

## Lesson 6 How Do New Adaptations Emerge in Populations?

### Overview:

#### Purpose:

The purpose of this activity is to discover how the combination of mutations, natural selection, and environmental change generate progressively better-suited adaptations.

#### Prerequisite Knowledge:

Students need to have developed a model for how mutations lead to the emergence of new genetic information and the loss of old genetic information. They also should know that mutations are the result of relatively random processes. They should have developed a model for mutations that includes at least these two types of mutations. One is **duplication**, *where the allele or gene that was already there was copied more times than necessary (e.g. a doubling of the number of genes for a trait (or chromosomes) thereby potentially leading to increased production of the related protein(s))*. The other is **deletion**, *where the genetic information for the alleles or genes for producing a protein was deleted*. *Both of these mechanisms are represented in the mutation mechanism in the model students will use in this activity*

#### Learning Performances

- Conduct an investigation to provide evidence for an explanation of how natural selection and mutation work together to generate new adaptations in a population over time using a class-wide participatory simulation.

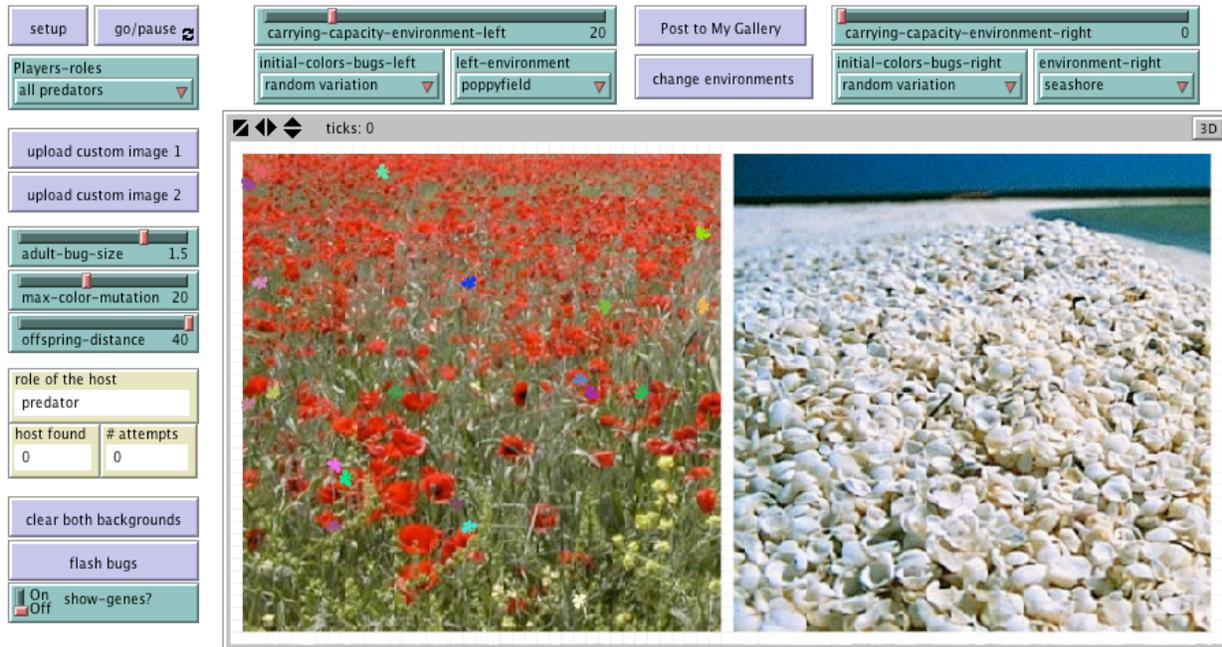
#### Scientific Principles Discovered In This Activity:

- ⤴ Mutations add new traits into a population when random errors occur in the replication of genetic information and are inherited by offspring.
- ⤴ A new trait might grant individuals a competitive advantage for survival in an environment (an adaptation), or a competitive disadvantage, or neither.
- ⤴ Advantageous traits tend to accumulate in populations over many generations yielding a population progressively better adapted to survive in that environment over time.

#### Description of the Lesson

Students compete as a team in a bug hunt competition generating a simulated form of natural selection with an outcome being that a population of bugs becomes progressively better camouflaged over time. They see how mutation is modeled as random changes, but slight changes to genetic information.

They investigate the outcome that results when a population of gray bugs is placed against an image of a field of red flowers as they compete to find bugs to eat. As each bug is eaten, a new offspring is asexually produced from one individual in the remaining population, with slight mutations in the genes that determine the pigments it produces (and resulting phenotype – color). After studying the adaptations that results, they then change the environment (a new background image of a glacier) and repeat the natural selection simulation. In this competition new colors emerge as adaptations for camouflaging, better suited to blending into the colors of glacier.



*Bug Hunters Camouflage Model*

Through discussion, the teacher helps build consensus about how populations adapt to an environment through mutation and natural selection, and how new trait variations emerge through these mechanisms that help the population become progressively better adapted to the environment over time.

In their homework students look at examples of camouflaging in animals and compare the Lamarckian perspective vs. the Modern Synthesis perspective to address misconceptions about the mechanisms that drive adaptation.

## Lesson Details:

**Time:** 60 minutes

### Materials

#### Per Student

- 1 computer with Java 7 and Firefox installed.
- A student WISE account for the class period was already created.
- One small post-it note and one large post-it note.
- One individual copy of Reading 6.1 – Adaptation and Survival

#### For Teacher

- 1 computer with Java 7 and Firefox installed and projector or large display screen for the teacher to display the computer model.
- The driving question board
- 1 piece of butcher paper or poster paper or space on the wall for students to stick the post it notes on.

### Lesson Outline and Timing

#### Launch

- Review driving question board (scientific principles from last lesson) and introduce today's question (3 min.)
- Review ideas related to mutations – deletion, duplication, and insertion (3 min.)
- Teacher demonstrates mutation, selection, and reproduction mechanisms using Screencast of model (steps 6.1 and 6.2) (5 min)

#### Explore – Exploration 1

- 1<sup>st</sup> whole class competition (step 6.4) (5 min)
- Making sense of data (step 6.5) – (3 min).

#### Explore – Exploration 2

- Students make a prediction (step 6.7) (3 min).
- 2<sup>nd</sup> whole class competition is resumed with new background (5 min)
- Making sense of data (steps 6.8-6.9) – (5 min).

#### Summarize

- Review and discuss answers for step 6.9 and record discoveries for step 6.10– (5 min.)
- Class Consensus Building Discussion (15- min.)

#### Homework Assigned:

- Assign tonight's homework (5 min.)

## Lesson Enactment Details

### Before the class starts:

Consolidate the ideas that all of your class periods discovered related to the prior lesson, on the driving question board.

### Launch:

Remind students that they have studied two ways that offspring might get genetic information different either of their parents. One of these is recombination of chromosomes in sexual reproduction (which is still inheriting  $\frac{1}{2}$  of the existing information that each parent had). The other is by mutation of genetic information that ends up in the sex cells of either parent (which is the cause for the inheritance of brand new genetic information)

Ask students to describe what happens in the 3 major types of mutations (duplication, deletion, and insertion)

**Duplication** – *This is where the allele or gene that was already there was copied more times than necessary (e.g. a doubling of the number of genes for a trait).*

**Deletion** – *This is where the some or all of the alleles or genes that were there were deleted.*

**Insertion** – *This is where a new allele or gene is inserted into a chromosome between existing genes. If an existing gene or allele is altered, it can be thought of as a deletion and insertion mutation (since the old genetic information is no longer there).*

Remind students that all of these mutations are the result of rearrangement of the existing sequence of genetic information (nucleotide bases in DNA) within cells, and that these changes are caused by processes random processes.

Put these principles on the driving question board:

- Mutations are the result of random rearrangement of genetic information within cells
- Deletion, duplication, or insertion of alleles into a chromosome is considered a mutation.

Ask students to imagine some possible outcomes of mutations for the following cases:

Imagine they had a tall plant, that is purebred, and it consistently produces tall offspring, even when pollinated with a short plant (since tall is a dominant trait). Now imagine that the tall plant undergoes a deletion mutation in the one of its cells in its pollen. That piece of pollen has lost the genetic code for building the protein expressing the tall trait. What do they predict the height of the offspring of this plant will be when it is pollinated with a short plant? *Students should say, probably short, since it now has no source of genetic instructions for creating the substance that would make it tall.*

Ask students to give an example of a trait, which is critical to the survival of the organism. It should be a trait, whose genes, if they were deleted, would result in the death of the offspring that inherited it. *Answers may vary.*

Ask students for an example of a trait that if the genes were **deleted** in it, probably would NOT result in the death of the individual offspring that inherited it? *Answers may vary.*

Ask students for an example of a trait that if the genes were **duplicated** in it, probably would NOT result in the death of the offspring that inherited it? *Answers may vary.*

Follow up by asking why would this missing or duplicated genes would not be critical to the ability of the organism to survive.

Tell students that they have brainstormed some examples where a mutation might be harmful (cause death) and some situations where it wouldn't.

Tell student that in this computer activity they will be exploring the effects of first two forms of mutation: duplication and deletion and the role of this mutation can play in contributing to the effects of natural selection. And they will be exploring the effects of different environments on the outcomes of natural selection.

You will demonstrate the mechanisms of mutation included in the model, by projecting a Screencast of the computer model. This will help students understand the mutation mechanism and how color variation in the bugs the outcome of mutation in genetic information for production of red, green and blue pigments. Students will be recording some of what you are demonstrating with the Screencast before launching the model and joining it themselves,

- **Make sure students are on step 6.1**

## Demonstrating the model via. Screencast

### Model Demonstration Directions For the Teacher

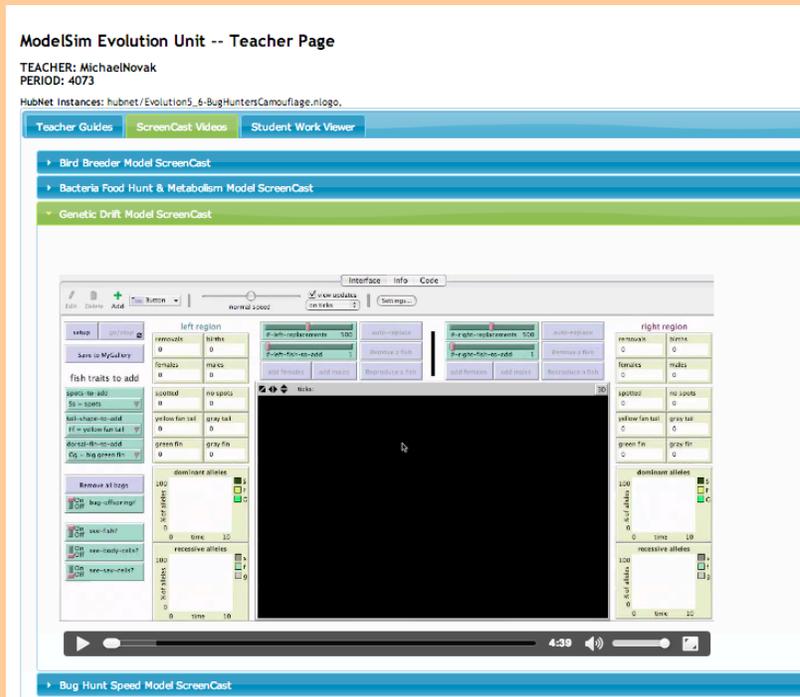
1. You too will want to log into WISE in teacher mode, but will launch the same model the students will be using in later steps. Click on the Teacher Home tab. You will see a list of all the active runs you have started for each class period. For the current class that you are teaching. In the example below, the first row show the Student Activity for this Teacher's Period 1 class

Evolution New Master		Period	Students	Grade by Step: Latest Work   All Revisions
Student Access	Swan004	1	0 registered	Grade by Team: Latest Work   All Revisions
Code:		<a href="#">Manage Students</a>		Project: <input type="checkbox"/> Preview   <input type="checkbox"/> Info   <input type="checkbox"/> Edit Content
Run ID:	215			
Run Created:	Sep 17, 2013			
Project ID:	349			
Copy of Project:	278			
<a href="#">Edit Run Settings</a>		<a href="#">Share with Another Teacher</a> <a href="#">Manage Announcements</a> <a href="#">Researcher Tools (Export Student Data)</a> <a href="#">Report a Problem</a> <a href="#">Archive (End Run)</a>		

2. Look for the Grading & Tools Column to the right. Under that look for the Grade by Step heading and click on the Latest Work link.
3. The teacher Grading & Feedback page will come up. Click on Launch Teacher Page on the top right of the page.

Select a step below to start grading (Point values are editable)	Point Value	Items to Review	Avg Score	% Visited Step
Activity 1: Selective Breeding				
Step: 1.1 Introduction (HimNode)				
Step 1.2: Observe (TableNode)	0	0	N/A	NaN%
Step: 1.3 Exploration 1 (HimNode)				
Step: 1.4 E1 - Open the Model (HimNode)				
Step 1.5: E1 - Record Your Observations (AssessmentListNode)	0	0	N/A	NaN%

4. Click on the Screencast Videos tab. Click on the Bug Hunters Camouflage Link.



- Tell students that when you play the video you will need them to record some information about how the model works and make a prediction.
- Press the play button. Audio narration is provided. Pause the video at 1:00, **have students complete step 6.2 at this point.**

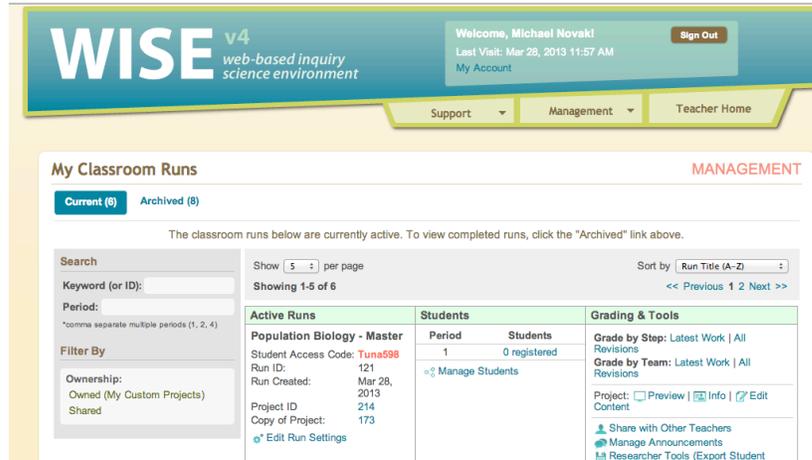
Explore:

**Directions for teacher: Model Introduction & Exploration #1**

These directions explain in detail how to launch run a HubNet based Participatory Simulation from WISE. Remember to have Java 7 downloaded and log into WISE using a 64-bit browser (Safari or Firefox). You will not be able to run Java content in Chrome. Do the following steps to launch the model before class starts.

- After logging into WISE, click on the Teacher Home tab. You will see a list of all the active runs you have started for each class period. For the current class that you are teaching. In

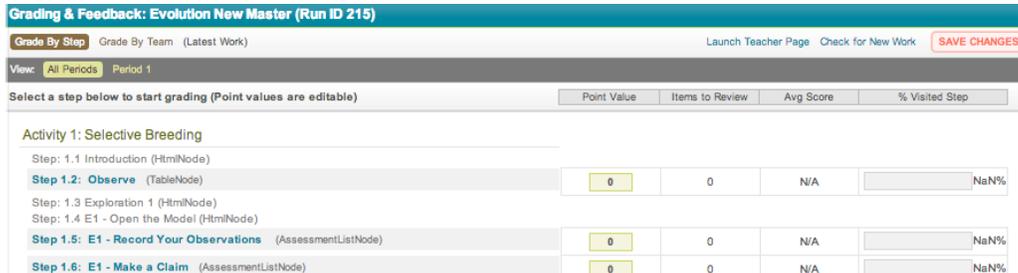
the example below, the first row show the Student Activity for this Teacher’s Period 1 class.



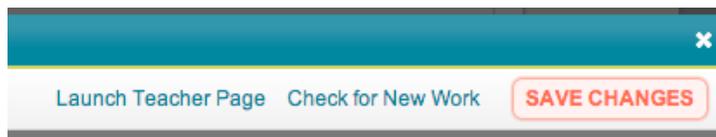
2. Look for the Grading & Tools Column to the right. Under that look for the Grade by Step heading. Next to that you will click on the link that says All Revisions.



3. A new window will pop up like the one shown below. This may take a moment to load.



4. In the top right corner of this window you will see the following links. Click on the one that says Launch HubNet Teacher App:

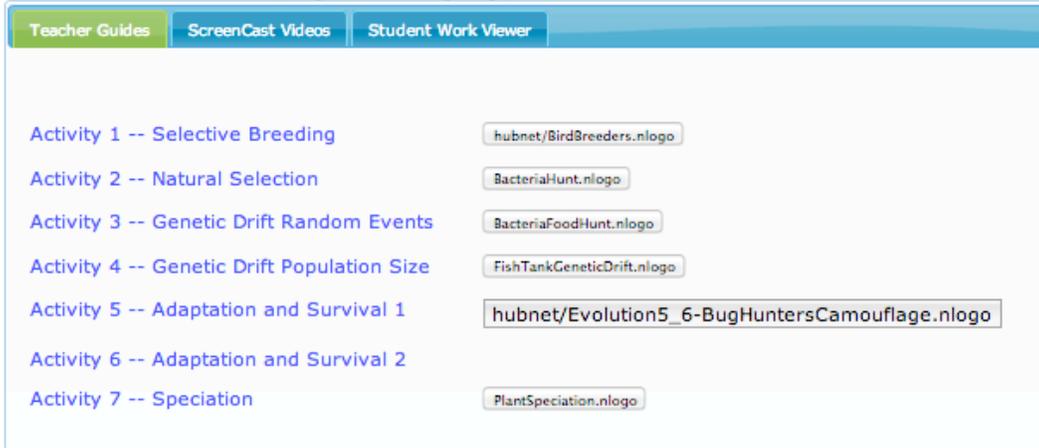


5. In the next window, press the hubnet/Evolution5\_6-BugHuntersCamouflage.nlog button to start the model.

### ModelSim Evolution Unit -- Teacher Page

TEACHER: MichaelNovak  
 PERIOD: 4073

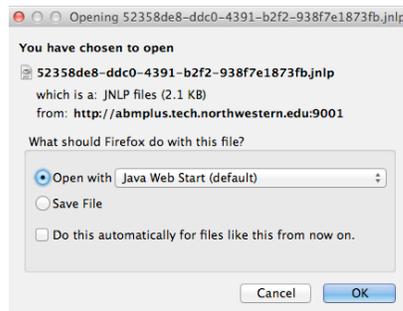
HubNet Instances: hubnet/Evolution5\_6-BugHuntersCamouflage.nlogo,



6. Next, a Security Warning dialog box will appear. Click on the **Run** button to run the program.



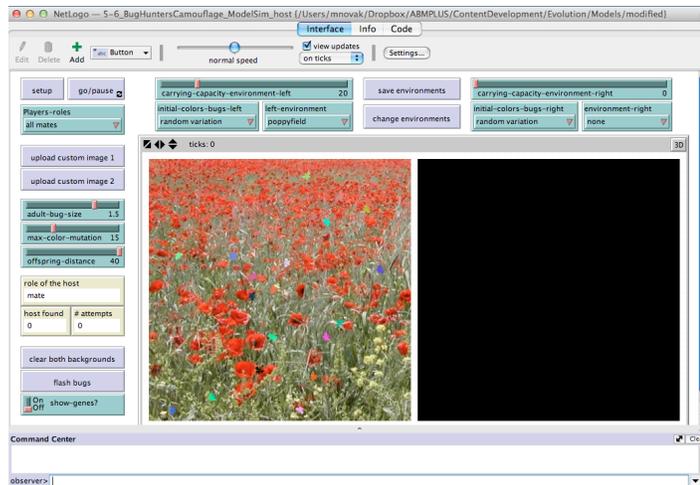
7. A Java Web Start file dialog box will now open. Press the **OK** button.



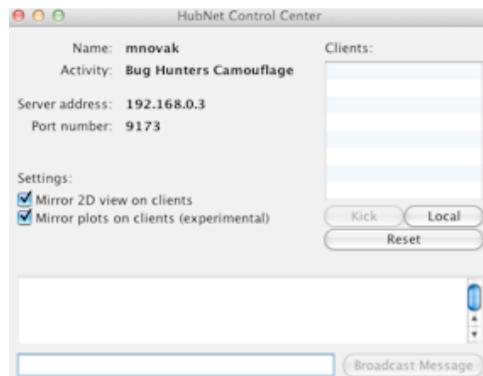
8. A 2<sup>nd</sup> Security Warning dialog window will open. Select the box that says **I accept the risk and want to run this application**, and then click **Run** to start the supplication.



9. A NetLogo – Bug Hunters Camouflage Window will now open. When it does press the **Start** button on the Start HubNet Activity dialog box.



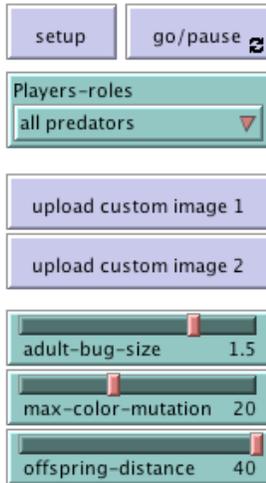
10. **Next have students follow the directions on step 6.4.** As they do so, you will see their names pop up on the client list in the **HubNet Control Center** window.



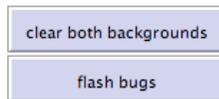
11. Once you have checked the Client List to make sure all students have joined the game.

12. When all students have joined, remind them that the goal is catch as many bugs as they can in this competition.

13. Make sure the model is set to the following settings:



14. Press the SETUP button again and then say, "go" as you press the GO/PAUSE button in the model to run the model.
15. After about 3 to 4 minutes stop the model (press GO/PAUSE again). Or stop the model when you feel the bugs have become difficult to find (camouflaged).
16. Ask students if it seems as if the bugs are easier or harder to find as when they started. Then press the FLASH button. Ask students to say which part of the screen had bugs that they didn't realize were there.
17. Then press CLEAR BOTH BACKGROUNDS and ask student's to think about why these bugs are not the same color as the gray bugs we started with.



**18. Have students complete step 6.5 and 6.6**

19. Then change the LEFT-ENVIRONMENT chooser to "glacier.jpg" and press CHANGE-ENVIRONMENTS



20. The glacier background will load:



**21. Have students complete step 6.7 to make their predictions.**

22. Press GO/PAUSE to run the model. Tell students to click on as many bugs as they can as quickly as they can.

23. After about 3-4 minutes stop the model (press GO/PAUSE again).

24. Again, discuss out the results of the model run. Press the FLASH button to see where the bugs are.

25. Then press the CLEAR BOTH BACKGROUNDS button again.

**26. Have the students answer the questions on steps 6.8 through 6.9.**

**Summarize:**

You may wish to **discuss the answers to the 2<sup>nd</sup> to last step (step 6.9)** with the class before having this final consensus building discussion: **Which of the following best explains the mechanisms responsible for the causing the change in the colors of the bug population?**

- This answer is incorrect: Each bug intentionally chooses a form of camouflage to help it survive. The bugs choose best, then that survive to pass that choice on to their offspring. Which helps their offspring know what the environment around them looks like. These bugs have a competitive advantage in that environment. **Preys aren't intentionally choosing – mutation is a random process.**
- This answer is correct: Predators unintentionally remove the easier to find bugs more often than the hard to find bugs. Each new prey that is born with random mutations in its genes. These mutations give more variations for the predators to pick from. Since some variations are harder to find than others, birds remove those more often and leave behind bugs that are more difficult to find. This causes each new generation to become progressively better camouflaged. **Predators are selecting, but it is unintentional and mutation is random. These two together drive adaptation.**
- This answer is incorrect: Predators intentionally choose which prey they want to survive. Each new prey that is born with random mutations in its genes. These mutations give more variations for the predators to pick from. Since the predator prefers to leave behind the hard to find prey, it intentionally selects for camouflaged bugs in this environment. **Predators aren't intentionally selecting, they are simply going for what they can find, and the easier to catch stuff tends to get taken out of the population first.**
- This answer is incorrect: Every bug is programmed to adapt and evolve a better genotype. Every bug recognizes the environment it is in, and changes the genetic information so that it has a trait variation to better help its offspring survive. **Prey doesn't know what the environmental change is going to be. And they can't change their genetic information (DNA) in a direction that benefits their offspring. The changes in genetic information that are mutations are random, but those that survive are not.**

**Have students complete step 6.10**

Have each student talk with a partner and select one idea they discovered today related to “How Do Adaptations Emerge in Populations?” Have students write this idea on a large piece of paper or a large post it note in dark pen/marker. Have one student from each pair of students bring their papers/post-its to the front of the room and stick them up on the board.

With the papers/post-its displayed for the class to look at together, lead a consensus building discussion. Facilitate the movement and reorganization/clustering of the ideas students brought up, under the headings listed below. This consensus building discussion and reorganization of the student descriptions of their discoveries will help students condense and summarize the big ideas from the day's lesson. If an idea that students suggest doesn't fit under these areas, don't leave it out. Rather, emphasize that the idea shared is another interesting discovery and that the main ideas that the students are responsible for knowing and reusing in future explorations are the ones organized under the areas listed. Try to write the categories in the student's own words, and using their own papers if possible. You may want to consider posting these big ideas in class, having students summarize these ideas now (or later) in their notes. Either way, try to use the students own words and the way the class expresses the ideas listed below, without feeling it is necessary to use this exact wording. Examples of possible student responses they might contribute on their sheet or post it note are shown in italics. Ask students whether they agree or disagree with how the ideas or organized and whether this summary helps pull out the main points they discovered.

The underlined statement is the suggested category. The non-bold italics statements are possible student ideas. The bold italics statement can serve as another way to summarize what is common amongst the student ideas and each underlined category.

## Conclusions & Big Ideas: "How Do Adaptations Emerge in Populations?"

### Mutation contributed to it

- *Example student idea: Mutations change what was there before to become slightly different*
- *Example student idea: Mutations are random*
- *Example student idea: Mutations occur in the genetic information.*
- **Summarize with this ideas: Mutation are random changes to genetic information. Some mutations add new genetic information and new trait variations to a population; Some of the mutation yield a trait variation that is more beneficial for survival, some are less beneficial and others give no gain/loss in competitive advantage for survival.**

### Natural Selection

- *Example student idea: Predators kill off the bugs that they can see*
- *Example student idea: Some types of traits aren't good to have and they get removed*
- *Example student idea: The bugs that blend in have more offspring more often than dead bugs*
- **Old idea: Natural selection removes individuals with traits (and genetic information) that have a competitive disadvantage, the other individuals that survive reproduce and have more offspring.**

### Environmental Change

- *Example student idea: When the environment changes, what trait is good changes*
- *Example student idea: Different traits are better for different places and different ones are worse*
- *Example student idea: You can blend in better if you are the color of the background*
- **Old idea: Changes to the environment often change which trait variation(s) give a competitive advantage.**

### Adaptation

- *Example student idea: The colors changed more and more as time went on.*
- *Example student idea: Bugs became harder to find the more you hunted them.*
- *Example student idea: The bugs look very different than they did at the start.*
- **Summarize with these ideas: Beneficial mutations tend to accumulate over many generations, yielding a population that becomes progressively better adapted to survive in its environment. This process is called adaptation (verb)**

*Also discuss this idea, which will be revisited in the homework: Populations adapt (verb) due to natural selection and survive. Adaptation does not refer to how individuals respond to their environment, nor is it the result of individuals trying to intentionally "change their characteristics" to pass on to their offspring. (While individuals adjust and respond to their surroundings (many organisms learn from their experiences, all organisms react to and respond to environmental stimuli), such adjustments are not considered adaptations, because such adjustment and responses to the environment does not change the genetic information to pass on to offspring, which is a critical outcomes that must occur if adaptations are to be passed on to future offspring in a population)*

Post these two principles (**bold** is newly added to a prior principle):

- Mutations add new traits into a population when random errors occur in the replication of genetic information and are inherited by offspring.
- A new trait variation might grant individuals a competitive advantage for survival in an environment (an adaptation), or a competitive disadvantage, or neither.
- Advantageous traits tend to accumulate in populations over many generations yielding a population progressively better adapted to survive in that environment over time.

***Homework Assigned:***

*Assignment 1:*

Tell students that they investigated two mechanisms of evolution today – natural selection and mutation, to see how a new outcome, **adaptation**, emerged in a population. They saw how this outcome was different in two different environments today in class. Tell them that tomorrow they will get to design their own experiment to conduct using this model and a team of four to six people. One option will be to choose whether they want to experiments with predation, mating, or both. The other option will be to load in background photographs of the natural world that they take with the camera phones. Another option will be whether they want to compare outcomes in the same environment or in two different environments.

- Assign students to teams of four to six people (or let the form their own teams with more than a couple students. This is necessary to generate faster outcomes in the participatory simulation they used today and will be reusing tomorrow)
- Assign students who have digital cameras this data collection assignment: take photographs of backgrounds they want to use in their experiment and email them to a web based mail account. They will need to access the account tomorrow in class using a web browser and download the images to the desktop in order to use them in their experiment. Some example ideas could include: dirt, mulch, rock piles, forest, prairies, the side of a rusted train car, the track at the school, and grass in the backyard. Encourage students to consider whether a birds-eye views or a side view would give the best image.

*Assignment 2:*

Pass out Reading 6.1 – Adaptation and Survival for students to complete before the next activity.

PDFs of the homework are available on the teacher resource page for the unit. Simply click on the blue link for each activity under the student assignments section to download the pdf of the homework.

**ModelSim Evolution Unit -- Teacher Page**

TEACHER: MichaelNovak  
PERIOD: 4073

HubNet Instances: hubnet/Evolution5\_6-BugHuntersCamouflage.nlogo.

In-class Activity	In-class Steps or handout	Estimated Time	Out of class assignment based on this activity
1: Introduction to the Case Studies Board	<a href="#">Case Study Board Introduction</a>	Option 1: 40-60 min. Option 2: 10-15 min.	<a href="#">Reading 1.1 – Interactions In Ecosystems</a>
2: Selective Breeding	2.1 to 2.8 <a href="#">Case Study #1</a>	60 min.	<a href="#">Reading 2.1 – Selective Breeding</a> Complete Case Study #1
3: Natural Selection: Predation	Case Study #1 3.1 to 3.7	60 min. 1st part of lesson is not on the computer, the 2nd part is.	<a href="#">Reading 3.1 – Natural Selection</a>
4: Natural Selection: Food & Metabolism	4.1 to 4.9	60 min.	
5: Genetic Drift and Case Study #2	5.1 to 5.13 <a href="#">Case Study #2</a> (printed in color for each student)	120 min. 1st part of lesson is on the computer, the 2nd part is not.	<a href="#">Reading 5.1 – Random Events</a> <a href="#">Reading 5.2 – Genetic Drift Population Size</a>
6: Adaptation Explorations	6.1 to 6.10	60 min.	<a href="#">Reading 6.1 – Adaptation and Survival</a>
7: Adaptation Experimentation	7.1 to 7.11	60 min.	Take of digital photo of an environment and send it to web based email to access tomorrow at school <a href="#">Reading 7.1 – Adaptation for Sexual Selection</a>
8: Speciation	8.1 to 8.13	60 min.	<a href="#">Reading 8.1 – Speciation</a> <a href="#">Reading 8.2 – Adaptive Radiation</a>
Final Case Study	<a href="#">Case Study #3</a>		To be completed in class or out of class