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To accompany the interview "Natural Selection: How Evolution Works" with Douglas Futuyma.
www.actionbioscience.org/evolution/futuyma.html

Natural Selection (February 2006)

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Grades and Levels

- **Handout 1:** high school (general/AP grades 10–12)
- **Handout 2:** undergraduate (year 1)

Time Recommendations

- Two 50-minute class periods
- For homework assignments, 2–3 hours per activity

NSES (USA) Content Standards, Grades 9–12

- 1.2. Evidence, models, and explanation
- 1.3. Change, constancy, and measurement
- 1.4. Evolution and equilibrium
- 4.2. Molecular basis of heredity
- 4.3. Biological evolution
- 4.6. Behavior of organisms
- 8.3. Historical perspective

Note: View the NSES content standards to choose other curricular applications for additional activities here:
www.actionbioscience.org/educators/correlationcharts.html.

Learning Objectives: Students will

- define the keywords listed below in their own words
- describe the concept of natural selection as postulated by Darwin and Wallace
- discuss the role that the concept of natural selection plays in the modern 21st century theory of evolution
- discuss, explain, and understand the roles of chance and randomness in evolution
- research the history of scientific thought leading to the modern theory of evolution

Key Words: agents of evolution, antibiotic resistance, chance, evo-devo, genes, genotype, modern synthesis, natural selection, probability, randomness, sexual selection, speciation

Preparation

Materials: Provide copies of the article for each student or student team. Students need access to school or university library and to computers with Internet connections for research needs.

Article Discussion: Article discussion questions are organized into content, extension, and personal viewpoint questions. Groups of two to four students may be formed to discuss them. Discussion may be concentrated in one time period (1 hour, minimum) or divided into smaller periods of time (10 to 15 minutes), considering several questions at a time. Educators can select questions from each part to create article discussion units.

Student Handout 1 or 2 Activities: Assign activities for individual or group work after article discussion.

Additional Resources: Refer students to the “learn more” and “useful links” at the end of the online interview; these Internet links can provide ideas and information for student activities. Additional resources for educators, including assessment suggestions, are provided in “useful links for educators” also found at the end of the online interview.

For Educators: Article Discussion

About the interview “Natural Selection: How Evolution Works” with Douglas Futuyma.

www.actionbioscience.org/evolution/futuyma.html

Content Questions

1. Define “natural selection.” How does it relate to evolution?
2. What role do genes play in evolution?
3. How important are the ideas of evolution and natural selection in biological sciences today?
4. What other natural mechanisms should also be considered as agents of evolution?
5. What role does natural selection play in speciation?
6. Why isn't the slogan “survival of the fittest” a good description of what really goes on in nature?
7. Does chance play a role in evolution? If so, what is that role?
8. Is the process of natural selection a chance process? Why or why not?
9. List the examples of natural selection at work that Futuyma describes.
10. What did Darwin and Wallace's idea of natural selection accomplish for biology that is comparable to what Newton and his successors accomplished for physics?

Extension Questions

1. Explain how certain genotypes may be favored by natural selection during a time of environmental change in an example species of your choice.
2. How might natural selection produce the appearance of design in nature?
3. Futuyma indicates the existence of several agents or mechanisms of evolution in populations. Are there others? Perform a Web search to answer this question. List and define any other agents or mechanisms of evolution you find.
4. Does natural selection primarily affect the proportions of varieties within species or create new species? Support your answer with at least three references from books, articles, or the Web.
5. Is there only one kind of natural selection? Again, do some research and list at least three references to support your answer. If you find that there is more than one kind of natural selection, give an example of how each might occur in a species of your choice.
6. Is chance the same as randomness? Is chance the same as probability? Does natural selection involve any of these concepts? How?

Source: www.actionbioscience.org/evolution/futuyma.html

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7. Why can't natural selection act on the future needs of a species? What do biologists mean by the concept of "pre-adaptation"?
8. Do you think that if the human species disappeared from Earth tomorrow, natural selection could produce a similar species in the future? What would this require?
9. Why might the idea of natural selection be considered a dangerous idea? Find one example of how the concept has been misused.

Personal Viewpoint Questions

A period of library and/or Web research would be helpful in answering the following questions.

1. Futuyma is quite clear that the concept of natural selection, as formulated by Darwin and Wallace, is sufficient to explain the apparent design of organisms in nature. With another student, discuss Futuyma's rationale.
2. Futuyma says that natural selection plays a role in speciation to some extent. Perform some Internet or literature research on the topic of speciation. What does your research indicate are common mechanisms of speciation? Is natural selection a part of any of them? Which ones? After performing your research, how important do you think natural selection is in producing new species?
3. Is evolution only a chance or random process? If not, is any process of evolution a chance process? Which ones? What about natural selection, is it random? Back up your analysis with at least three references from your library or the Web.
4. Futuyma agrees with Stephen Jay Gould that evolutionary history cannot be repeated exactly. What is their reasoning? Do you agree with their view? Choose a major environmental factor that changed evolutionary history dramatically; for example, what caused the extinction of dinosaurs? Speculate how evolutionary history would be different if this event had not occurred.
5. Futuyma states that the philosopher Daniel Dennett may be right in calling natural selection "Darwin's dangerous idea." What possible danger(s) does the idea of natural selection pose to some? How does science address this perceived danger(s)?

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Student Handout 1

Form groups of two to four individuals and consider one of the following topics. Assign a different task to each team member, such as Internet search, graphics, presentation. Conduct research on the topic (see “useful links for student research” at the end of Futuyma’s interview for some ideas, www.actionbioscience.org/evolution/futuyma.html). Present the team’s findings to the class for general discussion.

1. Antibiotic Resistance

Futuyma calls this the “single greatest crisis in medicine.” Why is this so, and how does it relate to evolution?

- Undertake further research (Internet and/or literature) on the topic of antibiotic resistance.
- Draw up a chart listing five or six commonly used antibiotics. Indicate which diseases are resistant to these antibiotics, and which organisms cause these diseases. Also indicate the degree of resistance expressed (light, moderate, strong) and the type of causative organism (bacteria, viruses, fungus, animal parasite).
- Prepare a poster based on the chart above and be prepared to answer questions about it.

2. Darwin's Finches

In his Pulitzer Prize–winning book *The Beak of the Finch* (Alfred A. Knopf, New York, 1994), Jonathan Weiner recounts the origins of the popular misconception that Darwin, on seeing the 13 species of finches in the Galapagos, deduced very quickly that natural selection had produced their diversity. Darwin was not immediately impressed by their possible significance; he even stored many of them (from different species) in the same bag!

- Find a figure or chart that illustrates the 13 species of Darwin’s finches. Also locate a map of the Galápagos Islands. Draw a table to indicate on which island(s) each species of finch is found. Also indicate which of these species was collected by Darwin.
- List evidence of speciation in these finches.
- Perform a Web or library search to locate other island groups and groups of animal or plant species that show a similar adaptive radiation to Darwin’s finches.
- Write a three- to six-page, illustrated report to explain what you have discovered.

3. Darwin Day

If a time machine could bring you face to face with Charles Darwin the year after Darwin’s publication of *On the Origin of Species* (1860), what would you talk about?

- Consider some questions Darwin would ask you, such as “How successful was my book?” “Have scientists discovered new things about natural selection?” Write the questions and your answers.
- Consider some questions you would ask Darwin, such as “Did you foresee that the idea of natural selection would change the field of biology?” Write your questions and Darwin’s possible answers.
- Present your conversation with Darwin as a play or radio talk show.

4. Natural Selection in Action

Search the interview with Futuyma, your library, or the Internet for five examples of natural selection at work. Use the table on the next page to record these cases. Present a summary of your findings to your class.

Cases of Natural Selection at Work

Case #	Species	Habitat	Natural Selection
1.			Agent:
			Type:
2.			Agent
			Type:
3.			Agent
			Type:
4.			Agent
			Type:
5.			Agent
			Type:

Species: Give the common name and scientific name.

Habitat: Where does the species live?

Agent: What organism or physical factor applies natural selection?

Type: What type of natural selection (directional, disruptive, or stabilizing) is occurring?

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Student Handout 2

1. Rewriting Darwin and Wallace's Idea in Today's Terms

Darwin and Wallace postulated that natural selection acted on organisms to select the individuals within populations that had the best overall collection of adaptive features suiting their environment, for survival and differential reproduction. But they could not explain the origin of the varieties within populations, nor could they explain the development of organisms as they matured. Today we can explain both these factors. Thus, it appears, that Darwin's theory is in serious need of rewriting (and, indeed, this has been done by a number of evolutionary scientists).

Some suggested activities:

- Perform a literature and/or Web search to determine the origins of the varieties of organisms in populations. Document the references.
- Draw up an outline of your "modernized" version of Darwin and Wallace's idea.
- Write a report (to the length and detailed requirements of your instructor) that would "modernize" Darwin's theory according to our current knowledge.

2. Sexual Selection in Humans

"Sexual selection depends on the success of certain individuals over others of the same sex, in relation to the propagation of the species; while natural selection depends on the success of both sexes, at all ages, in relation to the general conditions of life," wrote Charles Darwin in *The Descent of Man, and Selection in Relation to Sex* (1871). Darwin and his codiscoverer of the principle of evolution by natural selection, Alfred Russel Wallace, differed on the significance of sexual selection in humans. Wallace raised several objections to Darwin's ideas on this subject, and much of this book was spent answering Wallace's objections.

Choose **one** of these topics to research for a report:

- What were Wallace's objections to sexual selection? How did Darwin deal with them in *The Descent of Man*? Would we deal with them in the same way today?
- Does sexual selection continue in humans? Perform a literature and/or Web search to answer this question and record your findings in a paper.

3. What will the natural world be like in 50 million years?

One interesting possible scenario was described and illustrated by Dougal Dixon in his 1981 book, *After Man: A Zoology of the Future* (Harrow House Editions, UK, 1981). In it, Dixon speculates that *Homo sapiens* has disappeared from the face of the Earth along with his most closely associated domesticated species. After 50 million years, Earth is in the midst of a "New Age of Mammals."

Choose **one** of these topics for a presentation:

- Draw up three scenarios for a future Earth, about 50 million years in the future. Make one a worst-case scenario, one a best-case scenario, and the third a middle-ground scenario. Explain which one you think is most likely and why. One source for consideration is the Millennium Ecosystem Assessment, which has developed models of the near future. This and other links are provided in "useful links for student research" at the end of www.actionbioscience.org/evolution/futuyma.html.
- Perform a literature and/or Web-based search on the topic of future evolution. List the 10 or 12 most relevant references you find. You can begin your search with links suggested in the "useful links for student research" at the end of www.actionbioscience.org/evolution/futuyma.html. Write a report or chart summarizing your findings.