

## actionbioscience.org lesson

To accompany the peer-reviewed article by Richard E. Lenski, Ph.D.:

“**Evolution: Fact and Theory**” (Sept. 2000)

<http://www.actionbioscience.org/evolution/lenski.html>

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### **Evolution: Is It Fact and/or Theory?** (April 2002)

Lesson by **Ronald Brian Watts, Ph.D.**, Professor, Dept. of Biology & Chemistry, CEGEP De La Gaspésie et Des Îles, Gaspé, QC, Canada

Educator's section: *p. 1-2*

Student handout 1: *p. 3*

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Supplementary handout: *p. 5-6*

#### **Grades & Levels:**

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

**Time Recommendations:** This will vary depending on the combination of questions and activities used; however, minimum estimates are:

- 2 class periods and 2-3 hours homework time
- OR spread over 2-3 weeks

#### **NSES (USA) Content Standards, 9-12:**

- NSES 1.1. Unifying Concepts & Processes: systems, order, and organization
- 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 & 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 the concepts of evolution and theory
- explain the four major patterns of change in nature
- identify five mechanisms of the evolutionary process
- examine the contribution of Charles Darwin, Alfred Russell Wallace, and modern genetics to our current understanding of evolution
- describe evidence for the fact of evolution

**Key Words Include:** adaptation, allele(s), convergence, divergence, DNA, evolution, fact, fossils, gene(s), (genetic) drift, genetic recombination, genetics, genome, Linnaean classification, mutation, natural selection, phenotypic variation, sexual reproduction, speciation, theory (*note:* see definitions in the Supplementary Student Handout)

## Preparation

### Article Discussion:

- Have students read the article “Evolution: Fact and Theory” by Richard E. Lenski at <http://www.actionbioscience.org/evolution/lenski.html>
- Follow the reading with questions about the article. Suggested questions are listed under “Article Discussion” on page 2. Groups of two to four students could be formed to discuss these questions. Discussion may be concentrated in one time period or dispersed into smaller periods of time involving consideration of 2-3 questions at a time.

### Student Handout 1 or 2:

- Distribute Student Handout 1 for high school (general level) activities or Student Handout 2 for high school (advanced/AP) - undergraduate (year 1) activities.
- **Note:** The last activity on Student Handout 2 suggests that students use the “Website Evaluation Checklist” and “Website Evaluation Guidelines” created by educator Sandra M. Latourelle for the Actionbioscience.org lesson “*Human Cloning: Is It Biological Plagiarism*” (see “lesson directory”).

### Supplementary Handout (optional):

Provide copies to students of the Supplementary Student Handout, which consists of key word definitions and reference resources. The references could serve as research resources for activities.

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## For Educators: Article Discussion

About the article by Richard Lenski, Ph.D.: “Evolution: Fact and Theory”

<http://www.actionbioscience.org/evolution/lenski.html>

### Content Questions:

1. What does Dr. Lenski consider to be a “fact” about evolution? What does he consider a “theory”?
2. What is the fundamental cause of the variety in the outward appearance and behavior of individuals in almost all species?
3. What natural explanation is given by evolutionary biologists for adaptations that appear to equip organisms for their environment?
4. How does the Linnaean classification scheme reflect the idea that all forms of life today have descended and diverged from a common ancestor?
5. How do fossils provide evidence of evolutionary changes in organisms?
6. What two factors cause genetic variation within species?
7. How is genetic drift similar to the flipping of coins?
8. Who proposed the principle of natural selection? Define natural selection in your own words.
9. How does natural selection act as an agent of evolution?
10. Why is it inevitable that, if given enough time, two geographically isolated populations will become separate species?
11. What fundamental genetic fact strongly implies a common origin and evolution of all living species from pre-existing species?
12. Name one implication of the fact identified in question #11 that may be of direct value to us.
13. Give one example of a case of “evolution in action.”
14. Does the fact that there is a continuing debate among scientists about some aspects of evolution mean that the theory is wrong? Why or why not?

# Evolution: Is It Fact and/or Theory?

## Student Handout 1

### News of the Weird

In the 1890's, doctors wrongly believed that men and women breathed differently: men breathed by lowering their diaphragm and raising their ribcage; women, by moving the ribcage only. Why? Because it was observable! Fashionable women wore tight-waisted dresses and corsets that constricted the movement of their diaphragm. Hence they did not breathe in the same way as men. Some women were so desirous of being fashionable that they had their lower ribs removed!

- Find three ideas that we consider facts today (or have done so until recently) that may not be facts at all. Create a one-page newsletter about them. Include illustrations for each strange fact. Write captions for the illustrations, explaining what is it about these ideas that make you think they may not be true facts.
- Share your newsletter with other students and discuss:
  - suggestions how you might determine if each of these “facts” is true
  - whether the basic idea of evolution is a “fact” like those in your newsletter

### Unique DNA

In the article you read, Dr. Lenski states, “no two individuals have the same DNA sequence, with the exception of identical twins or clones.” Using your biology textbook or another reference from your school library or the Internet, explain or define the following briefly in a report:

- the structure of DNA
- the (base) sequence of DNA
- how a clone would be created
- using these definitions or explanations, discuss one implication of Dr. Lenski’s statement

### Charles Darwin

Write a short biography of Charles Darwin. Answer the following questions in the biography:

- What was the significance of Darwin’s five-year voyage around the world on HMS *Beagle* to his later formulation of the Theory of Evolution by Means of Natural Selection?
- What contributions did Charles Darwin make to our modern theory of evolution?
- What important questions did Darwin leave unanswered?

### Fossil Hoax

In November 1999, *National Geographic* magazine published an article announcing and illustrating the discovery of a new fossil of an ancient bird, *Archaeoraptor liaoningensis*, discovered in China in July 1997. The discovery was hailed as the finding of a new missing link! Then, 11 months later, it was shown that the “missing link” fossil was a hoax perpetrated by a Chinese farmer trying to please fossil collectors!

Investigate this case and write an essay about

- how and why scientists were duped by the hoax
- the implications of such hoaxes on science education and the public’s acceptance of evolution theory

### Well-Adapted

Choose three animals from different environments. Create a display that explains:

- each animal’s habitat and its place within the food chain
- how each animal is well-adapted to its environment

### Theory?

Write an essay explaining the difference between a hypothesis and a theory. Provide examples of each.

# Evolution: Is It Fact and/or Theory?

## Student Handout 2

### Play: *Charles Darwin and Gregor Mendel meet!*

Darwin provided a clear explanation of natural selection as the most important agent of evolution. However, Darwin could never clearly explain how the variation within populations could be maintained or produced generation after generation. Unknown to him, an obscure Austrian monk, Gregor Mendel, had begun the first crucial experiments that would begin to answer these questions. Darwin and Mendel never met. However, imagine a conversation between Darwin and Mendel at their first meeting. Write a play about their imaginary encounter and conversation. For example:

“I don’t really understand the mechanism of inheritance,” Darwin said.

“Yes, I guessed as much when I read your book about species,” replies Mendel.

Present the play in class. After the presentation, ask your audience for feedback.

### Classification

The modern scheme of classification used by biologists is based on that of Carl Linnaeus (1707-1778).

Use your textbook and other suitable reference sources to determine:

- the purpose of classification as performed by modern biologists
- the form of the modern classification scheme
- how the modern scheme is similar to that of Linnaeus
- how the modern scheme differs from that of Linnaeus

### The Cambrian Explosion

It is often noted that the number and diversity of fossils of multicellular plants and animals increases greatly in the fossil record from about 550 million years ago. This sudden appearance of abundant complex life forms, many sharing their most fundamental characteristics with modern species, is called “the Cambrium Explosion.” Write and illustrate an essay that presents:

- three hypotheses that you think might explain this phenomenon
- research, using at least three sources, that support or do not support your hypotheses

### Evolution Simulation or Game

Create a simulation or game based on the patterns and mechanisms of evolution described in Dr. Lenski’s article. Try for some creativity but be sure to include ways of modeling genetic variation, genetic recombination and/or sexual reproduction, genetic drift, natural selection, and if possible, speciation. Provide clear instructions for your simulation or game. Be prepared to demonstrate it to your class.

### Website Evaluations

Search the Internet to find three to six websites that deal with evolution. These may include text articles explaining some aspect of evolution, video clips, animations, simulations, etc. Use the “Website Evaluation Checklist” and “Website Evaluation Guidelines” found in the Actionbioscience.org lesson “*Human Cloning: Is it Biological Plagiarism*” (see “lesson directory”). Present your website evaluations as a report or as part of a class discussion.

# Evolution: Is It Fact and/or Theory?

## Supplementary Student Handout

**Sources:** *The following sources were used in the preparation of this lesson*

- Arms, Karen & Pamela S. Camp, 1988. *Biology: A Journey into Life*. Saunders College Pub., Toronto.
- Henig, Robin Marantz, 2000. *The Monk in the Garden*. Houghton Mifflin, MA.
- McComas, William F., 1997. "The Discovery & Nature of Evolution by Natural Selection: Misconceptions & Lessons from the History of Science." *Amer. Biol. Teacher* 59(8): 492-500.
- Moorehead, Alan, 1969. *Darwin and the Beagle*. Penguin Books, England.
- Simons, Lewis M., 2000. "Archaeoraptor Fossil Trail: A Report to Members." *National Geographic*, October: 128-132.
- Sloan, Christopher P., 1999. "Feathers for *T. rex*." *National Geographic*, Nov.: 98-107.
- Xing, Xu, 2000. "Feathers for *T. rex*?" *National Geographic*, March, Letter to Editor.

### Useful References:

- Clark, Ronald W., 1984. *The Survival of Charles Darwin: A Biography of a Man and an Idea*. Avon Books, New York, NY, 554 pp. [ISBN: 0-380-69991-5]
- Dawkins, Richard, 1996. *Climbing Mount Improbable*. W.W. Norton & Company, New York, NY, 352 pp. [ISBN: 0-393-31682-3]
- Gould, Stephen Jay, 1989. *Wonderful Life: The Burgess Shale and the Nature of History*. W.W. Norton & Company, New York, NY, 347 pp.
- Jones, Steve, 1999. *Darwin's Ghost: The Origin of Species Updated*. Doubleday of Canada Ltd., (Random House Canada), Toronto, ON, 406 pp. [ISBN: 0-385-25909-3]
- Stone, Irving, 1980. *The Origin: A Biographical Novel of Charles Darwin*. New American Library, Times-Mirror (Doubleday & Company), New York, NY, 697 pp.,
- Weiner, Jonathan, 1994. *The Beak of the Finch: A Story of Evolution in Our Time*. Alfred A. Knopf Publisher, New York, NY, 342 pp. [ISBN: 0-679-40003-6]
- Zimmer, Carl, 2001. *Evolution: The Triumph of an Idea*. HarperCollins Publishers, New York, NY, 383 pp. [ISBN: 0-06-019906-7] (This is the companion volume to the PBS video series "Evolution.")

### Definitions of Some Key Words:

**Adaptation:** A genetic change in a population of organisms, which tends to increase their chances of survival in a given environment. These genetic changes are expressed in morphological (structural), biochemical, and/or behavioral characteristics of the organism. As members of the population live and interact with their environment, those with adaptations, which preferentially improve their chances of reproduction, will tend to pass on those adaptations to their offspring.

**Allele(s):** Alternate forms of the same gene, occurring at the same location (locus) on homologous chromosomes.

**Convergence:** occurs when distantly related species living in similar habitats develop similar traits or adaptations.

**Divergence:** occurs when similar species living in different habitats develop very different traits or adaptations.

**DNA (Deoxyribonucleic Acid):** The genetic material in organisms. This long molecule shaped into a double helix is the molecular substance of genes, the units of heredity that code for genetic traits.

**Evolution:** A process whereby living organisms have acquired their structural and functional characteristics; the theory that organisms have had their origin in pre-existing types, and that hence species change with time.

## Evolution: Is It Fact and/or Theory?

### Supplementary Student Handout (cont.)

**Fact:** Something that is known to have occurred with certainty; a true or existent reality; an aspect of experience known without doubt to be true.

**Fossils:** (from Latin “fossilis” ... something dug up.) The remains (mineralized bones or shells) or impressions of organisms preserved from the distant geologic past.

**Gene(s):** Units of heredity consisting of DNA. They are the functional units along chromosomes, which code for given traits in an individual.

**(Genetic) Drift:** A shift in gene (allele) frequencies within a population that occurs at random rather than by natural selection.

**Genetic recombination:** The mixing of alleles of genes between members of a reproductive population occurring most frequently as the result of sexual reproduction.

**Genetics:** The science that investigates the mechanisms of heredity including the transference of traits from parents to their progeny.

**Genome:** A complete set of genes contained in one haploid complement of chromosomes. For example, sperm and egg cells contain one genome each.

**Linnaean classification:** Classification according to a hierarchical system of categories denoting broader (the “Kingdom” level) to more specific (the “Genus” and “Species” levels) similarities in form, function, and behavior of organisms. Such a scheme was constructed by Carl Linnaeus around 1750.

**Mutation:** (from Latin “mutatio” ... to change.) A random change in genetic information within the cells of an organism. This may occur as a change in the genetic coding within a gene or as a rearrangement of genes on chromosomes. This can result in a biochemical, physiological, morphological, or behavioral change in the organism that carries it.

**Natural selection:** The key mechanism of evolution proposed by Charles Darwin and Alfred Russell Wallace in 1858. Basically it states that: Individuals within a population vary in their attributes and these differences are genetically determined. Individuals having a collection of characteristics compatible with their environment survive and reproduce, thus passing on their advantageous attributes to their offspring.

**Phenotypic variation:** Variation between individuals in a population or species based on appearance, physiology, biochemistry, or behavior.

**Sexual reproduction:** Any reproductive process in which genetic information, usually genes, is exchanged between two individuals leading to the production of offspring with a mixture of this information from these two parents.

**Speciation:** The evolutionary process that leads to the production of new species. This usually involves some sort of reproductive isolation between populations of a single species until they become unable to interbreed under natural conditions and produce viable or reproductively capable offspring.

**Theory:** A hypothesis that has been rigorously and repeatedly tested by experiment and systematic observation performed by many teams of scientific investigators and thus shown to be most probably true.