Lesson 8: How Do New Species Emerge?

Overview:

Purpose:

The purpose of this activity is to understand how new species can form from old species through the mechanisms of evolution covered so far in the unit (mutation, genetic drift, changes in environmental conditions, and natural selection).

Connection to previous activities:

Students refer to the mechanisms of mutation (introduced in the last activity), genetic drift (from the activity before that), changes in environmental conditions and natural selection (from two previous activities), to develop the explanations for the outcomes in this activity.

Learning Performances

- *Analyze data from a computer investigation* applying concepts of statistics and probability to explain why adaptations for reproductive isolation can help reinforce specialized adaptations for survival for different niches within different gene pools in a population. [Emphasis is on analyzing shifts in numerical distribution of traits in a histogram and using these shifts as evidence to support explanations.]

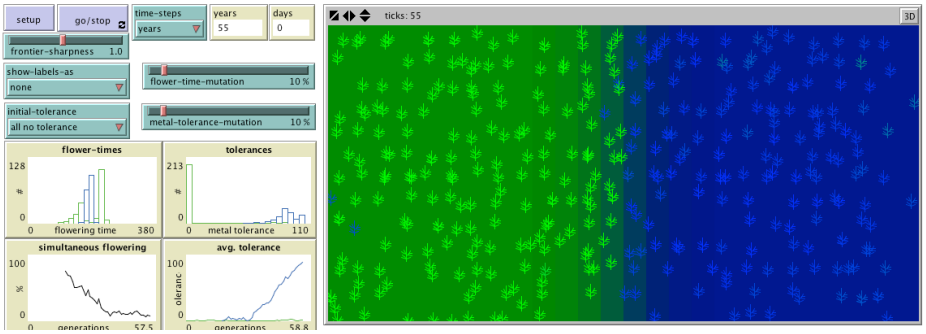
Scientific Principles Discovered In This Activity:

- New species emerge from old species (a group of organisms that is capable of interbreeding only between each other to produce fertile offspring).
- Speciation can occur when specialization for survival in different niches is available to a population; this specialization opportunity can tend to reinforce adaptations that lead to greater reproductive isolation between those populations.
- Speciation can occur when geographic isolation leads to separate populations that through mutation and genetic drift, develop genes and corresponding traits that make descendent from each population less reproductively compatible with each other over time.

Description of the Lesson

The class revisits their definition of a species and discusses whether genetic drift alone could account for why new species emerge.

They then use a computer model of plants in an ecosystem to explore how speciation always could also emerge from a single population over time under certain conditions.



Plant Speciation Model

Through discussion, the teacher helps build consensus about why speciation might occur when mutation initiates the pathway to speciation, but natural selection and adaptation are the driving mechanisms that continue to reinforce the emergence of this outcome.

In the homework they study examples of how speciation has been created in laboratory conditions with human intervention and contrast the mechanisms at work in real world ecosystems when new species emerge. And they read Darwin's finches on the Galapagos Islands as a real-world example of adaptive radiation.

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 8.1 – Speciation and of Reading 8.2 Adaptive Radiation

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

- Students log onto WISE (2 min.)
- Step 8.1 (2 min.)
- Discussion up to and including step 8.2 (8 min.)
- Discussion up to and including step 8.3 (5 min)

Explore

- Students complete steps 8.4 through 8.14 (20 min).

Summarize

- Students record discoveries in step 8.14 (5 min).
- Summary discussion and discuss answers for step 8.9 – (15 min.)

Homework Assigned: Assign tonight's homework (2 min.)

Lesson Enactment Details

You will add new discoveries to the driving question board at the end of the lesson, under the section "How Do New Species Emerge from Old Species?" But, just like in the last lesson its recommended that you use pieces of butcher paper to write the discoveries on so they can be temporarily taped in. You can then move that class period's discoveries to the driving question board for that class. And then before the next class, you can remove the last class period's discoveries (or cover them up).

Launch:

- **Have students log into wise**
- **Have students complete step 8.1 questions.**

After they do so, ask them how they knew the organism wasn't a cat? *Push back on answers such as "it has stripes. It has claws," saying cats do too.*

After students have suggested other traits, tell students, that many of their ideas have to do with describing the ways the traits are different between cats and raccoons. Tell students that this was the way that scientists classified different species of organisms for hundreds of years.

Say that another important way that scientists try to explain what they mean when they say "a different type of animal" is to introduce the idea of a **species**. Write the word species on the board:

A species is a group of organisms belong that is capable of interbreeding to produce fertile offspring.

Ask students to look at this definition and to use it to consider what it means for house cats and raccoons. Since raccoons and house cats are not capable of interbreeding together, they are considered different species of animals.

Then ask students about roses and corn. These two plants are not capable of interbreeding together. So then would they be different species or the same? *Different species.*

Ask students if they think dandelions and roses would be considered the same species or different and why? *Students will probably say that they are different species, because they have never heard of or seen an offspring of a rose and dandelion. Or they may say that they could be the same species if they were found to be able to interbreed together.*

Point out that there are lots of animals that show variations in type, but those different types are not always different species. For example dog breeds are all the same species. Even wolves and dogs are the same species. Ask students why they would be considered the same species? *They should say because the wolves and dogs can interbreed together and have offspring.*

Ask students to estimate how many species of mammals they think are on Earth. Ask students to estimate how many species of plants they think there on Earth. Have students share some estimates and reasons for these predictions.

- **Have students complete step 8.2 questions.**

Ask students if the number of species on Earth has always been the same. And write this as a question on the board "Do the number of species on Earth always stay the same?" *Have students share reasons why the number of species on Earth has changed over time. Some students will point out that species can go extinct. Other students may share examples from the fossil record.*

Ask students to share examples of other species they have heard have or studied that they went extinct.

"Do the number of species on Earth always stay the same?" write the answer the class has agreed upon (no) and point out that if the number of species on Earth is not always the same, then two types of changes in species number could be

occurring at any time – the number of species might be decreasing or the number of species might be increasing. Underneath this then write two sub questions

1. "What caused old species to go extinct"
2. "Where would new species come from?"

Tell students that many of them have probably heard of examples (such as dinosaurs or woolly mammoths) of species that have gone extinct. And many probably have also heard of species that are endanger of going extinct and are on the "endangered species" list. But many of them may not have heard of examples of new species that were not here in the recent past. Tell students that they will learn about examples new species that people have observed emerge in populations and ecosystems, and they will investigate the second question, thinking about where new species come from.

If students have complete the Population Dynamics WISE unit before this unit, then you can remind them that they discovered that environmental changes are one major reason species have gone extinct in the past.

Tell them that there are many species of animals and plants on earth now that were not here in the distant past. For example, flowering plants didn't exist at one time in the past. There is no fossil record of flowering plants earlier than 140 millions years ago. Scientists suspect the flowering plants evolved from gymnosperms (plants like pine trees and evergreen) somewhere between 350 and 140 million years ago.

- **Have students complete step 8.3.** Ask students to suggest any mechanisms of evolution that could work together to generate this outcome. *Accept all answers at this point.*

Ask students to share their predictions, writing on the board the pieces of their predictions that the class agrees upon. The pieces that they agree upon, probably will include:

- All new species come from existing species
- Evolutionary mechanisms might be responsible
- Not sure what evolutionary mechanisms would cause this to happen.

Introduce the word **speciation**. Tell them that this refers to whenever a new species is formed from an old species. When this happens, an existing population forms two separate groups within the population. Individuals in one group for some reason can no longer interbreed with individuals from the other group. So, really speciation refers to when one existing species separates or break apart into two or more new species.

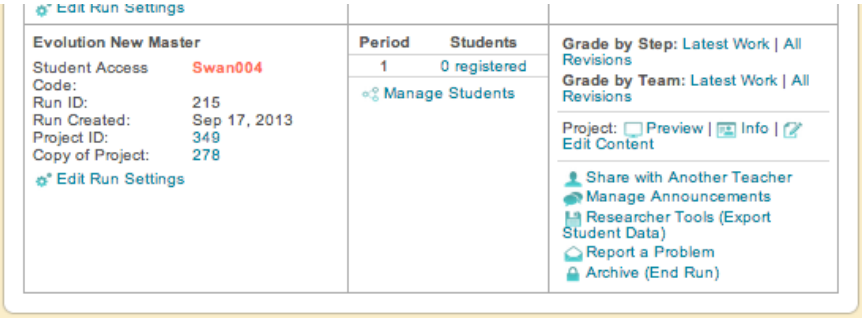
Tell students that they will be investigating speciation further in their exploration of a computer model today.

You will demonstrate the model students will use by projecting a Screencast of the computer model.

Demonstrating the model via. Screencast

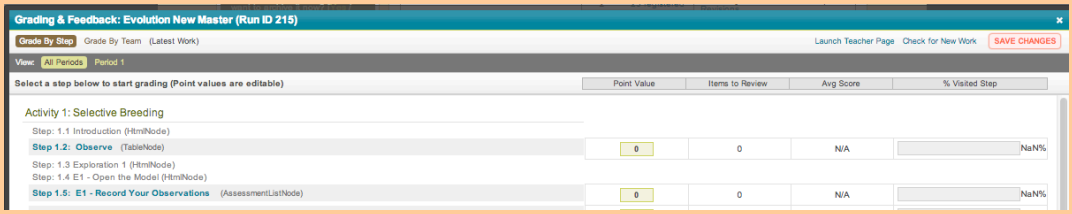
Model Demonstration Directions For the Teacher

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

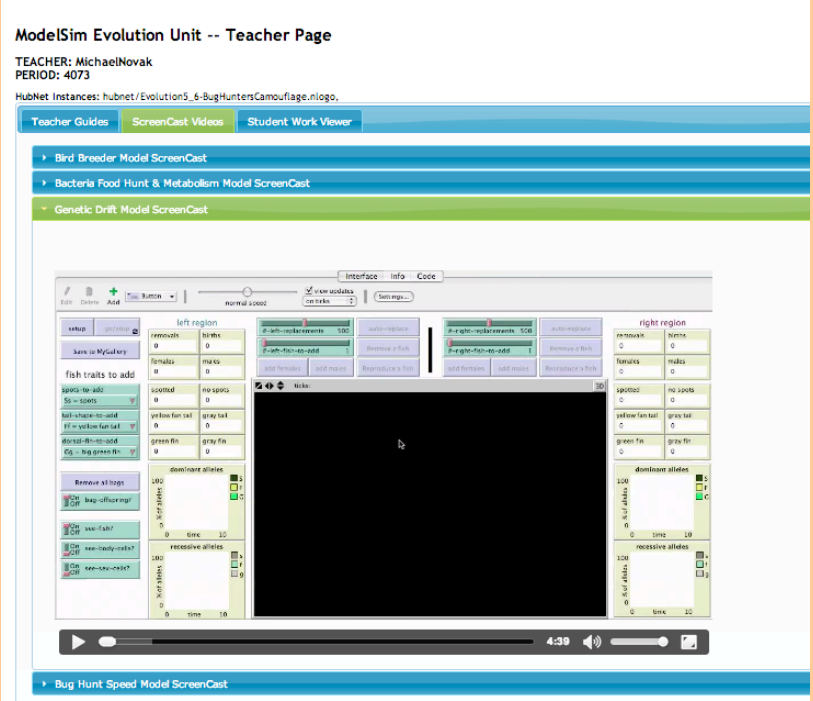


2. Look for the Grading & Tools Column to the right. Under that look for the Grade by Step heading and click on the Latest Work link.

3. The teacher Grading & Feedback page will come up. Click on Launch Teacher Page on the top right of the page.



4. Click on the Screencast Videos tab. Click on the Plant Speciation Link.



Explore:

Have students complete steps 8.4 through 8.13.

There are three explorations within these steps. It is ok if all students don't complete all steps, but allow time for students to end the step they are on and jump ahead to record their discoveries in the final step for this activity.

Summarize:

Have students record their discoveries in step 8.14 from the last step in the activity.

Ask students, "Even though individuals can get a mutation that would allow it to open its flower much later than any other flower in the population, why would this individual have a competitive disadvantage for reproducing new offspring?" *Students should reference the idea of decreased competitive advantage for reproduction, if you don't "mate" at the same time the rest of the potential mates do. So it's best to be close to the average mating time. Very late or very early blooming plants may not be able to reproduce with any other plant, so their genes are removed from the gene pool when they die, because they have no offspring.*

Ask students how does the shape of the FLOWER-TIME graph from this last model run support the claim that individuals that flower earlier than the average flower time or later than the average flower time, have a lower chance of having offspring? *Students may point to features of the graph that support the idea that most of the plants appear in the middle of the range of flower times. Most of the plants are clustered close to the average flower-time, and very few are surviving to the left or right of the average in the distribution graph.*

Tell students that genetic drift could cause the average to slowly drift higher or lower over time, but sexual selection would a continuous mechanism that would cause the shape of the graph to remain the same and the distribution to say clustered around the average.

Ask students to study the results of exploration 3. Ask students why weren't there many plants in the population with a tolerance in between 10 and 90? Show the example graphs in part d of transparency 18.1 a reference. *Students should say that this is because the environment doesn't have many "partially clean or partially contaminated" soils. Most of the left side of the ecosystem is very close to 0 metal and most on the right side of the ecosystem is very close to 100 metal.*

Ask students how natural selection leads to this outcome. *Students should use the idea of competitive advantage in different portions of the environment. For example: tolerances that match these metal levels have the greatest competitive advantage (depending what side of the ecosystem they are growing on), anything else would have less of a competitive advantage.*

Point out that any one of these outcomes shows that the population of plants on the left side of the ecosystem no longer breed with the population of plants on the right side of the ecosystem (in most cases), because there is very little (if any) overlapping blue and green bars. Tell students that the interbreeding of these sub-populations may still occur in one or two cases occasionally (due to mutation), there is apparently a mechanism or combinations that is forcing these sub-populations apart, strongly pushing them in them away from being reproductively compatible. In some cases it has pushed the population toward forming two separate species, and in other cases it has pushed the population into forming three separate species, by fragmenting the flower time of one of the populations. The two primary mechanisms of evolution at work here are two forms of natural selection: natural selection for survival and sexual selection. But they are interacting in an unexpected way due to the environmental variation in the ecosystem.

Ask students to describe what sort of trade off is occurring in the evolution of the plants, between survival advantage and reproductive advantage. *Students should say that the plants are getting more survival advantage,*

but less reproductive advantage.

Tell student that if a population speciates then the tradeoff of these two advantages must result in an overall advantage for both sub-populations. In this case, the overall advantage is allowing each sub-population to become specialized to survive very well in a different part of the environment. *But it is at the expense of not staying interbreed-able with every other plant. Anywhere ecosystem with large variation in the environment could lead to this type of specialization through speciation.*

Tell students that this is one possible set of mechanisms of evolution that scientists have proposed that could lead to speciation, but is not the only combination of possibilities. This set of mechanisms involved: 1) mutation leading to slightly different populations in an ecosystem with two distinct areas with different environmental conditions. In this environment, there was a 2) competitive advantage to having one trait variation in one environmental condition and a competitive advantage to having the other trait variation in the other environmental condition. A second trait variation (flower time) provided a potential opportunity to generate a "barrier" to interbreeding with all the plants and permitting interbreeding only with plants that would likely give offspring a competitive advantage. This is what begins to emerge as it becomes advantageous for the flower time for one plant to be similar to the flower time of another plant with the same metal tolerance, but slightly different than the flower time of other plants. This slight difference makes it more likely for "similar" metal tolerance plants to interbreed and less likely for dissimilar metal tolerance plants to interbreed.

Point out that any behavior; structure or chemical process that makes two individuals incapable of interbreeding would classify it as two separate species. In this case it was flower time. But there are other possibilities – mating behavior, physical structure, and biochemical processes are all potential barriers to creating fertile offspring (or offspring that can continue to interbreed). Tell students that some animals can interbreed, but have such different genetic information, that their offspring are infertile – the genetic information from both parent is compatible enough to make a living offspring but is not compatible for developing sex cells in that offspring. One example is of Horses and Donkeys and producing Mules as offspring. Horses and Donkeys are considered separate species because their offspring, Mules, can't reproduce and make more offspring.

Then tell students that genetic incompatibility for making a living offspring is another barrier to different animals reproducing. For example, if one potential parent passes on genetic information that gives conflicting genetic information compared to the other potential parent's genetic information, then the offspring cells would not be able to produce the necessary proteins and related traits to allow that organism to grow and repair the cells needed to make the organism. If genetic drift and mutations that lead to these incompatibilities start to accumulate, then two populations that were descendants of one species but are separated, might become two separate species in time.

Summarize that all new species will come from existing species; all existing species came from ancestor species and that new species form from old populations that used to be one species, when that population fragments or breaks apart into two or more non-interbreeding populations. Tell students that there are two important sets of mechanisms that cause speciation:

1. One set is the kind that drove the plants to become separate species. In environments with variation in conditions and in populations with variations in traits, not reproducing with the part of the population can increase the chances for offspring survival in one part of the environment.
2. The other is when two parts of a single species become geographically isolated from one another, mutation and genetic drift will start accumulate more and more differences in the organisms in each population over time. If these differences start influencing how the chromosomes match up in meiosis or fertilization or the behaviors and reproductive structures of individuals, then differences will lead populations to become progressively more incompatible for ever interbreeding back together in the future. This can lead to separate species as well.

Conclusions & Big Ideas: How Do New Species Emerge From Old Species?

- **New species emerge from old species (a group of organisms that is capable of interbreeding only between each other to produce fertile offspring).**
- **Speciation can occur when specialization for survival in different niches is available to a population; this specialization opportunity can tend to reinforce adaptations that lead to greater reproductive isolation between those populations.**
- **Speciation can occur when geographic isolation leads to separate populations that through mutation and genetic drift, develop genes and corresponding traits that make descendent from each population less reproductively compatible with each other over time**

Once these ideas in the bold have been agreed upon by the class make sure they have been added to the last section of your driving question board. One easy way to do this is to move the butcher paper or poster paper that you had been using to keep track of the ideas and tape it under the lesson question for today.

Homework: Assign the two homework assignments for this lesson (Reading 8.1 – Speciation and Reading 8.2 – Adaptive Radiation). 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,

Teacher Guides | ScreenCast Videos | Student Work Viewer | Student Assignments

Student Assignments for the ModelSim Evolution Unit

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	Case Study Board Introduction	Option 1: 40-60 min. Option 2: 10-15 min.	Reading 1.1 – Interactions In Ecosystems
2: Selective Breeding	2.1 to 2.8 Case Study #1	60 min.	Reading 2.1 – Selective Breeding 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.	Reading 3.1 – Natural Selection
4: Natural Selection: Food & Metabolism	4.1 to 4.9	60 min.	
5: Genetic Drift and Case Study #2	5.1 to 5.13 Case Study #2 (printed in color for each student)	120 min. 1st part of lesson is on the computer, the 2nd part is not.	Reading 5.1 – Random Events Reading 5.2 – Genetic Drift Population Size
6: Adaptation Explorations	6.1 to 6.10	60 min.	Reading 6.1 – Adaptation and Survival
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 Reading 7.1 – Adaptation for Sexual Selection
8: Speciation	8.1 to 8.13	60 min.	Reading 8.1 – Speciation Reading 8.2 – Adaptive Radiation
Final Case Study	Case Study #3		To be completed in class or out of class