Lab 17. Mechanisms of Evolution: Why Does a Specific Version of a Trait Become More Common in a Population Over Time?

Introduction

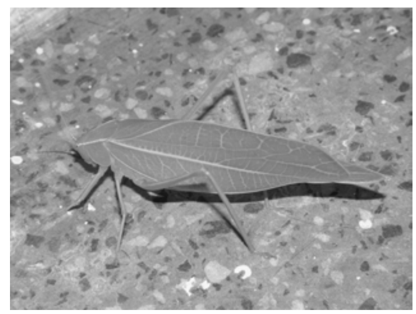
An *ecosystem* includes all the organisms and the nonliving parts of the environment that are found in a particular area. Organisms include things such as plants, animals, fungi, and bacteria. The nonliving parts of the environment include things such as air, light, water, and minerals. The organisms found within an ecosystem depend on the nonliving components for survival. The organisms also interact with each other. For example, plants need air, light, and water to produce the food they need to survive. Animals called herbivores eat these plants. Other animals called predators eat the herbivores. Herbivores and predators also need water to drink and air to breathe in order to survive. All the living and nonliving parts of the environment therefore function as a system. A change in one part of the system will, as a result, affect the other parts of the system. For example, a drought could reduce the number of plants in a particular area. A decrease in the number of plants will result in less food for the herbivores. When these animals do not have enough food to eat, some will starve. The predators will then not have enough food to eat.

Organisms often have adaptations that allow them to function in a specific ecosystem. An adaptation can be a physical feature that helps an organism to survive. Katydids, for example, are insects that look like leaves (Figure L17.1), and their unique appearance helps them to avoid predators. An adaptation can also be something that an organism is able to do that helps it survive in a specific environment. The creosote bush (Figure L17.2), for example, reduces competition for nutrients and water by producing a toxin that prevents other plants from growing near it. Biologists define an *adaptation* as a version of a trait that is common in a population because it provides some improved function over other versions of that trait.

Organisms that live in different ecosystems tend to have different adaptations. For example, a population of herbivores that lives in an ecosystem with a lot of predators will have different adaptations than a population of herbivores that lives in an ecosystem with few or no predators. Similarly, a herbivore population that lives in an ecosystem that gets very little rain will have different adaptations than a herbivore population that lives in an ecosystem that gets a lot of rain. It is therefore important for biologists to understand why specific versions of a trait become more or less common in a population and how changes in an ecosystem will affect the characteristics of the organisms in it. In this investigation, you will examine how a specific trait in a simulated population of bugs changes over time in two different environments. You will then develop a conceptual model that can be used to explain why a certain version of a trait becomes more common in a population over several generations.

FIGURE L17.1

A katydid



Katydids are insects that look like a leaf. The appearance of the insect is an adaptation.

FIGURE L17.2

A creosote bush

The creosote bush is a desert-dwelling plant that produces a toxin that prevents the growth of other plants.

Your Task

Use a computer simulation to explore how the frequency of different versions of the body color trait in a population of bugs changes over time in two different environments. You will then develop a model that can be used to explain why a certain version of a trait becomes more common in a population over several generations.

The guiding question of this investigation is, **Why does a specific version of a trait become more common in a population over time?**

Materials

You will use an online simulation called *Bug Hunt Camouflage* to conduct your investigation. You can find the simulation by going to the following website:
http://ccl.northwestern.edu/netlogo/models/BugHuntCamouflage.

Safety Precautions

Follow all normal lab safety rules.

Investigation Proposal Required? ☐ Yes ☐ No

Getting Started

The first step in developing your model will be to use the *Bug Hunt Camouflage* simulation to explore how the frequency of different versions of the body color trait in a simulated population of bugs changes over time in two different environments. The bugs that make up the simulated population belong to the same species but are different colors. There are, as a result, individual bugs with different versions of the body color trait in the simulated environment. The color of each bug in this simulation is described in terms of its hue, saturation, and brightness (HSB). Hue is a color such as red, green, or blue and is given a value ranging from 0 to 255 in this simulation. Saturation is the purity or richness of a color and ranges from 0 (gray) to 255 (colorful) in the simulation. Brightness is the intensity of the color and, like saturation, ranges from 0 (dark) to 255 (bright) in the simulation. Remember, all of the bugs in the simulated environment are from the same species, even though they look different.

In this simulation, you will act as the predator. You can eat the bugs (your prey) by clicking on them. When a bug is eaten, it is replaced through reproduction by another bug in the simulated ecosystem. The new bug will often (but not always) have the same color as the parent bug. The simulation provides information about the total number of bugs that you have caught since the simulation started, the current color composition of the bug population (in terms of HSB), and how the average color of the bugs in the population has changed over time. You can also change the number of bugs that are in the environment at any given time (carrying capacity) and the environment type (glacier, beach, poppy field). There are several other factors, such as bug size, that you can adjust as part of the simulation. Figure L17.3 illustrates the factors in the simulation.

To explore how the frequency of different versions of the body color trait in the population of bugs changes over time in two different environments, you must determine what type of data you need to collect and how you will collect it using the *Bug Hunt Camouflage* simulation. You also need to determine how you will analyze the data once it has been collected. To determine *what type of data you need to collect*, think about the following questions:

- What will you do to track how the body color trait in the bug population changes over time?
- What will serve as your dependent variable (e.g., average HSB value, current hue, current brightness, number of bugs caught)?
- What type of measurements or observations will you need to record during your investigation?

To determine *how you will collect your data*, think about the following questions:

- What will serve as a control condition?
- What types of treatment conditions will you need to set up and how will you do it?
- How many trials will you need to conduct?
- How long will you need to run the simulation during each trial (e.g., for three minutes or until 60 bugs are caught)?
- How often will you record an observation or collect a measurement?
- When will you make your observations or make a measurement?

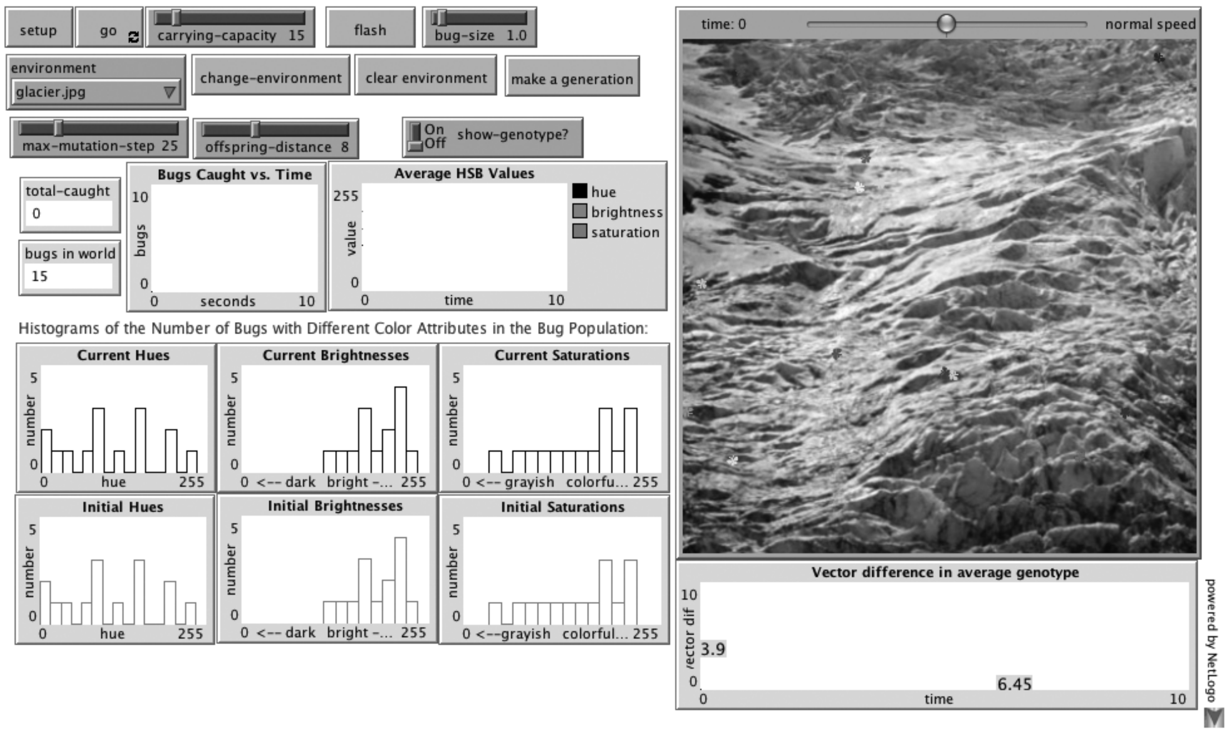
- How will you keep track of the data you collect and how will you organize it?

To determine *how you will analyze your data*, think about the following questions:

- How will you determine if there is a difference between the different treatment conditions and the control condition?
- What type of calculations will you need to make?
- What type of graph could you create to help make sense of your data?

FIGURE L17.3

Types of DNA-level mutations



Once you have collected and analyzed your data, your group will need to develop a conceptual model to explain why a specific version of the body color trait becomes more common in the population over several generations. Your model, however, should also be able to explain how traits in other populations of organisms can change over time. It will therefore be important for you to think about how your model could be used to explain a wide range of situations and not just what happened in your investigation.

The last step in this investigation is to test your model. To accomplish this goal, you can use a third environment in the *Bug Hunt Camouflage* simulation to determine if you can use your model to make accurate predictions about how the bug color trait changes over several generations under different conditions. If you can use your model to make accurate predictions about how the traits of the bugs in the population change in a new environment, then you will be able to generate the evidence you need to convince others that the conceptual model you developed is valid.

Connections to Crosscutting Concepts, the Nature of Science, and the Nature of Scientific Inquiry

As you work through your investigation, be sure to think about

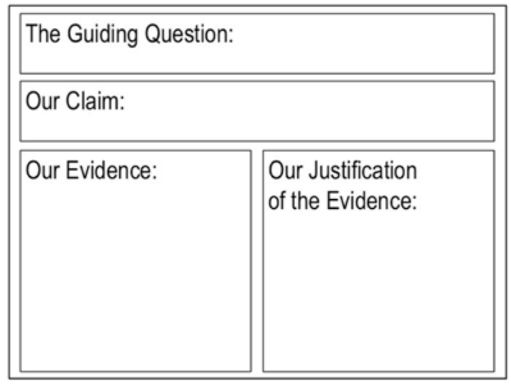
- the importance of looking for patterns in nature,
- the importance of developing explanations for a natural phenomenon,
- how scientists create and use models to understand a natural phenomenon,
- the different types of methods that scientists use to answer questions, and
- the important role that imagination and creativity play in science.

Initial Argument

Once your group has finished collecting and analyzing your data, you will need to develop an initial argument. Your argument must include a claim, evidence to support your claim, and a justification of the evidence. The claim is your group's answer to the guiding question. The evidence is an analysis and interpretation of your data. Finally, the justification of the evidence is why your group thinks the evidence matters. The justification of the evidence is important because scientists can use different kinds of evidence to support their claims. Your group will create your initial argument on a whiteboard. Your whiteboard should include all the information shown in Figure L17.4.

FIGURE L17.4

Argument presentation on a whiteboard



Argumentation Session

The argumentation session allows all of the groups to share their arguments. One member of each group will stay at the lab station to share that group's argument, while the other members of the group go to the other lab stations one at a time to listen to and critique the arguments developed by their classmates. This is similar to how scientists present their arguments to other scientists at conferences. If you are responsible for critiquing your classmates' arguments, your goal is to look for mistakes so these mistakes can be fixed and they can make their argument better. The argumentation session is also a good time to think about ways you can make your initial argument better. Scientists must share and critique arguments like this to develop new ideas.

To critique an argument, you might need more information than what is included on the whiteboard. You will therefore need to ask the presenter lots of questions. Here are some good questions to ask:

- What did your group do to collect the data? Why do you think that way is the best way to do it?
- What did your group do to analyze the data? Why did your group decide to analyze it that way?
- What other ways of analyzing and interpreting the data did your group talk about?
- What did your group do to make sure that these calculations are correct?
- Why did your group decide to present your evidence in that way?
- What other claims did your group discuss before you decided on that one? Why did your group abandon those other ideas?
- How sure are you that your group's claim is accurate? What could you do to be more certain?

Once the argumentation session is complete, you will have a chance to meet with your group and revise your original argument. Your group might need to gather more data or design a way to test one or more alternative claims as part of this process. Remember, your goal at this stage of the investigation is to develop the most valid or acceptable answer to the research question!

Report

Once you have completed your research, you will need to prepare an investigation report that consists of three sections that provide answers to the following questions:

1. What question were you trying to answer and why?
2. What did you do during your investigation and why did you conduct your investigation in this way?
3. What is your argument?

Your report should answer these questions in two pages or less. The report must be typed and any diagrams, figures, or tables should be embedded into the document. Be sure to write in a persuasive style; you are trying to convince others that your claim is acceptable or valid!