

SOLUTIONS MANUAL



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Essentials
of Physical
Anthropology

Seventh Edition



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CHAPTER 2: THE DEVELOPMENT OF EVOLUTIONARY THEORY

Learning Objectives

After reading Chapter 2, the student should be able to...

1. Trace the development of theories of biological evolution in light of advances in the natural sciences, resulting in part from the age of discovery and exploration
2. Understand Western European world views, particularly the notions of fixity of species and a general sense of stasis, and how these concepts inhibited the development of theories of biological evolution
3. Discuss the contributions of 18th and 19th century scientists to evolutionary theory
4. Understand the theory of evolution by means of natural selection, developed independently by Charles Darwin and Alfred Russel Wallace
5. Understand the importance of variation in species and how natural selection acts on this variation through differential reproductive success to alter species
6. Discuss the shortcomings of Darwin's explanation of evolution in reference to 19th century genetics and theories of inheritance
7. Discuss the present level of acceptance of evolutionary theory in the United States among scientists and lay people

Chapter Outline

I. Introduction

- A. Misconceptions about evolution result from the poor quality of education (particularly science education: biology) in the U.S.
- B. In the United States, evolution is considered to be anti-biblical and is often denigrated as being "only" a theory.
 1. Evolution is, in fact, a scientific theory that has a wealth of support and is the unifying theory of the biological sciences, including physical anthropology.
 2. There is ample proof that humans and apes last shared a common ancestor 5 to 8 million years ago.

II. A Brief History of Evolutionary Thought

- A. Discoveries of evolutionary principles took place in Western Europe through many ideas borrowed from other non-western cultures.
- B. Charles Darwin is credited with formulating the theory of natural selection, although Alfred Russel Wallace independently duplicated Darwin's ideas.
- C. The predominant European worldview throughout the Middle Ages was one of stasis and the fixity of the species.
 1. Christian teachings that God created all life were taken literally.
 2. Additionally, most believed that life could be ranked in a hierarchy called the Great Chain of Being, an idea that was first proposed by Aristotle in the 4th century B.C.
 3. The universe was perceived as being part of the Grand Design.
 - a. Archbishop James Ussher calculated that the world had been created in 4004 B.C.
 4. The belief that the earth was very young, coupled with the notion of fixity of the species, was a significant obstacle to the development of evolutionary thought.

III. The Scientific Revolution

- A. In Europe, the scientific revolution developed as fundamental ideas of the earth and the biological world were overturned. However, in Arabia and India, scholars developed concepts of planetary motion centuries earlier.
 - 1. In 1514, Copernicus argued that the solar system was heliocentric.
 - 2. In the 1600s, Galileo Galilei restated Copernicus concepts and was sentenced to house arrest.
 - 3. The laws of physics, motion, and gravity were developed in the 17th century.
 - 4. Europeans began to investigate nature as though it was mechanistic and sought to discover its fundamental natural laws.

IV. Precursors to the Theory of Evolution

- A. The first step to understanding the many forms of organic life was to list them and describe them.
 - 1. John Ray (1627-1705), an ordained minister at Cambridge University, was first to recognize that groups of plants and animals could be distinguished from other groups by their ability to produce offspring.
 - a. These groups were termed species.
 - b. Ray also coined the term genus, recognizing that similar species could be grouped together.
 - 2. Carolus Linnaeus (1707-1778), a Swedish naturalist and believer in the fixity of species, developed the binomial system of classification plants in his publication, *Systema Naturae* (1735).
 - a. He added the taxonomic levels class and order.
 - b. Humans were classified as *Homo sapiens*.
 - 3. George-Louis Le Clerc de Buffon (1707-1788) stressed the importance of change in the universe and the dynamics between nature and living forms in *Natural History* (1749).
 - a. He did not believe that one species could give rise to another species.
 - 4. Erasmus Darwin (1731-1802), Charles Darwin's grandfather, was a freethinking physician who wrote about evolutionary ideas in verse.
 - a. The degree to which he influenced his grandson's ideas is unclear.
 - 5. Jean-Baptiste Lamarck (1744-1829) was the first to propose an explanation of the evolutionary process.
 - a. He proposed a theory of the inheritance of acquired characteristics, in which an animal's body parts are altered through use or disuse.
 - (i) These altered characteristics are transmitted to their offspring.
 - (a) Although this is biologically impossible, he nevertheless is credited with being the first to recognize the importance of the interaction between organisms and their environment in the evolutionary process.
 - 6. Georges Cuvier (1769-1832), a French vertebrate paleontologist, was an opponent of Lamarck's evolutionary ideas.
 - a. Cuvier introduced the concept of extinction to explain the existence of hitherto unknown fossil forms.
 - b. Cuvier was a proponent of **catastrophism**, the idea that the earth's geological features are a result of catastrophic events, the most recent being the biblical flood.
 - (i) These events destroyed old life forms, and the newer forms were the result of creation events.
 - (ii) Cuvier obviously believed in the concept of the fixity of the species.
 - 7. Charles Lyell (1797-1875), author of *Principles of Geology* (1830-1833), is considered the founder of modern geology.
 - a. He demonstrated that uniform processes (**uniformitarianism**) could account for present geological features.

- (i) His ideas provided the time depth necessary for biological evolution to have occurred.
- 8. Thomas Malthus (1766-1834), an English clergyman and economist, wrote *An Essay on the Principles of Population* (1798).
 - a. He noted that population sizes increase exponentially but food supplies remain stable.
 - (i) This concept inspired both Charles Darwin and Alfred Wallace.
- 9. Mary Anning (1799-1847), an amateur geologist and famous “fossilist,” unknowingly contributed significantly to the field of paleontology by discovering hundreds of fossils, including the first complete *pleiosaurus*.

V. The Discovery of Natural Selection

- A. Charles Darwin (1809-1882) proposed the first credible mechanism for evolutionary change, natural selection, in *On the Origin of the Species* (1859).
 - 1. After graduating from Cambridge University, where he studied theology but also cultivated his interests in natural science and geology, he was recommended to join the five-year expedition of the HMS *Beagle*.
 - a. Darwin began the voyage as a believer in the fixity of species, but his observations of, among other things, fossils of giant ancient versions of living animals and varieties of Galápagos finches eventually convinced him to the contrary.
 - b. After his return to England in October 1836, he began to formulate his theory of natural selection.
 - (i) He wrote summaries of his ideas in 1842 and 1844, but felt he needed more evidence before he published.
 - (ii) He was sent Wallace’s papers, which spurred him to put all his ideas in writing.
 - (iii) Darwin published his book titled *On the Origin of Species*. The initial reaction was mostly negative, but scientific opinion gradually shifted to Darwin’s favor.
- B. Alfred Russel Wallace (1823-1913) developed his own theory of natural selection after collecting bird and insect specimens in Southeast Asia.
 - 1. He first published some of his ideas in 1855, and then in 1858, Wallace wrote *On the Tendency of Varieties to Depart Indefinitely from the Original Type*.

VI. Natural Selection

- A. Darwin envisioned natural selection as a process in which individuals with favorable variations survive and reproduce at a higher rate than those with unfavorable variations. The key elements in Darwin’s formulation include the following.
 - 1. The potential for reproductive rates that outpace the rate of increase of food supplies.
 - 2. The presence of biological variation within all species.
 - 3. Constant competition among individuals for survival.
 - 4. Individuals with favorable traits are more likely to survive and reproduce.
 - 5. The environment “determines” which traits are favorable.
 - 6. Favorable traits are passed on to offspring at a higher rate than non-favorable traits, thus increasing in frequency through time and eventually producing new species (reproductive success).
 - 7. Over long periods of geological time, successful variations accumulate in populations, resulting into later generations being distinct, thus new species appear.
 - 8. Geographical isolation may lead to the formation of new species and different selective pressures.

VII. Natural Selection in Action

- A. Natural selection is an empirically studied phenomenon.
 - 1. Industrial melanism is a documented case of evolutionary shifts in the frequencies of pigmentation patterns in peppered moth populations near Manchester, England.
 - a. Evolutionary shifts in response to the environment are called adaptations.
 - 2. Natural selection has been demonstrated on the (Galápagos) island of Daphne Major.
 - a. Measurements of beak thickness that changed through time among the medium ground finch indicate the thicker-beaked individuals had greater reproductive success during droughts.
 - 3. Natural selection, through the use of antibiotics by humans, is responsible for the increased number of antibiotic-resistant strains of microorganisms.
- B. These examples of natural selection in action indicate that certain common principles apply.
 - 1. A trait must be inherited if natural selection is to act on it.
 - 2. Natural selection cannot occur without variation in inherited characteristics.
 - 3. Fitness is a relative measure that will change as the environment changes. Fitness is differential reproductive success.
 - 4. In evolutionary terms, natural selection can act only on traits that affect reproduction.
- C. Natural selection can act through not only differential death rates, but also through differential fertility rates.

VIII. Constraints on 19th Century Evolutionary Theory

- A. Darwin argued that natural selection acts on variation within species, yet no one could explain the source of this variation.
- B. Darwin also didn't know how favorable traits were passed from generation to generation.
 - 1. The laws of heredity were unknown, and most believed that parental traits were blended in the offspring.
 - 2. Gregor Mendel had worked out the modern principles of heredity, but his work was not recognized until the beginning of the 20th century.
 - 3. In 1953, the DNA structure was identified and the field of genetics became a supportive evidence for evolutionary theory.

IX. Opposition to Evolution

- A. Darwin's formulation of evolution was offensive to Christians because it was in conflict with Biblical versions of the creation.
- B. Today, evolution is considered to be a fact by most scientists.
 - 1. Scientific explanations are grounded in data analysis and interpretation, while religious explanations are not amenable to scientific testing and falsification.
 - a. Yet, evolutionary theories are accepted, in part, by the Catholic Church and most mainstream Protestants.
 - b. Most fundamentalists reject all scientific explanations of evolution.
 - (i) Historically, religious fundamentalists opposed the teaching of evolution in public schools at the pre-baccalaureate level. They continue to do so, although recent attempts to legislate against the teaching of evolution have been overturned in courts.
 - (ii) Creationists have dropped the term "creationism" in attempts to mask their fundamentalist ideologies with less religious sounding terms such as "intelligent design theory."
 - c. Unfortunately, most students remain ignorant of evolutionary theories until they reach college.

Key Terms and Concepts

Christian fundamentalists	p.33	Transmutation	p.25
Fertility	p.31	Reproductively isolated	p.21
Fixity of species	p.19	Reproductive success	p. 29
Natural selection	p.19	Selective pressures	p. 29
Binomial nomenclature	p.21	Fitness	p. 31
Taxonomy	p.21	Biological continuity	p. 33
Catastrophism	p.23	Genome	p. 32
Uniformitarianism	p.24		

Lecture Suggestions and Enrichment Topics

1. Beginning students usually have little knowledge of the history of science and are therefore unaware that creationist/evolutionist debates have been ongoing for over 150 years. It is enlightening to demonstrate that many current “creationist” arguments are merely recycled ideas.
2. Most students have heard of Darwin, but few really understand the full impact of his ideas not only on scientific thought but also on his personal life. The author has found that, rather than lecturing, showing a video on Darwin’s life brings home these points. The video *Charles Darwin: Evolution’s Voice* from A&E’s *Biography* series is particularly relevant. Be sure to reinforce the fact that Darwin waited over twenty years to publish his ideas after returning from the voyage of the HMS *Beagle*, mostly because he was aware that his theories ran contrary to widely accepted Biblical doctrines.

InfoTrac Exercises

1. Why I won’t debate creationists. Richard Dawkins. *Free Inquiry*, Winter 2002 v23 i1 p. 12(3). What are the main points in this article?
2. In *InfoTrac*, subject search “natural selection” and read one article that interests you. How does the subject matter of the article demonstrate the principles of natural selection?

Internet Exercises

1. Visit the National Center for Science Education’s website, <http://www.ncseweb.org/>, and read about creationist attempts to teach “creation science” in public schools. Use the “Critiques of Creationism” link and write a paragraph summarizing one of the critiques.
2. One historical figure that vehemently opposed Darwin’s ideas was Louis Agassiz (1807-1873). Go to the University of California, Berkeley’s Museum of Paleontology website for information on Agassiz (<http://www.ucmp.berkeley.edu/history/agassiz.html>); write a brief paragraph on his life and ideas.
3. Go to the University of California, Berkeley’s Museum of Paleontology website (<http://www.ucmp.berkeley.edu/fosrec/Scott.html>) for a discussion of antievolutionism. Why is it important that evolution be taught?