actionbioscience.org lesson

To accompany the peer-reviewed article by Niles Eldredge, Ph.D.:
"Species, Speciation, and the Environment" (Oct. 2000)
http://www.actionbioscience.org/evolution/eldredge.html

How Do New Species Form? (April 2002)

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Grades & Levels:

- **Handout 1:** high school (advanced)
- **Handout 2:** high school (AP) - undergraduate (year 1)

Time Recommendations:

- **Handout 1:** 1-2 weeks
- **Handout 2:** 2-4 weeks (some activities can become semester projects)

NSES (USA) Content Standards, 9-12:

- NSES 1.2. Unifying Concepts & Processes: evidence, models, and explanation
- NSES 1.4. Unifying Concepts & Processes: evolution and equilibrium
- NSES 2.2. Science as Inquiry: understanding about scientific inquiry
- NSES 4.3. Life Science: biological evolution
- NSES 8.2. History and Nature of Science: nature of scientific knowledge
- NSES 8.3. History and Nature of Science: historical perspective

Note: View the NSES content standards on this site to choose other curricular applications for additional activities at http://www.actionbioscience.org/educators/correlationcharts.html

Learning Objectives: Students will…

- understand and apply the basic definition of speciation
- articulate Eldredge's argument for punctuated equilibrium/stasis
- evaluate evidence of Eldredge's view, as well as opposing views held by gradualists

Key Words Include:

Coordinated stasis: new unrelated species appear at about the same time after an extinction event.
Gradualism: the view that evolution proceeds by accumulated natural selection very slowly through time.
Punctuated equilibrium: a theory proposing that species usually arise very quickly in terms of geological time and seldom through a process of gradual change.
Speciation: the formation of a new species, either by one species splitting into two, or by a species changing enough over time that it is considered a different species.
Species: the biological concept of species is based on organisms that can successfully interbreed but cannot breed with other populations.
Stasis: a given species remaining similar through long periods of time.

Preparation

- **Article Discussion:** The questions on page 3 are divided into content, extension, and personal questions. They are suitable to accompany both Handouts 1 and 2. Several approaches are possible for using the questions about the article:
    - Have the students read the article on their own, after which the instructor should pose these questions in class for group discussion.
    - Have the students read the article on their own, and then divide them into small groups for discussion; give copies of the questions to group leaders.
    - Copy the questions for each student and have them do the reading and complete the content questions on their own. They could then discuss the more complex questions as a large group or in small groups.
    - The questions could also be divided by type: content questions are answered individually, and general/extension questions in groups, for example.
- **Handout 1 Projects:** Student Handout 1 consists of projects appropriate for advanced-level high school students. Tell students how long they have to complete the project of their choice and assign a due date for presentation in class. Refer students to the links at the end of the Eldredge article as a starting point for their research.
- **Handout 2 Projects:** Student Handout 2, for AP high school and undergraduate classes, is based on the lesson "Adaptation and Evolution" developed by the British Columbia Ministry of Education, Canada, 1996. It is adapted for this handout by permission of the Ministry. Some activities in this Handout require at least 2 weeks for completion. Some activities can be used as semester projects. Refer students to the useful links in *Educator Resources* at the end of the Eldredge article as a starting point for their research. Special instructions are provided below.
    - **Prescribed Learning Outcomes**

      It is expected that students will:
        - describe the basic structure of DNA
        - identify the roles of DNA in evolution
        - explain the role of sexual reproduction in variation and evolution
        - describe the process of natural selection
        - suggest conditions under which the allelic frequencies of a population could change, including genetic drift, differential migration, mutation, and natural selection
        - differentiate among and give examples of convergence, divergence, and speciation
        - compare and contrast the gradual change model with the punctuated equilibrium model of evolution
        - identify the role of extinction in evolution
    - **Suggested Instructional Strategies**

      Distribute Student Handout 2. As students progress through the activities, they will begin to understand that the evolution of organisms can be explained by a theory based on scientific observation and experimentation, subject to scrutiny and change. The Handout consists of two parts:
        - **Part A** lists a variety of activities that can be divided among groups of students, or 2 or more activities can be assigned to each group.
        - **Part B** is the culminating activity that each student must perform with another classmate. It consists of a report and a peer assessment of the report.
    - **Materials Needed**

      Marbles, computers, construction material (see Student Handout 2)

For Educators: Article Discussion

About the article by Niles Eldredge, Ph.D.: "Species, Speciation and the Environment"
http://www.actionbioscience.org/evolution/eldredge.html

Content questions

1. Who is credited with convincing the world that life has evolved?
2. Explain the biology definition of species.
3. According to Mayr and Dobzhansky, what conditions are necessary for speciation?
4. What is meant by stasis?
5. Explain the "habitat tracking" view of evolutionary change.
6. Explain the "widespread populations" view of stasis.
7. What is coordinated stasis, and why did scientists ignore the idea for a long time?
8. Give an example of the sort of extinction pattern that Eldredge claims is normal
9. What are the likely causes of major "species turnovers?"
10. What is allopatric speciation?

Extension/general questions

1. Write a paragraph in which you summarize the author's main point with three supporting pieces of evidence.
2. Describe what sort of scientific work should be done to further support the author's point.
3. Does the author make his point clearly? What else would be needed to convince you to accept his view?
4. In what way has our view of speciation changed since Darwin's time?
5. Why is the mode of speciation a relevant question? How does it affect biological research and theory?

Personal viewpoint questions

1. Why is the work Eldredge and others are doing on speciation important?
2. Are the two models for evolutionary change that Eldredge presents mutually exclusive? Could they both be true? Explain and/or provide examples.
3. How would Eldredge's proposed theory change if a paleontologist found a series of fossils showing gradual change?
4. Suppose you were in charge of presenting Eldredge's viewpoints on evolutionary change in poster or display format. How would you approach this assignment? Outline the general concepts as they relate to each other.

How Do New Species Form?
Student Handout 1

Rapid or Gradual Change?
Conduct literature research comparing two competing models of evolutionary change:
- the stasis/punctuated equilibrium model suggested by Eldredge in the article you read
- the gradualist model promoted by Richard Dawkins

Write an essay comparing the strengths and weaknesses of each view.

3-D Punctuated Equilibrium
Construct a three-dimensional flat model or vertical display, depicting the pattern of change that Eldredge suggests is common. Write accompanying text placards to explain the model. Arrange for it to be displayed in a prominent place at your school, such as a hallway or library.

Continental Drift
Create a presentation that illustrates that continents were not always in the position they are now. Write a short essay to accompany the presentation that
- describes fossil evidence for continental drift
- examines how continental drift contributed to speciation

Plate Tectonics
Write a report that addresses the following:
- Who were Alfred Wegener and Glomar Challenger and what did they contribute to science?
- Make a list of the major plates of the world.
- What are the three main types of plate boundaries? Give examples of each from different places around the world.

Niles Eldredge
Write a biography about Niles Eldredge, highlighting his contributions to science.

Allopatric vs. Sympatric
Create a presentation that compares allopatric to sympatric populations. Provide some examples of each.

How Do New Species Form?
Student Handout 2

Part A: Group Projects

1. Build models of DNA, identifying the four nucleotides, deoxyribose, and phosphoric acid.

2. Mix up equal numbers of coloured marbles (two or three different colours), place all the marbles in a large pop bottle, and then pour out four to six marbles at a time as the class observes. Note that the proportions of the colours pouring out are not equal. Can you deduce factors leading to genetic drift?

3. Work in small groups and use coloured marbles in a container or a computer simulation to demonstrate the difference between genetic drift and natural selection. Make sure that you:
- model each process accurately
- differentiate between the processes in terms of cause and result
- account for the changes to their "populations"

4. Research and prepare an oral or written report on the extinction of a plant or animal within the last century. Make sure you:
- identify causative factors in extinction
- identify how factors work in combination
- recognize the importance of extinction in evolution
- compare natural extinction versus extinction related to human activity

5. Use Darwin's research findings on Galapagos finches to illustrate examples of speciation and divergence.

6. Write a list of extinct species and the factors that led to their extinction. Develop an illustrated portfolio of currently endangered species including the reasons for the drastic reductions in their numbers.

Part B: Pairs Project

With a classmate, research the gradual change model of evolution OR the punctuated equilibrium model of evolution. Write a short essay based on the model chosen. Exchange your essay with classmates who wrote on the other model. Ask them to provide you with feedback based on whether:
- the information about the model is accurate and complete
- the examples used are consistent with the model
- the essay makes it clear how this model differs from the other