Natural Selection Lesson

Bug natural selection model

In this activity, students will use a model of natural selection acting on a population of bugs. The model includes birds to serve as a predator and the ability for students to test the three requirements for natural selection to occur by manipulating them within the model.

Learning Objectives:

1. Describe Darwin's theories and explain how heritable variations and limits on reproductive success lead to differential reproduction (natural selection).
2. Propose explanations for the rise of adaptations that are consistent with evolution by natural selection.
3. Compare and contrast differences between Lamarck's hypothesis of evolution by inheritance of acquired characteristics and Darwin's theory of evolution by natural selection.

Student pre-class prep:

1. Video 4 (natural selection)
2. Reading 3 (*Biology* textbook chapter 18, section 1, "Understanding Evolution")

Materials:

1. Netlogo online
2. Computers, ideally one per pair of students
3. Netlogo model link and instructions on Blackboard
4. PowerPoint with clicker questions for participation/attendance

To print:

1. Nothing for this activity

Classroom setup:

1. Introductory PowerPoint presentation from instructor
2. Turning Point

Activity:

Students will use an agent-based model to understand the components of natural selection. Students will be able to manipulate variation, heritability, and selection within the model, which simulates bugs that are preyed on by birds. Have the students work through each simulation. As the students are working through the experiments, be sure to ask them questions to make them think about why they are seeing the results they are. Discuss the results of each simulation as a class after the first experiment and then at the end of all experiments.

Activity Outline:

- Intro
- Experiments 2 – 5 (depending on timing, could stop between each experiment for discussion)
- Class discussion about requirements for natural selection and experiment results

- Clicker question for attendance

Student Instructions:

Using an agent-based model to understand natural selection

Learning Objectives:

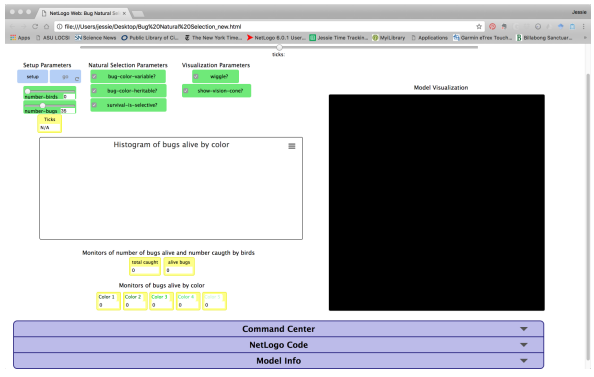
4. Describe Darwin's theories and explain how heritable variations and limits on reproductive success lead to differential reproduction (natural selection).
5. Propose explanations for the rise of adaptations that are consistent with evolution by natural selection.
6. Understand the differences between Lamarck's hypothesis of evolution by inheritance of acquired characteristics and Darwin's theory of evolution by natural selection.

Instructions:

Today you'll use a computer simulation model to explore natural selection and gain a better understanding of the necessary components for natural selection to occur. This model will show bugs of various colors that live in the grass. The background is white for ease of viewing the bugs, but they would naturally be found in a green grassy area. The simulation includes birds that prey on these bugs by using their vision to detect them in the grass. We will explore the effect of the birds eating these bugs. The bugs in this model all have the same birth and natural death rates.

Follow the instructions on this sheet to run the simulation. Be sure to answer all questions in red. Then open the questions document on Blackboard, and answer and submit the document. Submitting the answers to these will allow you to earn your participation points for the day. You do not need to submit this instruction manual.

1. To start the model, navigate to the active learning module 4 Friday content and click on the model link (bug natural selection.html). The model should open in your web browser and look like the image below.



2. Toward the top, left of the model you'll see three groupings of buttons ("Setup Parameters", "Natural Selection Parameters", and "Visualization Parameters"). In the "Setup Parameters" section, you'll see a monitor labeled "Ticks", which is a representation of time. Below the parameter buttons, you'll see an area for a graph with monitors below it. The graph will be populated with a histogram showing the number of bugs of each color. The monitors below the graph will keep a count of the current number of bugs alive, the

number of bugs that have been eaten by the birds, and the number of bugs of each color alive at any given time. The graph and monitors will update in real time. The black box on the right of the screen will show the model. Finally, along the very tip of the screen, you'll see a slider that will allow you to speed up and slow down the model.

3. Tor run the model, you will do the following:
    a. Adjust any settings you want to change.
    b. Press "setup". The black square will populate with the elements of your model run.

    c. Press "go", and the model will begin continuously running. If you press "go" again, the model will pause.
    d. As you run the model, you will see the birds and bugs moving around. If a bug is eaten by one of the birds, an "X" in the color of the bug will be displayed briefly.
    e. Try changing some of the settings and running the model a few times to get a feel for how it works.
    f. Next, you will do several experiments with the model to test the requirements of natural selection and see how natural selection works.

Parameter Descriptions

Variable Group	Variable Name	Description
Setup Parameters	setup	Sets up the model using the parameters you choose and populates the model with those elements
	go	Starts the model
	number-birds	Sets the number of birds that will be present in the model
	number-bugs	Sets the number of bugs initially present in the model
	Ticks	This is a monitor that shows time in ticks
Natural Selection Parameters	bug-color-variable?	Sets whether the bugs are multiple colors or a single color
	bug-color-heritable?	Sets whether bug color is inherited from parent or random
	survival-is-selective?	
Visualization Parameters	wiggle?	

	show-vision-cone?	

Now that you have familiarized yourself with the model, you'll use it to run a series of experiments to test the criteria of natural selection.

Questions and Experiments:

Experiment 1: What happens when birds are present and selectively prey on the bugs?
The birds use their vision to detect the bugs in the grass that they will eat. This means that some might be easier to see than others.

1. Use the parameter table below to setup your experiment. Press "setup".

Variable Group	Variable Name	Setting
Setup Parameters	number-birds	3
	number-bugs	50
Natural Selection Parameters	bug-color-variable?	√
	bug-color-heritable?	√
	survival-is-selective?	√
Visualization Parameters	wiggle?	Your choice
	show-vision-cone?	Your choice

2. **Which color is most prominent among the bugs? Which bug color is rarest?**

3. Form a hypothesis and a prediction with your group to answer the question: "How will the distribution of bug colors change over time?". Be sure to record your hypothesis, prediction, and reasoning.
   Hypothesis:

   Prediction:

4. Next, select "go" and run the simulation for ~3000 ticks (watch the ticks monitor to know when you've run your model long enough). If you would like to speed the model up, use the "model speed" slider at the top of the model page to do so. Run the simulation multiple times to see if you get the same result each time.

Discuss the results with your group. Was your hypothesis supported? Why or why not? If not, what happened and why? Where any of the requirements for natural selection violated in this experiment? Write notes from your discussion..

Results:

Was your hypothesis supported?:

Conclusions/why did this happened:

Experiment 2: What happens when birds are present and randomly prey on the bugs?
In this scenario, the birds can see all colors of bugs equally well. They eat the birds at random as they encounter them.

5. Use the parameter table below to setup your experiment. Press "setup".

Variable Group	Variable Name	Setting
Setup Parameters	number-birds	3
	number-bugs	50
Natural Selection Parameters	bug-color-variable?	√
	bug-color-heritable?	√
	survival-is-selective?	unchecked
Visualization Parameters	wiggle?	Your choice
	show-vision-cone?	Your choice

6. **Which color is most prominent among the bugs? Which bug color is rarest?**

7. Form a hypothesis and a prediction with your group to answer the question: "How will the distribution of bug colors change over time?". Be sure to record your hypothesis, prediction, and reasoning.

Hypothesis:

Prediction:

8. Next, select "go" and run the simulation for ~3000 ticks (watch the ticks monitor to know when you've run your model long enough). If you would like to speed the model up, use the "model speed" slider at the top of the model page to do so. Run the simulation multiple times to see if you get the same result each time.

   Discuss the results with your group. Was your hypothesis supported? Why or why not? If not, what happened and why? Where any of the requirements for natural selection violated in this experiment? Write notes from your discussion.

   Results:

   Was your hypothesis supported?:

   Conclusions/why did this happened:

Experiment 3: What happens when bug color isn't heritable?
In this scenario, the bugs' offspring will be a random color rather than inheriting the color from a parent

9. Use the parameter table below to setup your experiment. Press “setup”.

Variable Group	Variable Name	Setting
Setup Parameters	number-birds	3
	number-bugs	50
Natural Selection Parameters	bug-color-variable?	√
	bug-color-heritable?	unchecked
	survival-is-selective?	√
Visualization Parameters	wiggle?	Your choice
	show-vision-cone?	Your choice

10. **Which color is most prominent among the bugs? Which bug color is rarest?**

11. Form a hypothesis and a prediction with your group to answer the question: “How will the distribution of bug colors change over time?”. Be sure to record your hypothesis, prediction, and reasoning for each.
    Hypothesis:

    Prediction:

12. Next, select “go” and run the simulation for ~3000 ticks (watch the ticks monitor to know when you’ve run your model long enough). If you would like to speed the model up, use the “model speed” slider at the top of the model page to do so. Run the simulation multiple times to see if you get the same result each time.

    Discuss the results with your group. Was your hypothesis supported? Why or why not? If not, what happened and why? Where any of the requirements for natural selection violated in this experiment? Write notes from your discussion.
    Results:

    Was your hypothesis supported?:

Conclusions/why did this happened:

Experiment 4: What happens when bug color isn't variable?

13. Use the parameter table below to setup your experiment. Press "setup".

Variable Group	Variable Name	Setting
Setup Parameters	number-birds	3
	number-bugs	50
Natural Selection Parameters	bug-color-variable?	unchecked
	bug-color-heritable?	√
	survival-is-selective?	√
Visualization Parameters	wiggle?	Your choice
	show-vision-cone?	Your choice

14. **Which color is most prominent among the bugs? Which bug color is rarest?**

15. Form a hypothesis and a prediction with your group to answer the question: "How will the distribution of bug colors change over time?". Be sure to record your hypothesis, prediction, and reasoning.
    Hypothesis:

    Prediction:

16. Next, select "go" and run the simulation for ~3000 ticks (watch the ticks monitor to know when you've run your model long enough). If you would like to speed the model up, use

the "model speed" slider at the top of the model page to do so. Run the simulation multiple times to see if you get the same result each time.

Discuss the results with your group. Was your hypothesis supported? Why or why not? If not, what happened and why? Where any of the requirements for natural selection violated in this experiment? Write notes from your discussion.

Results:

Was your hypothesis supported?:

Conclusions/why did this happened:

17. **Open the Blackboard assignment, answer the questions, and submit one per group. Please submit a Word document, pdf, or just write your answers into the text field. Do not submit a Pages document.**

Blackboard Assignment (0.25 pts per question)

1. Natural selection…
   a. **is a mechanism of evolution**
   b. is evolution
   c. is a process that shapes an individual over its lifetime
   d. benefits the species

2. Select **all** of the requirements that need to be met for natural selection to occur.
   a. **traits must be heritable**
   b. **traits must vary**
   c. **must result in differential fitness**
   d. only good traits will persist

3. Which of the following is the best example of fitness gains in evolutionary terms?
    a. **A barnacle with a jagged shell produces more offspring than one with a smooth shell resulting in the next generation having more jagged-shelled barnacles than smooth shelled barnacles.**
    b. A stingray participating in social feeding gives up optimal access to food to allow an unrelated stingray to have fair access to the food.
    c. Usain Bolt, the fastest runner in the world, trained his entire life to increase his ability to run fast as he aged.
    d. In a chimpanzee group, one female forgoes having offspring to ensure that her unrelated group members' offspring receive enough shelter and food.

4. If you were to run another experiment with the bug simulation using the parameters below. What would you expect the result of the experiment to be?

Variable Group	Variable Name	Setting
Setup Parameters	number-birds	0
	number-bugs	50
Natural Selection Parameters	bug-color-variable?	√
	bug-color-heritable?	√
	survival-is-selective?	unchecked
Visualization Parameters	wiggle?	Your choice
	show-vision-cone?	Your choice

    a. All bug colors would be represented equally in the population.
    b. The color most similar to the grass color will have the most individuals.
    c. The color with the strongest contrast to the grass will have the most individuals.
    d. The color with the highest frequency of individuals at the beginning will have an even higher frequency at the end.

5. In terms of the scientific process, why is it important to run the simulation that contains randomness more than once before drawing a conclusion?
    a. A group member may have entered the parameters in incorrectly, and so it is important to make sure that the result was not incorrect due to human error.
    b. Each run of the simulation represents a single replicate, and multiple replicates are needed to have a good representative sample of natural phenomena.
    c. A single run of the simulation represents an experiment, and doing multiple runs with different parameter settings allow for the completion of multiple experiments before drawing a single conclusion from all of the data.
    d. Running the simulation multiple times ensures that everyone in the group gets a chance to control the model and set parameters.

6. In a population of mice that live on a beach with black sand, some have black fur, some have gray fur, and some have white fur. The black fur provides more camouflage from predators on the black sand. However, all mice are born either white or gray. Some mice have black fur because they eat a type of berry that changes their fur color from gray to black. Will new mice in the population be born with black fur?
    a. No. Trait is not variable
    b. **No. Trait is not heritable**
    c. No. Traits do not lead to differential reproductive success
    d. Yes. All conditions for natural selection are met

7. In a population of mice that live on a beach of black sand, all of the mice have black fur. The black fur is good camouflage from predators. Will natural selection occur?
    a. **No. Trait is not variable**
    b. No. Trait is not heritable
    c. No. Traits do not lead to differential reproductive success
    d. Yes. All conditions for natural selection are met

8. In a population of mice that live on a beach with white sand, some have black fur and some have gray fur. Neither type of fur color provides more camouflage from predators on the white sand. Will natural selection occur?
    a. No. Trait is not variable
    b. No. Trait is not heritable
    c. **No. Traits do not lead to differential reproductive success**
    d. Yes. All conditions for natural selection are met

9. Type the names of each of your group members present today