Model 3 – Evolution

Essential Questions

How did organisms become so diverse?

How is behavior an adaptation?

Instructional goals

Develop a cause and effect model for the process of natural selection:

- Species have the potential to increase in numbers exponentially.
- Populations are genetically variable due to mutations and genetic recombination.
- There is a finite supply of resources required for life.
- Changing environments select for specific genetic phenotypes.
- Those organisms with favorable adaptations survive, reproduce and pass on their alleles.
- The accumulation and change in favored alleles leads to changes in species over time.

Explain how natural selection influences the changes in species over time.

Compare organisms on a phylogenetic tree in terms of relatedness and time of appearance in geologic history

Explain how various disease agents (bacteria, viruses, chemicals) can influence natural selection.

Summarize and analyze the survival and reproductive success of organisms in terms of behavioral, structural, and reproductive adaptations.

Explain various ways organisms interact with each other (including predation, competition, parasitism, and mutualism) and with their environments resulting in stability within ecosystems.

Misconceptions

Transmitted characteristics are acquired during the life time of the organism.

Individuals can adapt to a changing environment. These adaptations are heritable.

Evolution is goal-directed.

Natural selection is a theory, not a fact.

Natural selection requires a very long time.

Organisms change intentionally (an organism tries, needs, wants to change its morphology or physiology).

Changes in populations occur through a gradual change in a trait of all members of population.

Sequence

1. Model Development – Thirsty Bird simulation
2. White Board (WB) and discuss
3. Reading – Genetic Drift
4. Model Deployment – Exercise 1 – Natural Selection - White Board (WB) and discuss
5. Model Development – Becoming Whales – Activity 1 – Whales in Transition; Activity 2 – DNA comparison
6. Reading – How new species arise, Page 330-331 Exploring how Life works
7. Exercise 2 – Speciation - White Board (WB) and discuss
8. Quiz
9. Reading - Sneaky Cricket – Behavior and Natural Selection
10. Model Deployment – Behaviors are adaptations too! – Research and jigsaw
11. Reading – What about fitness? – Read and discuss
12. Test

Instructional Notes

Model Development Activity – Thirsty Bird Simulation

Apparatus

Class data sheet
Activity data sheet 1 and Activity data sheet 2
Fork and Spoon cards
Blue and Gold color cards
Forks (enough for all students)
Spoons (enough for all students)
Plastic cups for “stomachs”
1000ml beakers (1 per every two students)
Large, low containers for beakers (to contain sloshing water)
Liquid (or small pasta such as orzo)
Calculators
Stopwatch

Balance

Pre-lab

What makes something living? On the board draw the concept map of living things – include those traits identified through consensus in Model 2.

Living things – are diverse, grow, get/use energy, reproduce, are made of cells, respond to their environment.

What have we noticed from looking at different organisms?

There is great variety in organisms
Shared characteristics
All organisms come from other organisms

What kind of factors might influence the variety of organisms?

Food, climate, temperature, competition, predation, moisture, homes, sex, time, characteristics of organisms (from parents), evolution, adaptations

Challenge students on the meanings of words such as evolution and adaptation. If they cannot explain without resorting to a textbook definition (which they cannot elaborate on), ask them to hold off on those ideas until we have a better understanding.

Do these factors affect traits of the organisms? What type of traits would be affected by the factors? How would you test these factors?

Have the students come up with answers – note the difficulties in creating experiments with many of the given factors.

Propose doing a simulation in class. Why? Because many of the factors change over a long period of time and we only have a couple periods to measure changes.

In our simulation we will examine the relationship between competition for food, mouth parts and bird color.

Instructions

For clarity, walk students through the first couple of rounds.

To expedite the collection of data create the class data sheet on the board, use a document camera, or copy the class data sheet on a transparency. Have students record their color and mouth parts using hash marks.

Alternately, if there are an odd number of students assign one student to be recorder or the teacher can be the recorder.

a. Provide the recorder with a class data sheet.

b. If you have multiple classes it is very useful to compile all the classes' data for analysis. Trends are more easily seen with greater amounts of data.

Assign each student a color (blue or gold) by giving them 4 cards (4 blue; 2 blue & 2 gold; 4 gold). Distribute color cards to class to attain the following percentages,

a. 25% Blue: 4 blue
b. 50% Gold: 2 blue & 2 gold
c. 25% Gold: 4 gold

On the **class** data sheet, record the # of students with a particular color.

Assign each student a mouth part by giving them 4 cards (only forks to start).

On the **class** data sheet, record the # of students with a particular mouth part.

Have each student mass their stomach and record the amount on the **student** data sheet.

Each team should fill their 1000mL beaker (food source) with 700mL of water.

Establish feeding rules: hold stomach in one hand, use mouth part to scoop food into the stomach, no dipping stomach in the food source, no taking food from someone else's stomach, etc.

Have students feed for 1 minute from the food source.

After 1 minute, determine the mass of the food collected in the stomach by massing the cup with the water and subtracting the mass of the cup. Record the data on both the student and class data sheets.

Mate

1. Find a partner (must choose a different partner each time).
2. Determining mouthparts of offspring: Each student randomly draws one utensil card from their partner to determine mouth parts of the offspring. On each student data sheet, record both cards (it takes two cards to determine the mouth).

Repeat to obtain the mouthparts for the 2nd offspring.

Spoon + Spoon = Spoon
Spoon + Fork = Spoon (if dominant) or Fork (if recessive)
Fork + Fork = Fork

3. Determining color of offspring: Each student randomly draws one color card from their partner to determine the color of offspring. Record both cards (it takes two cards to determine the color). Repeat to obtain the color for 2nd offspring.

Blue + Blue = Blue
Blue + Gold = Gold
Gold + Gold = Gold

4. One student will then choose to be the 1st offspring and the other student will choose to be the 2nd offspring.

5. Students will get the appropriate cards so they again have 4 cards that represent the desired trait:
   For example, for 1st offspring, if 1st pick was gold and 2nd was blue, student who becomes the first offspring will make sure they have 2 gold cards and 2 blue cards.
   If for the 2nd offspring, 1st pick was gold and 2nd pick was gold, student who becomes that offspring will make sure they have 4 gold cards.

6. Now that the students have become their own offspring, record the class data for both color and mouth parts.

Complete 4 rounds of feeding then mating. Record the class data for color and mouth part after each mating and food after each feeding. This creates baseline data for comparison.

a. Each time mating should be random – simulated by students having to mate with someone they haven't mated with before.
b. Number of rounds of mating is not as important as having distribution of traits stabilize (so you have both colors represented).

Selective Pressure

Have students feed for 1 minute from the food source beaker.

After 1 minute, determine the mass of the food collected in stomach cup by massing the cup with the water and subtracting the mass of the cup. Record the data on both the student and class data sheets. Include student initials on the class data sheet.

Eliminate the 2 students with lowest mass (ate the least). Assign them to the two highest eaters to become an extra offspring.

Mate
Follow the mating instructions described above.

Complete 4 rounds of feeding then mating. Record the class data for color and mouth part after each mating and food after each feeding.

a. Each time mating should be random – simulated by students having to mate with someone they haven't mated with before.
b. Number of rounds of mating is not as important as having distribution of traits stabilize (so you have both colors represented).

Environmental Change – Drought

Reduce the amount of food to 300 mL due to drought conditions.

Have students feed for 1 minute from the food source beaker.

After 1 minute, determine the mass of the food collected in stomach cup by massing the cup with the water and subtracting the mass of the cup. Record the data on both the student and class data sheets. Include student initials on the class data sheet.

Only those with 20mL of "food" have enough energy to mate.

Mate
If there is anyone left to mate, follow the mating instructions described above

Graph

Have students graph class data for all conditions thus far. If time is limited instruct students to create bar graphs.

WB

White board graph trends and conclusions thus far (specifically the relationship between characteristics and survival). Make sure students discuss the relationship between the color of the birds and their survival; the mouthpart of the bird and survival.

Post-activity discussion

Conduct a post lab discussion on results so far. What happened when we had only forks with no selection pressure, with selection pressure, with environmental change, what effect did color have on the ability to get food or survive? Introduce the terms, allele, variation and genetic drift. Emphasize the random nature of trait distribution. Ask students about changes in the number of blue or gold birds and if that was related to reproductive success.

Two traits – Different characteristics

Tell students that chicks born from eggs laid near radiation have fused mouth parts and introduce 2 spoons (or a number of spoons that will represent approximately 25% of population). Give the students with spoons the appropriate number of spoon cards based on whether spoons are dominant or recessive.

Complete 4-6 rounds of feeding then mating (without any eliminations) until numbers stabilize.

Record the class data for color and mouth part after each mating and food after each feeding.

a. Each time mating should be random – simulated by students having to mate with someone they haven't mated with before.
b. Number of rounds of mating is not as important as having distribution of traits stabilize (so you have both colors represented).

If the spoons have increased greatly, reset the population to the original number of spoons and then re-introduce the selective pressure (competition) and complete another 4-6 rounds. Follow the same protocols used when there were only forks in regards to student elimination, mating, child assignment and data recording.

Graph

Have students graph the class data. If time is limited, instruct students to use bar graphs.

WB

White board graph trends and conclusions (specifically the relationship between characteristics and survival).

Post-activity discussion

Ask students to predict future spoon population
Bring out in discussion

- Is there a need for variation in a population?
- What is the effect of competition when there is variation?
- When do you see a change in the population?
- Do any traits ever completely disappear?

Develop consensus through summary boards:

- If a trait helps an organism survive to reproduce then the trait is passed on
- If a trait does not affect an organisms ability to survive then the frequency varies
- If a trait hurts an organisms survival then it decreases
- Populations change – not organisms

Introduce the terms: adaptation, natural selection.

Reading – Genetic Drift

Model Deployment Activity – Exercise 1 – Natural Selection

Complete individually, discuss in groups, whiteboard and hold a board meeting. In the board meeting make sure to bring out that acquired traits are not passed on.

Model Deployment Activity – Becoming Whales

When copying the fossil strips for student use, be sure to remove fossil strip #6.

Pre-activity discussion

What evidence do we have that organisms have changed? How do we know what they looked like in an earlier time?

Begin whale evolution PowerPoint.
Slide 1 – Ask students: Have you ever seen a whale? How big are they?

Slide 2 - What type of creature is a whale? Video link at bottom of slide will take you to a YouTube video of a humpback whale nursing. If you cannot access YouTube at school use another method of acquiring nursing whale footage.

What type of creature is a whale? Whales are mammals.
Ask: what are some other mammals? Do whales look like these other mammals? No, do all whales look similar? What are common traits whales share? Show slides 3 and 4.

From where did whales arise? Show slide 5 – Darwin's ideas

How can we determine whale origins? What are fossils?

Instructions

Activity 1 – Whales in Transition - Slides 6 and 7 have directions for this activity.

Let's look at some pictures of whale fossils. Distribute envelopes of whale fossils and student reading.

Have students make a time line from 35mya to 50 mya on a whiteboard. Slide 8 shows the Eocene time line -

As they read the whale hunt (#1-5) they should place whale strips on the time line. Slides 9 – 13 show pictures of each animal, its skeleton and teeth.

Slide 14 has directions for drawing a prediction. How would #6 look.

In a board meeting compare student predictions. Discuss similarities and differences in student predictions. Have students explain why they chose to include certain traits. Show slide 15 and have students compare the actual animal to their prediction. Slide 16 is an artist depiction of an *Ambulocetus* in its habitat.

Have students answer the discussion questions at the end of the student reading in their notebooks. Assign specific questions to groups to whiteboard. Hold a WB meeting to discuss the responses. Ask students to identify characteristics of early whale ancestors make sure they include hooves. Ask students what mammals alive today have hooves?

Slide 17 asks "what is the closest land dwelling relative of whales?"
Slide 18 – A cladogram of early whale ancestors to modern day whales, discuss with students the "blind" alley of *Mesonychids* and how the cladagram supports the discussion held in the whiteboard meeting.

Slides 19 and 20 depict modern day hooved animals

Slide 21 - Is there a way to demonstrate relatedness between whales and hooved mammals?
Lead students to the idea that DNA can be used to demonstrate relatedness. Ask: What do you know about DNA? How is used to show who is the "daddy" or who committed the crime? Is DNA passed on? Is it exactly the same for all creatures that are related?

We will compare a small sequence of DNA for hooved mammals and whales.

Activity 2 – DNA Comparison
Distribute the 11 DNA strips and the data sheets to student groups of four.

Students will align the DNA sequence for two species and count the number of places where the bases differ. Slide 22 – Example of how to compare

Next, record the number of differences the appropriate box on the data sheet.

Continue the comparison and counting until all cells in the data table are complete.

Create class data on board, overhead transparency or document camera. Have groups add their data to this table. Make sure consensus is reached and all students have the same data. Slide 23 – Answer key for the data table

Have students answer the discussion questions in their small groups. These answers will assist them in creating the cladogram.

Draw the cladogram on the whiteboard. Hold a board meeting to share cladograms,

Discuss process used to construct cladagram, discuss what type of information can be gleaned from the cladogram. Who is the whales closest land dwelling hooved cousin? Slide 24 gives the answer.

Slide 25 - Farewhale

Post-activity discussion

Ask students to list the elements of the process of science reflected in this lesson and give examples of each (for example):

a. recognition of a problem: how did whales emerge from some land-dwelling mammal?
b. hypothesis formation: they evolved by gradual change over time, losing terrestrial features, and gaining aquatic adaptations.
c. predictions based on hypothesis: what to look for (fossil whales with legs), where to look (Eocene sediments from warm shallow seas)
d. searching for evidence: (digging for whale fossils in Pakistan, etc.
e. popular "generally accepted" concepts replaced with new concepts, based on new evidence (DNA analysis).

Reading – How new species arise page 330-331 in Exploring the way Life works

Exercise 2 – Speciation –Question 2 gives rise to a discussion on co-evolution (give name). Question 3b gives rise to a discussion on geographic and reproductive isolation (give name)

Quiz – Evolution

Model Development Activity – Sneaky Cricket Cartoon

Apparatus

Sneaky cricket cartoon

Pre-activity discussion

What does survival of the fittest mean?

Instructions

Distribute and read the cartoon. Assign reading parts to students (actors).

Post-activity discussion

1. When it comes to crickets, what does fitness mean?
2. Give some examples of selection at work in this cricket story.
3. Is calling good or bad for a cricket's fitness?
4. How does selection favor calling? How does selection favor not calling?
5. How does selection favor sneaking? How does selection not favor sneaking? What kind of characteristic is “sneaking?” (behavior) How is this example different from other examples?
6. What other behaviors could be advantageous for organisms? (solicit a list from students) (May need to group behaviors into similar categories). Adaptation is behavior.

Model Deployment Activity- Behaviors are adaptations too!

Choose behaviors from the list below and have student groups research the behavior, white board and present information in the form of a jigsaw activity.

Possible behaviors include reflex, instinct, biological clocks, territoriality, social hierarchy, mating behaviors, social behaviors, and learned behaviors. Have students sort the list of behaviors into innate and learned categories.

Reading – What about fitness?

Test