Science Objectives

- Students will know how natural selection determines the differential survival of groups of organisms.
- Students will know why natural selection acts on the phenotype rather than the genotype of an organism.

Vocabulary

- Natural Selection
- phenotype
- population
- parent
- dominant
- non-mutant
- selective advantage
- differential survival
- trait
- wild-type
- evolution
- genotype
- generation
- offspring
- recessive
- fitness
- selection pressure
- predation
- environment
- allele

About the Lesson

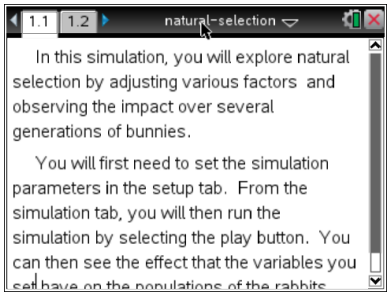
- This lesson allows students to model natural selection, providing an opportunity to investigate the mechanisms that lead to evolutionary changes.
- As a result, students will:
  - Understand natural selection as a driver of evolution.
  - Understand how populations change as a result of mutations and selection.
  - Be able to distinguish phenotype and genotype.

TI-Nspire™ Navigator™

- Send out the *Natural_Selection.tns* file.
- Monitor student progress using Class Capture.
- Use Live Presenter to allow students to show how they manipulate variables that effect results.

Activity Materials

- Compatible TI Technologies: TI-Nspire™ CX Handhelds, TI-Nspire™ Apps for iPad®, TI-Nspire™ Software



Tech Tips:

- This activity includes screen captures taken from the TI-Nspire CX handheld. It is also appropriate for use with the TI-Nspire family of products including TI-Nspire software and TI-Nspire App. Slight variations to these directions may be required if using other technologies besides the handheld.
- Watch for additional Tech Tips throughout the activity for the specific technology you are using.
- Access free tutorials at http://education.ti.com/calculators/pd/US/Online-Learning/Tutorials

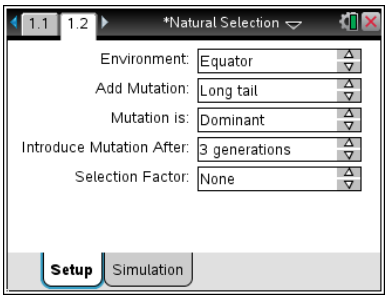
Lesson Files:
Student Activity

- Natural_Selection_Student_HS.doc
- Natural_Selection_Student_HS.pdf
- Natural_Selection.tns

Discussion Points and Possible Answers

Part 1: No Selection

Your students will be running a simulation of a rabbit population with no selection. A mutation will be introduced after three generations, and they will see what the final result is when the mutation is dominant or recessive. Without selection, the growth of one phenotype in the population is only influences by genetics. A dominant mutation will appear more prominently in the population then a recessive mutation, but both will remain in the population.



 Wild-type

 White Fur

 Long Teeth

 Long Tail

Your students can explore the different mutations, but it will slow down the planned simulations if they change the "Introduce Mutation After" selection.

Basic Simulation Help:

When the simulation is running, some of the rabbits will hop.

There is a subtle difference between the pictures of the different phenotypes. These images are included for your reference.

Alternatively, you should be able to export data from a simulation to retrieve the exact numbers of each mutation after a simulation.

Tech Tip: To export the data for a simulation, select menu and then select **4: Export Data > 1: Export All**.

Tech Tip: To export the data for a simulation, select > **Export Data > Export All**. Students may need to back-out to the main Tools Menu to see the desired menu option.

Q1. What is a phenotype?

Answer: A phenotype is an observable trait that is influenced by genetics.

Q2. How would you expect the simulation to be different if there were a selective advantage to one trait?

Answer: If there were an advantage to a trait, you would expect those individuals to be more likely to survive and pass their traits on to the next generation.

Q3. After 6 generations, how many rabbits show the dominant phenotype? The recessive phenotype?

Answer: Check students' work. These numbers can be exported from the simulation. The important point is that more rabbits are showing the dominant phenotype.

Q4. Can you determine the genotype of the rabbits in this simulation? If so, what is it?

Answer: No, when the phenotype is dominant, all animals that show the phenotype have at least one copy of the mutation. But it is impossible to distinguish between rabbits with one or two copies of the mutation. (This is also true when the mutation is recessive.)

Even discussing basic genetics can bring up some confusion about vocabulary The **phenotype** is the visible, observable trait. The **genotype** is the heritable information, or the genetics. Since each person receives two complete sets of their genes (one **allele**, or copy of a gene, from mom, one allele from dad), it is possible to have a mixed genotype, such as one each of the dominant and recessive alleles, which will result in the dominant phenotype. A **dominant** trait simply masks the effect of a **recessive** trait. Freckles are a good example of a dominant gene—if you have one dominant copy, you show freckles. Other examples of clear dominant and recessive phenotypes are hair on the second knuckle and color blindness.

Students often confuse "dominant" for common. Counter examples of this are Down's Syndrome, Huntington's disease and some forms of deafness.

Alleles refer to genotype, traits refer to phenotype.

Q5. Do you predict most or few rabbits will show the recessive mutation versus no mutation after 6 generations? Explain.

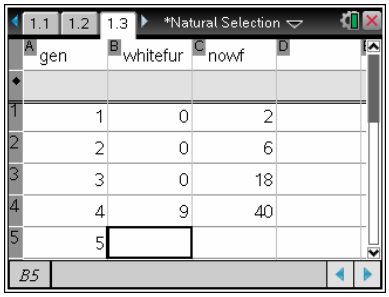
Answer: Without selection, most rabbits will show the wild-type trait, not the mutation.

Q6. How would you expect the simulation to be different if there were a selective advantage to one trait?

Answer: If one trait were to increase the fitness of individuals with that trait, they are more likely to have the chance to pass on the favorable trait. After a few generations, less fit traits may be depleted in the population. You should expect to see the advantageous trait to be most common in the population. Instead, the simulation keeps it a constantly low level in the population.

Students sometimes get confused about the idea of "survival of the fittest." If there is not an objective difference between the probabilities that two animals will survive to reproduce, then we don't see natural selection. This simulation should remind students that many mutations don't make a difference in an animal's ability to survive.

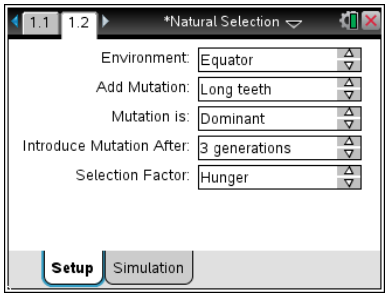
Students could also be encouraged to create a spreadsheet to keep track of the results after each generation. To add a spreadsheet, select Insert *Lists & Spreadsheets*, which will add a new tab to the simulation. Data can be added to the spreadsheet.



Tech Tip: To add a spreadsheet, select + **> Lists and Spreadsheets.** To type in the spreadsheet, tap any cell twice. The keyboard view will appear. To enter text into a cell, select the "ABC" button.

Part 2: Selection by Hunger

Students will repeat the simulation with Hunger as the Selection Factor. In this case, explain to students that the simulation indicates that there is a new, and difficult to eat food available for the rabbits. Rabbits with long teeth have an advantage for eating the food. Unlike the other mutations, when long teeth are present, this mutation will expand in the population.



The nature of the simulation may give a variety of individual results, so encourage students to share their answers and identify overall themes.

Tech Tip: To change the speed of the simulation, select **b** or **> Speed** and then select the desired speed. You may need to back-out to the main Tools Menu to see the desired menu option.

Q8. In general terms, how does a phenotype provide a selective advantage to an animal?

Answer: An advantageous phenotype allows the individual to survive better in its environment, and pass on its genes to future generations.

Q9. How does the result of the simulation change when you introduce the advantageous mutation as a recessive mutation?

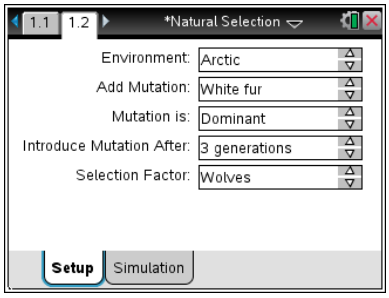
Answer: In most cases, the total population number is decreased. This is because it takes more generations for the recessive trait (long teeth) to become common in the population.

Q10. How does the rabbit population change when there is a *Selection Factor* in the population, in contrast to the *No Selection* simulation?

Answer: When there is natural selection, rabbits with one phenotype are more likely to survive and reproduce. Without selection, this process is random.

Part 3: Selection by Wolves

In this part, students will be testing how predation by wolves acts as a form of natural selection. In this case, white fur can influence the selection—it makes white rabbits more visible in the equatorial climate, and less visible in the arctic environment. Testing two variables at once might confuse some students, so encourage them to focus on one factor at a time.



Q11. Which phenotype do you predict will be most common after 9 generations?

Answer: Students might predict that the coat color that makes them least visible to predators will give a selective advantage. They also might predict that other mutations give no selective advantage in this condition. In this case, they should be clear what that would look like (long teeth or tail will not expand rapidly in the population).

Students will test this predication, and can amend this prediction.

Q12. Perform the simulation. Was your prediction correct?

Answer: Check students' answers.

Q13. When wolves are performing natural selection, which phenotype(s) give(s) the selective advantage? What do the rabbits that are most likely to survive look like under the conditions in this part?

Answer: White rabbits survive best in the arctic, brown rabbits survive best at the equator.

Q14. How does the simulation change when the advantageous trait is dominant vs. recessive?

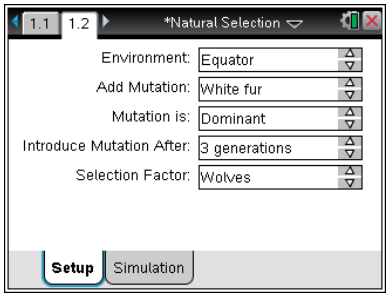
Answer: When the coat color is recessive, it takes it longer to permeate into the population, but it is still advantageous.

Q15. How does the choice of environment influence natural selection? Do you get the same or different results in the Arctic and at the Equator?

Answer: The results are opposite at the Arctic and Equator. The environment affects which color is the best camouflage. As the environment changes, populations must adapt with them.

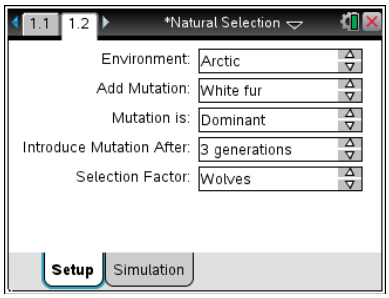
Extension

Students will perform a simulation and change the environment part-way through. This is a nice way to demonstrate how populations can adapt to their environment. Have them set up the following simulation: At the equator, white fur is the dominant mutation, and introducing the mutation after three generations with a Selection Factor of wolves.



Let this simulation go for at least 6 generations before *changing the environment to the Arctic* (don't pause or restart the simulation). Students need to see what happens to a population when the conditions of natural selection change.

This will change the selection pressure of a larger number of rabbits.



Q16. What did you observe? Was one allele advantageous in both environments?

Answer: White fur is a disadvantage at the Equator, but quickly becomes advantageous in the Arctic.

Q17. How did the population change after the environment is switched?

Answer: White rabbits at the equator are nearly extinct, but in the new environment the phenotype is able to spread throughout the population.

TI-Nspire™ Navigator™ Opportunities

Allow students to volunteer to be the Live Presenter and demonstrate how to adjust the parameters of Mutation, Dominance, Environment, and Selection Factor. Use Quick Poll to check for understanding during the course of the activity.

Wrap Up

When students are finished with the activity, collect students' worksheets.

Assessment

- Formative assessment will consist of questions embedded in the student worksheet. Analyze questions in the student worksheet with the students.
- Summative assessment will consist of questions/problems on the chapter test.