Using an agent-based model to understand natural selection

Learning Objectives:

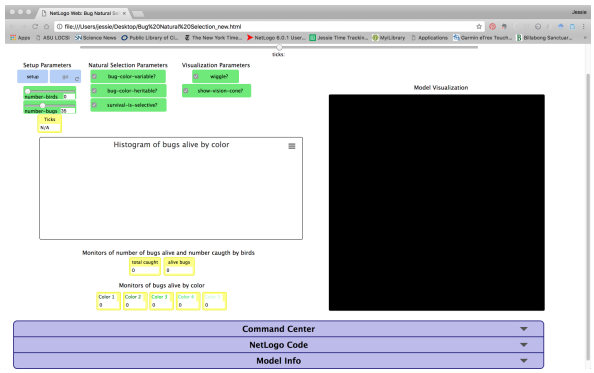
1. Describe Darwin's theories and explain how heritable variations and limits on reproductive success lead to differential reproduction (natural selection).
2. Propose explanations for the rise of adaptations that are consistent with evolution by natural selection.
3. Compare and contrast the differences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

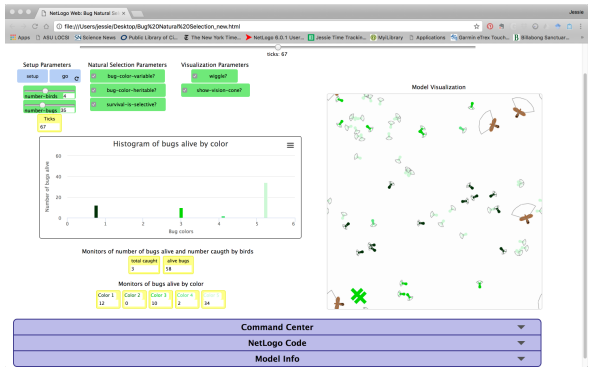
1. To start the model, navigate to the active learning module 4 Friday content and click on the model link (bug natural selection.html). The model should open in your web browser and look like the image below.



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 Canvas assignment, answer the questions, and submit one per group. Please submit a Word document, pdf, or just write your answers into the text field.**