier let the predator count for themselves.

9. At the end of the feeding frenzy, make sure you have 60 between the two predators, if you're short, catch the remaining number.

10. Count the remaining light and dark butterflies, and now it's time to replicate. Take three of the same colored butterflies from the original bags, so the new population is now 80 in total as before. This simulates each survivor having 4 surviving offspring and then dying.

11. Now the predators leave, and the helpers mix and redistribute the population as before. Repeat steps 7-10 two times, so there have been three rounds of selection and reproduction.

After completing the steps above, graph any changes in population frequency over time, and summarize your conclusions below.

In the turn of the century a book was published accusing Kettlewell of several forms of malpractice, by a science journalist J Hooper. Though the book may have been inspired by critics hoping to discredit evolution by natural selection in general, that was not the author's goal (Rudge 2005). However, it missed a fundamental understanding of how science works. The peppered moth isn't a good example because Kettlewell did the definitive or perfect experiment. They did neither, and there often is no single definitive experiment possible. Fortunately, neither the pattern of industrial melanism nor the concept of natural selection rest on any single example. Rather the *B betularia* example is part of a pattern that has been repeatedly tested and supported in multiple diverse ways. Right when Kettlewell was doing their experiments, changes in fossil fuel use (away from coal) and pollution regulations were cleaning the air, and starting in the late 1950s the trees lightened and the *typica* morph started to increase in frequency. In fact, several species of insects in Europe and North America experienced a similar rise and then fall in dark morphs. The original experiments were replicated decades later in a more rigorous way with similar results (Majerus 1998). Finally, in 2016 the mutation responsible for the dark form of peppered moths was identified as a transposable element that inserted into a gene called *cortex*, dated to approximately 1819, consistent with the industrial origin of the trait. A good general rule is to never accept any single piece of evidence as definitive in science, the true patterns and mechanisms will be repeatable and supported by multiple approaches.

NATURAL SELECTION SIMULATION DATA SHEET #1
Basic Selection in a Multi-Colored Prey Population

Description of Habitat Board:

Prediction of Outcome:

DATA SHEET 1. Number of individuals for each body color morph in a population of undergoing simulated predation by *Homo sapiens*.

Generation	dark	light	TOTAL
1 Before Selection	40	40	80
1 After Selection			20
2 Before Selection			80
2 After Selection			20
3 Before Selection			80
3 After Selection			20
4 Before Selection			80

Graph of color morph of butterfly under simulated predation

Label axes and graph the proportion light or dark as a function of time in generations.

Did the frequency change over time? Did the change match your predictions? Why or why not?

How would you suggest we change the simulation next time?

ECOMORPHS HHMI VIRTUAL LAB

In lecture you will soon discuss the definitions of species, the most common being the group of all potentially interbreeding individuals capable of producing fertile offspring. In this part of the lab we will learn how to define **Ecomorphs**, species that may or may not share a common ancestor recently (may not be closely related) but share an ecological niche, and so are similar in morphology (shape) and behavior to match that niche (after E. E. Williams). This week and next you will replicate some of the experiments carried out by Jonathan Losos and colleagues to understand rapid evolution of ecomorphs in a natural laboratory, the large and small islands in the Caribbean, some of which have multiple anole lizard species and others that have had previous populations wiped out by storms, so they can be manipulatively inoculated with lizards to see how they evolve.

Open the link Lizard evolution virtual lab (https://media.hhmi.org/biointeractive/vlabs/lizard2/) . If that doesn't work, go first to HHMI lizard evolution launchpad (https://www.biointeractive.org/classroom-resources/lizard-evolution-virtual-lab). We will carry out module 1, work in pairs to first arrange and label the 8 anole species into groups. When you do that, write here what your groups and labels are. The program will store them for today, but it's useful to write down as well to work faster later. You don't need a certain number of groupings, determine the traits you will use with your partner.

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Group ___________________
Sp1 _____________________
Sp2 _____________________
Sp3 _____________________

Group ___________________
Sp1 _____________________
Sp2 _____________________
Sp3 _____________________

Group ___________________
Sp1 _____________________
Sp2 _____________________
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Group ___________________
Sp1 _____________________
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Sp3 _____________________

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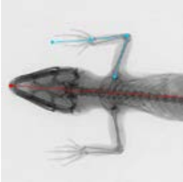
Work through module 1, you'll find that using a calculator from the dock or your own calculator is easier than the one you can call up in the virtual lab. Finally complete with your partner the worksheet at the end of this handout in lab. If there is time your instructor can review it in class.



LIZARD EVOLUTION VIRTUAL LAB

Answer the following questions as you finish each module of the virtual lab or as a final assessment after completing the entire virtual lab.

Module 1: Ecomorphs

1. At the beginning of the virtual lab, you were asked to sort eight lizards into categories. What criteria did you initially use to make your groups? Did you revise your criteria later? Why?

2. An adaptation is a structure or function that is common in a population because it enhances the ability to survive and reproduce in a particular environment. Provide one example and an explanation of one adaptation in the *Anolis* lizards.

3. Provide one evolutionary explanation for why lizards living in the same part of the habitat (i.e., grass) would have similar characteristics.

4. What is an ecomorph? Provide one example from the virtual lab.

5. How is an ecomorph different from a species?

6. Explain how a particular body feature of one of the lizard ecomorphs from the virtual lab is an adaptation to their particular niche.

References

Rudge, D. W. 2005. Did Kettlewell commit fraud? Re-examining the evidence. Public Understanding of Science, SAGE Publications, 2005, 14 (3): 249-268. 10.1177/0963662505052890. hal-00571065

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Hof, A.E.v., Campagne, P., Rigden, D., C. J. Yung, J. Lingley, M. A. Quail, N. Hall, A. C. Darby & I. J. Saccheri. 2016. The industrial melanism mutation in British peppered moths is a transposable element. *Nature* 534: 102–105. doi:10.1038/nature17951

The natural selection part of the lab was adapted from an exercise by Hanych, Sipe, Anderson, & Hasler, 1998 at Franklin and Marshall College