The Theory of Evolution: A History of Controversy

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Born in central Ohio, Edward J. Larson attended Mansfield, Ohio, public schools. He earned a B.A. from Williams College, a law degree from Harvard, and an M.A. and Ph.D. in the history of science from the University of Wisconsin—Madison. He currently holds a joint appointment in the history department and law school at the University of Georgia, where he teaches the history of science to undergraduates, and health, science, and technology law to law students. Before accepting a teaching position at Georgia in 1987, he served as Associate Counsel for the U.S. House of Representatives Committee on Education and Labor and as an attorney with a major Seattle law firm.

The author of four books and more than fifty published articles, Larson writes mostly about issues of science, medicine, and law from a historical perspective. His books are *Evolution's Workshop: God and Science in the Galapagos Islands* (2001); *Sex, Race, and Science: Eugenics in the Deep South* (1995); *Trial and Error: The American Controversy Over Creation and Evolution* (1985 and 1989 expanded edition); and *Summer for the Gods: The Scopes Trial and America's Continuing Debate Over Science and Religion* (1997), for which he received the 1998 Pulitzer Prize in History. His articles have appeared in such varied journals as *Nature*, *Scientific American*, *The Atlantic Monthly*, *The Nation*, *Oxford American*, *Wall Street Journal*, *Virginia Law Review*, *Journal of the History of Medicine*, and *British Journal for the History of Science*. He is the co-author or co-editor of four additional books. The Fulbright Program named Larson to the John Adams Chair in American Studies for 2001 and he received the 2000 George Sarton Award for science history from the American Association for the Advancement of Science.

The recipient of multiple teaching awards from the University of Georgia, Larson lectures and speaks on history, law, and bio-science for academic, professional, and public audiences. He has given endowed or funded lectures at dozens of colleges and universities and presented scores of legal and medical education talks to professional legal, judicial, and medical groups throughout America. He is interviewed frequently for broadcast and print media, including multiple appearances on major programs for PBS, the History Channel, Court TV, CNN, and C-SPAN. He has also taught in Austria, China, France, New Zealand, and the Netherlands.

Larson is married to a pediatrician, Lucy Larson. They have two children, Sarah and Luke. Together, they enjoy traveling, hiking, bicycling, and working on their 180-year-old house in Athens, Georgia.

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Scope:

The theory of organic evolution is central to modern thought. A people's view of human origins, and the origins of life itself, shapes their worldview. It influences their values and how they conceive of themselves and others. This was true of various religious accounts of origins, including the biblical account in Genesis that speaks of humans being created in the image of God, and it is true of scientific accounts as well. The secularization of Western society over the past two centuries has coincided with changing views of human and organic origins. Fitfully at first, but increasingly dogmatically over the past seventy-five years, an evolutionary account of origins has taken hold in Western science. This view is utterly materialistic. It is perceived by many of its supporters and opponents as hostile to spiritual belief. Some theists have objected to the new view and continue to oppose its acceptance. The public remains divided. This course chronicles the history of this epic development in Western thought.

The first four lectures carry the story through Charles Darwin, who remains the single scientist most associated with launching the modern theory of evolution. Lecture One explores how mainstream Western scientists conceived of origins before 1858, when Darwin announced his theory of evolution by natural selection. This pre-Darwinian view had already moved sharply away from biblical literalism. Indeed, as Lecture Two points out, evolution was already in the air by 1858. Darwin's work built on a firm foundation of evolutionary developments in Western geological, biological, and social scientific thought. Lectures Three and Four deal directly with Darwin and his theory of evolution. They tell his biography and trace his intellectual development as he grapples with the most revolutionary scientific idea of his time.

The second group of four lectures continues the history of evolutionary science from Darwin's initial work through the rise of the modern neo-Darwinian synthesis. This critical period, extending roughly from 1875 to 1925, was marked by intense scientific controversy as biologists struggled to come to terms with the theory of evolution and determine how the process operated. Lecture Five discusses the various mechanisms proposed during the late nineteenth century for how evolution worked and explores why Darwinism fell from favor even as evolutionism gained support. The next two lectures look at two particular scientific developments central to the turn-of-the-century debate over evolution. First, Lecture Six traces the search for fossil evidence of human and animal evolution. Second, Lecture Seven introduces the decisive role played by the discovery of Mendelian genetics in resolving the scientific debate about how evolution works. Even as scientists wrestled with the theory of evolution, their increasingly materialistic thinking on the subject had a profound impact on late nineteenth- and early twentieth-century social scientific thought. To complete the examination of early evolutionism, Lecture Eight discusses the initial stages of this impact in the rise of social Darwinism and eugenics.

The final four lectures carry the debate over creation and evolution to the present, with particular emphasis on developments in the United States. As Darwin's purely materialistic, highly secular theory of evolution gained ascendancy in science during the mid-twentieth century, it engendered increased resistance from conservative Christians. Lecture Nine examines America's first popular crusade against evolutionary teaching, which arose during the 1920s and culminated in the famous trial of John Scopes for teaching evolution in Tennessee public schools. Lecture Ten describes the coming together, during the period from 1920 to 1950, of the modern scientific theory of evolution, the so-called neo-Darwinian synthesis. This synthesis applies a refined understanding of genetics to the problem of changes in gene frequencies in wild populations to construct a model sufficient to account for evolutionary change through a Darwinian process of chance variations and competition. Under the new view, a purely material substance, the gene, lies at the heart of evolution. There is no place for God in the modern synthesis, though it does not necessarily preclude divine action in other areas. The result was an increased disconnection between religious and scientific thinking about origins. As discussed in Lecture Eleven, many conservative Christians hardened their own views on origins by relying on hyper-literal readings of the Genesis account. Some of them demanded that scientific evidence of a creation event, so-called "scientific creationism," get a hearing in public education. During the 1980s, these demands led to the adoption of state laws and school-board policies according balanced treatment for creation and evolution in public school science classes. In America at least, the public controversy over organic origins continues today. The last lecture in this course examines recent developments in this ongoing controversy, as evolutionists refine how evolution works against a backdrop of continued popular resistance to materialistic Darwinism.

Lecture One
Before Darwin

Scope: People have speculated about the origins of species ever since they noticed that, in nature, likes breed with likes and produce more of the same. If so, some asked, where did the first members of each species come from? The Bible says that God created Adam and Eve to start the human species and suggests that God specially created all the various kinds of plants and animals. Some early Greek natural philosophers proposed the idea of organic evolution but never fully developed it.

By 1800, the ancient accounts of origins no longer satisfied many scientifically sophisticated Europeans. French naturalist Georges Cuvier maintained that species were not created recently in some singular Garden of Eden. His study of the fossil record indicated that various species had appeared and disappeared over vast eons of geologic history. He did not find evidence of lineal descent linking species, however. Rather, he concluded that the earth's history was punctuated into epochs by life-destroying catastrophes, with a distinctive array of species populating each epoch. This was the leading scientific theory of origins during Darwin's youth.

Outline

I. People think, and in so doing, they have always wondered about how the universe and things in it originated, particularly themselves.

- **A.** The earliest stories, myths, and writings contain accounts of gods creating the world, the heavens, people, animals, and plants.
- **B.** The account set forth in Genesis carries particular importance to Jews, Christians, and Moslems because they accept that account as gospel—the revealed word of God.
  - **1.** The first chapter of Genesis tells of God creating the heavens and the earth, then plants and animals, then "man in His own image"—all in six days.
  - **2.** Significantly, each type of plant and animal was said to reproduce according to its own kind. Read literally, this precluded evolution.
  - **3.** The Bible does not state when this creation occurred, but most early Christians probably assumed that it was not too long ago. In the 1600s, Anglican bishop James Ussher used biblical evidence to fix the year of creation as 4004 B.C.
- **C.** Science began with the ancient Greeks.
  - **1.** Although many Greeks retained religious theories about nature founded on revelation, some Greek philosophers proposed materialistic ones founded on reason.
  - **2.** Biological origins posed problems for Greeks intent on devising purely materialistic explanations for natural phenomena. Creation implied a creator; to deny a creator, Anaximander and the atomists proposed crude theories of evolution.
  - **3.** Based on his close study of animals, Aristotle concluded that the species are fixed. Rejecting both creation and evolution, he saw species as eternal.
  - **4.** Integrating Genesis with Aristotle, pre-modern Christian natural philosophers typically viewed each species as created by God in the beginning; thereafter, those species remained fixed for all time in a perfect (albeit fallen) creation.

II. Notions of evolution, or creation by natural law, revived during the Enlightenment.

- **A.** As religious authority broke down during the 1700s, particularly in France, natural philosophers again struggled to devise purely materialistic explanations for life.
  - **1.** Seeking to push back God to the beginning, the deist Buffon proposed that the solar system was created by a comet hitting the sun and that the current array of species devolved from a few ancestral types.
  - **2.** Committed materialists, such as Denis Diderot and Baron d'Holbach, proposed that all living forms developed by chance mutations from spontaneously generated organisms.
  - **3.** Proposing the nebular hypothesis for the origin of solar systems, Pierre Laplace famously quipped, "I have no need for God in my hypothesis."

B. Except for William Herschel's discovery of stellar nebula and Abraham Trembley's detection of regeneration by polyps, eighteenth-century scientists found little empirical evidence to support these materialistic speculations.

III. French naturalist Georges Cuvier founded modern biology on empirical research during the early 1800s.

A. Focusing on the internal structure of various species rather than external characteristics, Cuvier concluded that there were only a few basic types of animal organization, with the various species representing variations on these types.

1. Bodily interactions within each species are so delicate that any significant change in them would render the individual incapable of survival.

2. Experience shows that species breed true to type with only superficial variations.

3. The origin of new species through evolution was, therefore, impossible.

B. As chief of the French Museum of Natural History during the Napoleonic era, Cuvier oversaw the first comprehensive collections of fossils and biological specimens.

1. He found no significant changes in living organisms over time either in the fossil record or during recorded history. These types worked, he maintained, and could not change.

2. He established that certain fossils (such as those of a woolly mammoth from Russia and mastodon from America) represented extinct species. He concluded that environmental changes must have rendered them incapable of survival.

3. He found sharp breaks in the fossil record corresponding to epochs of geologic history, with each succeeding layer of rock strata containing a distinctive array of fossil types. To Cuvier, this suggested catastrophic extinctions—probably by floods.

4. When his followers could not find any source for repopulating regions following these catastrophes, they concluded that God or a vital force in nature had re-created life modeled on viable basic types.

5. Fully developed in the mid-1800s, this theory held that the earth underwent a series of floods or ice ages shaping geologic features, followed by new creations of life in each age.

C. While elongating the biblical chronology of creation, Cuvier's theory allowed Christians to reconcile the fossil record with the Genesis account by equating the days of creation with geological ages, with God recreating life after each catastrophe. The intelligent design of each species proved God's existence and goodness.

Supplementary Reading:

Bowler, *Evolution*, chs. 1–3.

Greene, *Death of Adam*, chs. 2, 4, and 8.

Lloyd, *Early Greek Science*, chs. 1–2 and 8.

Questions to Consider:

1. Does philosophical materialism and religious atheism necessarily lead to belief in organic evolution? Is the reverse true?

2. Why would educated nineteenth-century Christians be willing to embrace Cuvier's theory of geologic and biologic history despite its implicit rejection of the traditional view that God created the universe and all species in six literal days within the past 10,000 years?

Lecture Two
Evolution in the Air

Scope: The idea that species evolve from pre-existing species began gaining currency early in the nineteenth century. Many factors pointed toward it. First, the emerging fossil record suggested change over time. Today's species did not appear among older fossils, and many ancient types are extinct. Cuvier might explain these observations with successive creations and catastrophes, but to his colleague at the French natural history museum, Lamarck, the evolution of new species from pre-existing species seemed more likely. Lamarck's hypothesis remained a minority view, however, because his explanation for how evolution operated—that acquired characteristics are inherited—lacked credibility.

Beyond the fossil record, developments in geology laid a foundation for evolution theory. Building on the work of James Hutton, the gentleman-scientist Charles Lyell developed the gradualist theory that existing processes acting over time are sufficient to shape the earth's features. This approach posited a very long earth history without catastrophes. The earth's environment would change over time under Lyell's view, suggesting that species living in it must differ as well. This was the springboard for Darwin's thinking about evolution.

Outline

I. The idea of organic evolution was in the air by the early 1800s. Many factors contributed to this development in Western science.

- **A.** The emerging fossil record played a major role in this development.
  - **1.** Around 1800, British civil engineer William Smith began documenting, for the first time, dramatic differences in the fossils found in each layer of rock strata. Each era of rock formation appeared to have its own unique population of living things.
  - **2.** By reconstructing these earlier life forms from their fossil remains, French naturalist Georges Cuvier found systematic development over time: First came invertebrates, then fishes, then reptiles, and last, mammals.
  - **3.** During the 1820s and 1830s, British geologist William Buckland and anatomist Richard Owen captured the popular imagination by first describing and naming dinosaurs from the reptilian age. Adam Sedgwick identified trilobites from the earliest eras.
  - **4.** By the mid-1800s, most European naturalists (though not Cuvier) and many in the general public interpreted the fossil record as one of progressive development over time, with humans appearing last. The earth was very old.
- **B.** Widespread acceptance of Pierre Simon Laplace's nebular hypothesis established an evolutionary view of cosmic origins as early as the late 1700s.
- **C.** Beginning in the eighteenth century, French naturalist Comte de Buffon and British physician Erasmus Darwin (Charles Darwin's grandfather) had begun speculating about the possibility of one species evolving (or devolving) from another.
- **D.** Building on the work of late eighteenth- and early nineteenth-century thinkers, philosophers G. W. F. Hegel in Germany and Herbert Spencer in England popularized the view of progressive social development (or evolution) over time.

II. In 1802, a French naturalist, the Chevalier de Lamarck, outlined the first comprehensive theory of organic evolution.

- **A.** A strict materialist, Lamarck believed in the ongoing spontaneous generation of simple living organisms through the active invention of a natural life force corresponding to electricity or the nervous fluids.
- **B.** This natural life force or energy continues to act in organisms after they were formed, driving them to develop ever more complex forms.
  - **1.** The development process was guided through the use or disuse of organs, which would concentrate the life force toward used organs and away from disused ones.

2. Environmental change resulting from gradual geological change would push the adaptation of an organism in particular directions.
3. The most famous example of supposed Lamarckian evolution was that of giraffes stretching their necks in response to drying conditions of the African savannah.
4. Lamarck posited that these acquired characteristics (such as a stretched neck) would be inheritable, leading to the evolution of new species from old ones over time.

C. The current array of species was not fixed, Lamarck maintained, but rather a snapshot of development over time, with less complex organisms being younger and more complex ones, older.

D. Overshadowed by Cuvier, Lamarck's superior in the French natural history museum, the Lamarckian theory of evolution gained little attention and even less acceptance. Cuvier saw sharp breaks in the fossil record, not gradual development; no evidence of species changing over time; and the impermanence of acquired characteristics.

III. In 1844, British writer Robert Chambers popularized the idea of organic evolution in an anonymously published treatise.

A. Chambers revived the notion of the spontaneous generation of simple life forms.

B. He posited that these different organisms progressed in a series of jumps to the current array of organic species. This development was linear, not branching, and somehow preordained.

C. Chambers offered no material cause of how species change over time, leading British scientists to ridicule the idea. His opponents also stressed the lack of intermediate fossils.

D. The scientific reaction to Chambers's theory drove Charles Darwin, who was already privately at work on his theory of evolution, to tighten and improve his ideas before announcing them.

IV. The acceptance of a uniformitarian view of geologic history provided further critical foundation for the emergence of scientific theories of organic evolution.

A. Neptunism dominated geological thought during the early 1800s.
1. As originally proposed by German geologist Abraham Werner in the late 1700s, Neptunism saw rock strata, fossils, and the earth's geological features formed through the gradual retreat of a vast primeval ocean that once covered the earth.
2. To better account for the fossil record, Cuvier and his followers believed that this process repeated itself, with each catastrophic flood ending a geologic era and laying down characteristic fossils. Some Christians saw Noah's flood as the last flood.
3. Although Neptunists typically saw the earth as far older than under the traditional biblical chronology, geologic history still had a beginning, a direction, and a probable end. Replace days with eras, and it roughly fit the Genesis account.

B. In 1795, Scottish naturalist James Hutton published his rival theory of steady-state Vulcanism.
1. As a deist, Hutton objected to the need for God's active intervention in geologic history. As an empiricist, he objected to hypothesizing past catastrophes to account for current geologic features.
2. Hutton posited a cyclical process of igneous rock mountains and volcanoes rising from the earth's molten core, then eroding to create inhabitable land. As land built up, bottom layers would push down into the core. The resulting pressure would push up new mountains, and the cycle would continue.
3. In all of creation, he famously quipped, there was "no vestige of a beginning—no prospect of an end." This would give ample time for organic evolution.
4. Although popularized in Britain by John Playfair, Hutton's theory attracted little scientific support. Breaks in the fossil record and the supposed sedimentary origin of most rocks discredited his theory of volcanic gradualism.

C. Beginning in the 1830s, the gentleman-naturalist Charles Lyell reworked Hutton's theory into modern uniformitarianism.
1. Lyell posited that science should only use observable processes to explain nature.
2. His observations in Italy and other volcanically active and earthquake-prone regions suggested that the earth's inner heat could dramatically shape geologic features.
3. James Hall's research suggested that the most common rock forms, granite and basalt, are igneous rather than sedimentary.

4. Intense worldwide fossil research had greatly filled in the fossil record so that the breaks in it were neither so complete nor so dramatic as they had seemed. This weakened the case for catastrophism and strengthened the case for gradualism.
5. Although the abrupt appearance and disappearance of species in the fossil record convinced Lyell that each species was separately created by God, this now appeared to him as an ongoing localized process rather than a massive worldwide one.
6. Gradual geological change suggested that organisms would need to adapt to a changing environment. Uniformitarianism gave ample time for these changes to accumulate. The geologic stage was set for the theory of organic evolution.

Essential Reading:

Bowler, *Evolution*, chs. 3–5.

Supplementary Reading:

Edey and Johanson, *Blueprints*, ch. 1.

Greene, *Death of Adam*, chs. 3, 5, and 9.

Larson, *Evolution's Workshop*, chs. 1–2.

Questions to Consider:

1. What role did the discovery of fossil evidence play in shaping nineteenth-century thought about organic origins and geologic history? What does this suggest about the role of new physical evidence in the development of new scientific theories?
2. How did Lyell's work in geology lay the foundation for Darwin's theory of evolution? What does this suggest about the role of new theoretical insights in the development of new scientific theories?

Lecture Three
Darwin's Inspiration

Scope: Charles Darwin sailed into the debate over creation and evolution aboard H.M.S. *Beagle*. An indifferent student at Cambridge, Darwin set sail aboard the *Beagle* in 1831 as ship's naturalist and travel companion to the ship's aristocratic captain. Trained in Cuvier's creationist biology, Darwin took Lyell's *Principles of Geology* with him. His observations of geological forces in action on the South American continent converted him to Lyell's view. Once predisposed to gradualism, Darwin was persuaded by observations of birds and tortoises on the Galapagos Islands that existing species evolved from pre-existing ones.

Back home in 1836, Darwin settled into the life of a gentleman-scientist without announcing his radical views on the origin of species. Struggling to devise a suitable explanation for how evolution operated, he struck upon the idea of natural selection. In 1858, after learning that naturalist Alfred Wallace had independently hit on the same idea, Darwin finally announced his theory. He published *On the Origin of Species* a year later.

Outline

I. Charles Darwin entered the scientific debate over origins inconspicuously.

A. Born in 1809, Darwin came from the British landed gentry. His maternal grandfather was the wealthy china manufacturer Josiah Wedgewood and his father, a prosperous physician.

1. On both sides, members of his family were active capitalists at the dawn of the industrial age.

2. After his mother died when he was nine, Darwin went to a dismal boarding school.

3. Science became an early outlet and led, in 1825, to Darwin's attendance at medical school at Edinburgh, the traditional center of experimental science in Britain. He could not stomach dissection, surgery, or the sight of blood; he liked only natural history.

4. Darwin transferred to Cambridge University to prepare for a career in the ministry at a time when the Anglican clergy served mostly a social function. He continued to study natural history, which was then viewed as a prop to religion.

5. He excelled in natural history, and his professors recommended him to serve as naturalist aboard the *Beagle* on a five-year British naval survey of the South American coast, with return voyage around the world.

B. Darwin's experience on the *Beagle* changed the course of intellectual history.

1. Darwin took with him Charles Lyell's *Principles of Geology* and was converted to uniformitarianism after seeing a volcano on the Cape Verde Islands and experiencing an earthquake in Chile.

2. Adopting Lyell's evolutionary view of geologic history did not shake his faith in the special creation of organic species. Lyell, too, accepted a form of creationism.

3. Species on the Galapagos Islands changed Darwin's view of origins. He found only a few basic types of plants and animals there, but those few took a wide variety of forms.

4. On his return voyage, Darwin began speculating that those various Galapagos forms must have evolved from a common ancestor. He adopted this view after ornithologists confirmed that various birds in his collection constituted distinct species.

5. Darwin kept his views on evolution a secret. He knew that the idea had been ridiculed by scientists and that he lacked a satisfactory explanation of how it worked.

II. Returning to England in 1836, Darwin assumed the life of a gentleman naturalist, living first in Cambridge and London, then at a country home with his growing family.

A. Having married his wealthy first cousin, Emma Wedgewood, Darwin did not need to work. He devoted himself to natural history, secretly developing his theory of evolution.

B. Darwin gradually gained stature and friends in the British scientific community.

1. He oversaw the identification and study of specimens brought back on the *Beagle*.

2. He published a highly popular narrative of his voyage and numerous scientific articles and books about his findings on it.

3. He became an active member of leading British scientific associations.

C. As his health deteriorated, he spent more time at home consumed by his biological studies. Although this research seemingly dealt with various topics, it all related to his obsession with understanding how evolution worked.

III. Darwin's breakthrough came in 1838 while reading Thomas Malthus's well-known 1798 essay on population.

A. Malthus was a gloomy Anglican cleric who maintained that because the human population far outstripped the food supply, only the fittest can or should survive. His social thinking was popular among rising Whig capitalists of Darwin's class.

B. Applying Malthus's theory to all living things, Darwin struck on a purely materialistic mechanism that he believed capable of driving the evolutionary process: natural selection.

1. Despite the obvious similarity of individuals in a species, all do vary slightly.

2. Assuming overpopulation, only the fittest of these can survive to reproduce.

3. Just as artificial selection propagates varieties in domestic breeding, so this natural selection process should create and maintain variety in the wild.

4. Given enough time and a changing environment, as postulated by uniformitarian geology, selected varieties would gradually deviate into separate species.

C. Darwin composed a first draft of his theory in 1842 and a second in 1844, yet he kept his idea secret from virtually everyone. He published seven books of basic science during the years from 1842 to 1857 but nothing about evolution.

1. Knowing the scientific opposition to earlier theories of evolution, Darwin labored to anticipate and answer every conceivable objection to his theory.

2. Although Darwin was never deeply religious himself, his beloved wife was a pious Christian and he valued the social role of religion. He feared the impact of his theory would undermine religious faith by making humans a product of nature and showing that a cruel process of survival of the fittest (rather than a loving God) formed species.

3. Darwin gradually lost his own faith in God during this period through a combination of his focus on materialist causes in nature and his struggles with the problem of evil.

IV. Darwin was shocked out his self-imposed intellectual exile by the receipt in 1858 of an essay from Alfred Russel Wallace outlining the theory of natural selection.

A. From a poor family in rural England, Wallace had developed a passion for natural history, particularly the study of beetles. He became a paid collector of natural history specimens in the Amazon valley and East Indies.

1. Radical in his political, social, and religious views, Wallace favored a theory of evolution over creation on philosophical grounds.

2. He went to the tropics with the ulterior motive of seeking proof for evolution by looking for evidence that similar species inevitably live near one another.

3. Obsessed with conceiving a sufficient mechanism to drive the evolution process, Wallace realized, during a malarial fever in 1858, that Malthus offered an answer.

4. He immediately wrote up his theory of natural selection in a cogent essay and sent it to Darwin, whom he knew had thought favorably of his early writings on evolution.

5. Darwin showed Wallace's work to Lyell, who was one of the three people who knew of Darwin's work on the same theory, and Lyell arranged that essays by both men on the theory of evolution by natural selection be published jointly in 1858.

B. Driven to get his evidence for evolution by natural selection before scientists and other educated readers as soon as possible, Darwin worked furiously to complete his classic book, *On the Origin of Species*, in 1859. This book revolutionized biological thought.

Essential Reading:

Darwin, *Voyage of the Beagle*, ch. 19.

Larson, *Evolution's Workshop*, ch. 3.

Supplementary Reading:

Browne, *Charles Darwin: Voyaging*.

Bowler, *Evolution*, ch. 6.

Edey and Johanson, *Blueprints*, chs. 2–3.

Raby, *Alfred Russel Wallace*, chs. 1–8.

Wallace, "On the Tendency of Varieties to Depart Indefinitely from the Original Type."

Questions to Consider:

1. What role did Darwin's voyage aboard the *Beagle* play in convincing him that species evolve from pre-existing species?
2. How did Malthus's essay on population lay the foundation for Darwin and Wallace to develop the theory of evolution by natural selection? Is it surprising that two people would discover the same fundamental theory independently and nearly simultaneously?

Lecture Four
An Intellectual Revolution

Scope: *On the Origin of Species* spawned an ongoing revolution in human thought. In it, Darwin does not "prove" his theory of evolution by natural selection. Rather, he argues that his theory offers a better explanation for the origin of organic species than creationism. In his later book, *The Descent of Man*, Darwin carries this argument on to provide materialistic explanations for the origin of the human species and such supposedly human traits as love and consciousness.

The implications of Darwin's theory provoked immediate controversy. Although accepting his theory did not preclude belief in God, it did dispense with the need to believe in a supernatural creator of species. Further, it undermined natural theology by suggesting that species evolve through random chance and a struggle for survival. As extended in *Descent of Man*, Darwin's thinking dispensed with God as the creator of humans, love, and consciousness. The study of man and nature became an investigation of natural (rather than supernatural) causes.

Outline

I. Darwin wrote his 1859 masterpiece, *On the Origin of Species*, to persuade scientists and educated readers that evolution was a better explanation for the origin of species than creation and that natural selection was a plausible mechanism for driving the process.

- **A.** Darwin could not offer a traditional "Baconian" scientific proof that evolution had transformed one species into another because he had not observed it happen. Rather, he artfully marshaled overwhelming circumstantial evidence for evolution.
  - **1.** Descent from a common ancestor accounts for the existence of natural groupings or families of similar species; creation does not.
  - **2.** Descent from a common ancestor accounts for the geographic proximity of similar species (Wallace's argument); creation does not.
  - **3.** Evolutionary descent accounts for the existence of rudimentary organs; creation does not.
  - **4.** Evolutionary descent accounts for progression in the fossil record; creation does not.
  - **5.** Descent from a common ancestor more logically accounts for the geographic distribution of species than does creation.
- **B.** Darwin also could not prove that natural selection of random, inborn variations caused evolution, but he argued that it could do so.
  - **1.** Artificial selection in agriculture showed the power of selection to maintain a variety.
  - **2.** The ability of introduced species to displace native ones both shows the power of selection and discredits the notion of special creation by a beneficent creator.
  - **3.** Competition and cruelty in nature support selection over creation.
  - **4.** Bright colors for male animals and for flowers support selection over creation.
- **C.** None of Darwin's arguments proved that evolution actually occurred, but together, they were persuasive for readers already inclined toward naturalism over supernaturalism.

II. Darwin's theory dealt a body blow to traditional Western religious thought.

- **A.** Darwin's chronology of, and outline for, the origin of species differed on its face from that set forth in the Genesis account.
  - **1.** Early nineteenth-century theories of geologic history had already forced many educated Christians to accept a metaphorical interpretation of the Genesis account.
  - **2.** Cuvier and Lyell had offered new chronologies and outlines for creation without arousing significant religious opposition.
- **B.** Darwin exceeded Cuvier and Lyell in dispensing with the need for a creator to fashion individual species.
  - **1.** Although some atheists had appealed to science in their rejection of God, most eighteenth- and early nineteenth-century scientists accepted either a theistic or deistic God and posited the need for a creator as prime evidence for God's existence.

2. Although Darwin acknowledged some place for an initial creation, the creator's acts were pushed back in time and out of the realm of science.

C. Darwin's theory undermined natural theology, which had become a mainstay of Protestant Christianity.

1. Natural theology sought objective evidence of God's existence and indications of his character in his creation. This was a key prop to religion in Protestant cultures that had rejected Church authority and elevated individual interpretation of scripture.
2. Without the special creation of species, there was less immediate evidence for God's ongoing interaction with the physical world and, thus, less evidence of His existence.
3. Under Darwin's theory of natural selection, new species evolved through chance variations and a ruthless struggle for survival. If nature reflected its creator, then natural selection challenged His justice and love.
4. In 1874, in a tightly reasoned book, the noted Princeton theologian Charles Hodge spoke for many when he concluded that Darwin's denial of design in nature denies God.

D. Although Darwin consciously avoided the issue of human origins in *Origin of Species*, to the extent that his theory of evolution applied to man, it also threatened deeply entrenched religious and philosophical opinions on human uniqueness and dignity.

III. Scientific, religious, and popular debate swirled over the applicability of evolution to the origin of humans.

A. The central issue concerned the origin of man's mental and moral attributes, not whether his physical body had evolved.

1. Traditional Christianity had ascribed these attributes to a divinely created soul, the existence of which divided humans from other animals.
2. Scientists generally segregated humans from other animals on this basis, from Aristotle's theory of the rational soul found only in humans, through the Cartesian dualism between physical matter and the human and divine soul, to Cuvier's classification of humans and primates into separate orders.
3. To the extent that the human mind, human behavior, and human morality had become topics of academic study, humans were studied on their own terms or through religion.

B. Darwin equivocated on the matter in *Origin of Species* but announced for the materialistic origins of humans from simian ancestors in his 1871 book, *Descent of Man*.

1. Darwin did not believe that humans descended from apes (because they coexist now) but argued that they had a common ancestor.
2. He asserted that the difference between the mental powers of humans and animals was one of degree rather than of kind. To do so, he exaggerated the human-like qualities of animals, such as in intelligence, emotions, and communication.
3. Darwin argued that moral feelings (including love and belief in God and immortality) would have survival value such that they could incrementally increase through natural selection.
4. He appealed to Lamarckian mechanisms to suggest that the force of habit could augment the development of mental and moral attributes in humans.
5. He invoked sexual selection to account for the development of traits in humans (such as monogamy) and in other animals (such as the male peacock's tail) that have no direct survival value.
6. Although more speculative and less influential than *Origin of Species*, *Descent of Man* anticipated developments in the social sciences and evolutionary psychology.

C. Even such loyal supporters as Charles Lyell and Alfred Russel Wallace broke with Darwin over the evolution of man. Both maintained that humans were simply too different from other animals for those differences to have evolved by chance variations.

D. Applying materialistic Darwinism to the origins and nature of human beings carried profound significance for Western thought. It ended the perceived divide between humans and the rest of nature enshrined by biblical religion and Aristotelian science.

Essential Reading:

Darwin, *On the Origin of Species*, ch. 14.

Darwin, *The Descent of Man*, ch. 21.

Supplementary Reading:

Desmond and Moore, *Darwin*.

Bowler, *Evolution*, ch. 7.

Greene, *Death of Adam*, chs. 9–10.

Raby, *Alfred Russel Wallace*, chs. 9–11.

Wallace, "Spiritualism and Human Evolution."

Questions to Consider:

1. How did Darwin succeed in so quickly overcoming scientific opposition to the theory of organic evolution?
2. Why would the evolution of humans from so-called "lower animals" arouse such sustained scientific, religious, and popular opposition even after most scientists and many others accepted the notion of organic evolution generally?

Lecture Five
Debates over Mechanism

Scope: Buoyed by Darwin's arguments, the idea of evolution gained ascendancy in Western biology. It offered a plausible explanation for the origin of species and raised a host of new issues for scientific study. By 1875, virtually all biologists in Europe and America adopted an evolutionary view of origins.

Even as biologists accepted the basic theory of evolution, they came to doubt the sufficiency of Darwin's idea that the evolutionary process proceeded through random, inborn variations selected by a competitive struggle for survival. Alternative theories flourished, particularly a revived Lamarckism invoking the inheritance of acquired characteristics, vitalist notions that indwelling life forces pushed the development of species, and the belief that God guided evolution. In addition to addressing scientific problems with Darwinism, these alternative theories diminished the social and religious implications of evolutionary thought.

Outline

I. The theory of organic evolution (i.e., that species descend from prior species) quickly found near universal acceptance among American and European scientists.

A. The first printing of *Origin of Species* sold out on the first day. It was widely discussed and debated—critically at first, but more favorably over time.

B. Within a decade after Darwin and Wallace announced their theory of evolution, the idea that species evolved from other species dominated biological thought in the United States and Britain.

1. Central to this conversion was a conviction that the world is governed by natural law rather than divine caprice, which had been Darwin's principal thrust.

2. Harvard botanist Asa Gray, a devout Christian and early Darwin confidant, worked to smooth the reception of Darwinism in the United States.

3. By 1870, only three prominent American naturalists—Louis Agassiz at Harvard, Arnold Guyot at Princeton, and John Dawson at McGill—still rejected the basic idea that species evolve from other species.

4. Acceptance came somewhat slower in Britain but was essentially complete by 1880. T. H. Huxley wrote to Darwin in 1868: "You will have the rare happiness to see your ideas triumphant during your lifetime."

C. The most prominent holdouts in the scientific community were established proponent's of Cuvier's view of successive creation, not believers in biblical creationism.

1. Agassiz in the United States and Richard Owen in Britain argued that complex organs (such as the eye) and interdependent species (such as flowers and bees) simply could not have evolved by intermediate steps. They must have been designed.

2. Opponents also stressed the gaps and missing links in the fossil record, although they readily accepted a long geologic history and the appearance and disappearance of species over time. Indeed, Agassiz had "discovered" the ice ages.

3. These opponents never called themselves "creationists" or referred to their ideas as "creationism." Agassiz was not religious.

4. Darwin acknowledged the force of these objections, and once described the eye as "an antidote to atheism," but maintained that more research would prove him right.

5. These last holdouts simply died out, Dawson being the last of them when he died in 1899, and were never replaced. Their students all became evolutionists.

II. The theory of evolution raised a host of interesting new questions that quickly came to dominate the research agenda of field naturalists and laboratory biologists.

A. The best scientific evidence for evolution came from highly technical studies of morphological relationships among species.

1. Biologists detected ever more rudimentary organs in species—seemingly useless holdovers from their ancestral forms.
2. They also found structural similarities among supposedly related species that had no functional explanation, such as the hand-like bones of marine mammal flippers.
3. Lunged fish were seen as a link between true fish and land animals.
4. The duck-billed platypus and marsupials were seen as steps toward mammals.
5. Ernst Haeckel postulated the hypothetical *Pithecanthropus* (Greek for "ape-man") as the missing link of humans and apes.

B. Microscopists, particularly in Germany, sought evidence of evolution in the study of animal embryos.
1. Believing in progressive development, Haeckel and his followers postulated that "higher" organisms should exhibit more embryonic development than "lower" ones, with "higher" embryos "recapitulating" past stages of evolution.
2. During the 1870s and 1880s, seeing what they wanted to see in the microscopic world of embryos, Haeckel and others offered highly influential scientific "proof" of evolution in the alleged similarity of embryonic development.
3. Haeckel's views reflected his belief in Lamarckian evolution and were later discredited. Darwinian evolution should not fit the "recapitulation" model.

C. Bio-geographers followed Alfred Russel Wallace in giving an evolutionary interpretation to the geographic distribution of species.
1. The so-called "Wallace line" dividing Asian from Australian species was simply the most distinct of several barriers dividing the earth in biologically distinct regions. Evolution provided a more logical explanation for these divisions than creation did.
2. Naturalists looked for and found an ever-increasing array of intermediate species linking similar types. Just as Wallace had predicted, these similar species typically were found just beyond a barrier to distribution from kindred types.
3. Holdover types, such as giant reptiles, marsupials, and the duck-billed platypus, tended to be found in the most isolated places, such as oceanic islands and Australia.

D. With limited success, paleontologists began filling out the evolutionary tree of life with discoveries from the fossil record. Pointing to these finds, American paleontologist Edward Drinker Cope in 1872 declared evolution an "ascertained fact."

III. Even as the theory of evolution gained acceptance during the 1860s and 1870s, doubts grew as to the sufficiency of natural selection alone to drive the process.

A. Evidence and interpretations mounted against natural selection.
1. As originally conceived by Darwin and Wallace, the natural selection of random variations would lead to evolution, but under the prevailing notions of inheritance, even beneficial variation could not survive in the wild.
2. Estimates from the physical sciences as to the age of the solar system (200 million years) did not give enough time for natural selection alone to produce life as it then existed.
3. Many scientists, including Wallace, denied that the natural selection of random variations could lead to the major jump in intelligence and morality separating humans from other animals.
4. Continued evidence of gaps in the fossil record convinced some scientists that evolution must proceed in spurts and stops that were unexplainable under a theory of natural selection.
5. Even Darwin and Wallace increasingly sought other evolutionary mechanisms to supplement natural selection, though Darwin clung to materialism.

B. Three main alternatives to classical Darwinism emerged.
1. Neo-Lamarckian evolution relied on the inheritance of acquired characteristics modified through use and disuse to account for the speed and direction of evolutionary development. Darwin increasingly appealed to this approach.
2. Orthogenesis attributed evolution to internal forces within living things that pushed them to develop in fixed directions.
3. Theistic evolution saw God as a source and guide of variations along lines beneficial to species.

C. These alternatives potentially fit the scientific evidence for the occurrence of evolution without all the religious and philosophical consequences of natural selection. Theistic evolution and orthogenesis were particularly compatible with a spiritual view.

D. By 1900, natural selection had been so discredited that few scientists accepted it as the mechanism of evolution. By all accounts, however, they all accepted the so-called "fact" that species evolve.

Essential Reading:

Bowler, *Evolution*, chs. 7–9.

Supplementary Reading:

Bowler, *The Non-Darwinian Revolution*.

Larson, *Evolution's Workshop*, ch. 4.

Livingstone, *Darwin's Forgotten Defenders*.

Numbers, *Darwinism Comes to America*, chs. 1–2.

Questions to Consider:

1. What scientific and philosophical factors led to the rapid and widespread acceptance of the "fact" of evolution following the publication of Darwin's *Origin of Species* in 1859? Did scientists simply want to believe in evolution or did the evidence compel them to accept it?
2. Why did T. H. Huxley's grandson, the Darwinist biologist Julian Huxley, characterize the period around 1900 with the phrase "the eclipse of Darwinism"?

Lecture Six
Missing Links

Scope: Although by 1900 most Western biologists and intellectuals accepted some theory of evolution, popular and religious opposition remained. Technical arguments that appealed to scientists failed to persuade the public, particularly when it came to the notion that humans evolved from apes. The same fossil record that inspired Lamarck and Darwin increasingly became a barrier to popular acceptance of their ideas. Opponents decried the lack of fossils linking either major biological types (such as reptiles and mammals) or humans to their supposed simian ancestors.

Beginning late in the nineteenth century, those intent on proving the theory of evolution hunted for missing links in the fossil record. Scientific and popular interest focused on finding evidence of prehistoric humans and hominids. Any such "missing links" became front-page news and boosted the popular acceptance of evolution.

Outline

I. Fossils have long been both a principal basis for, and a barrier against, belief in evolution.

A. Georges Cuvier's early work with fossils suggested that species generally remain constant throughout their lives and are replaced quite suddenly by significantly different forms. Ever since, this pattern has been used as evidence against evolution.

B. In arguing for uniformitarianism in geology, Charles Lyell countered that fossils were laid down only intermittently; therefore, discontinuities proved nothing. To Lyell, the progressive order of the fossil record suggested gradual change rather than catastrophes.

C. Building on Lyell's argument, Darwin devoted a chapter in *Origin of Species* to showing that (despite notable gaps) the overall outline of the fossil record supports his theory.

1. The fossil record displays a basic similarity in the succession of forms in a contiguous area. There is also a tendency toward greater variety and complexity.

2. As unguided natural selection would suggest, there was no fixed rate of change. Some organisms endure; others rapidly change; none reappear.

3. Darwin was confident that once naturalists began looking for them, many of the missing links in the fossil record would be found.

D. During the late 1800s, paleontologists culled the fossil record for evidence of evolutionary development.

1. T. H. Huxley posited that the birdlike legs of some dinosaurs linked birds to reptiles.

2. The discovery during the 1870s of the fossil remains of a feathered reptile called *Archaeopteryx* further linked birds and reptiles.

3. During the 1880s, O. C. Marsh uncovered a complete series of fossils tracing the modern broad-hoofed horse back to a small multiple-toed ancestor.

4. Although such finds satisfied most paleontologists that species evolve, major gaps remained in the fossil record. Anti-evolutionists dismissed the intermediate species as separate creations and pointed to the remaining gap as evidence against evolution.

5. Especially problematic were: (1) the absence of fossils in Precambrian rocks (which suggested that life abruptly appeared at the beginning of the Cambrian era) and (2) the lack of fossils connecting humans to apes.

E. To the extent that some scientists and many non-scientists continued to reject the theory of evolution in the 1890s, their opposition focused on the issue of human evolution. The absence of hominid fossils became a stumbling block to popular acceptance of evolution.

II. Darwin and other evolutionists never claimed that humans descended from apes. Rather, they believed that modern humans and modern apes had a common ancestor.

A. As if to emphasize their differences, Cuvier had placed humans and apes into distinct orders based on differences in their hand and brain structures. Asserting that Cuvier had exaggerated these differences, Huxley now argued that humans and apes belonged in the same order.

B. Huxley offered Neanderthal skulls, first found in Germany in 1856, as a possible ape-like hominid but ultimately acknowledged that, with a cranial capacity equal to that of a human, the Neanderthal could not come from a species linking humans with smaller brained ancestors.

C. As late as the 1850s, Lyell cited the absence of ancient human fossils to support man's recent creation. In his 1863 book, *The Antiquity of Man*, he drew on new archaeological evidence to greatly push back the supposed first appearance of humans.

D. Accumulating archaeological evidence pointed to a long history of human cultural development, which such evolutionists as Huxley and Ernst Haeckel saw as evidence for the biological evolution of human races. Haeckel's views reflected his belief in an extreme racist variant of Lamarckism that later influenced Nazi thought.

III. Dutch physician Eugene Dubois set out to "prove" evolution by finding fossil evidence of the missing link between apes and humans.

A. Born in 1858 in the conservative Catholic southeastern provinces of the Netherlands, Dubois consciously rejected religious superstition for scientific truth.

1. A brilliant and driven boy, Dubois sought to advance science and discredit religion.

2. He accepted a materialist form of Lamarckian evolution through reading Haeckel and Huxley, studied medicine in Amsterdam, and became a teacher there.

3. Following Haeckel, Dubois conducted morphological studies of the larynx, looking for physical evidence of human evolution in the origins of speech, but he became bored with the study. He wanted to find more dramatic proof of human evolution.

B. In 1887, Dubois abandoned a promising academic career and, with his young family in tow, became an army physician in the Dutch East Indies.

1. Although Darwin and Huxley proposed that humans evolved in Africa, Dubois convinced himself that it happened in the East Indian islands then ruled by the Netherlands. He aimed to find hominid fossils among the orangutans there.

2. Unable to obtain funding for his project, Dubois became an army physician and devoted all of his free time to searching caves and river valleys for fossils.

3. In 1892, after five years of searching on two islands, native workers digging under Dubois's directions in a canyon on Java uncovered the skullcap, thigh bone, and teeth of a hominid that Dubois named *Pithecanthropus* in honor of Haeckel.

C. Popularly known as "Java Man," *Pithecanthropus* was sensational but controversial.

1. Its distinguishing characteristics were an intermediate-sized brain case and an upright posture. This fit Darwin's prediction that an upright posture (which freed the hands for carrying and using tools), rather than a big brain, led to human evolution.

2. After initial interest, paleontologists generally dismissed Dubois's claims of the great age and ape-like character of his fossils. Back in the Netherlands, Dubois became reclusive and refused to show the fossils to critics.

3. Preferring to see brain development as the cause of human evolution, paleontologists embraced the 1912 fossil discovery of a big-brained hominid in Piltdown, England. Until discredited in 1953, "Piltdown Man" confused the story of human evolution.

IV. Beginning in the 1920s and increasingly in the last half of the twentieth century, fossil evidence of human evolution captured the popular imagination.

A. At first, these fossils came from South Africa.

1. In 1925, Raymond Dart identified the fossil remains of an earlier human ancestor, which he named *Australopithecus africanus*. Much older and smaller brained that Java Man, it walked upright and had humanlike teeth.

2. In 1936, Dart's disciple Robert Broom found more *Australopithecus* fossils, but apparently of a later type, *A. robustus*. These finds fit the linear pattern of human evolution typically associated with Lamarckism.

B. Beginning in 1929, more fossils like those from Java were found in China, with the group later reclassified as *Homo erectus*, an early human type.

C. Beginning in the 1950s, East Africa became the primary source of early hominid fossils.
   1. The Leakey family and Donald Johanson, leading well-funded research teams, uncovered fossils of various overlapping *Australopithecus* species, some older and some younger than the ones from South Africa.
   2. In 1961, Mary Leakey found fossil evidence of an older species of humans, *Homo habilis*, that lived among later types of *Australopithicus* in East Africa up to 1.8 million years ago. *H. habilis* used tools and had a human-sized brain.
   3. A branching pattern of hominid evolution took shape in accord with Darwinism.
   4. During the 1990s, paleontologists found fossils they assigned to two new hominid genuses, *Ardipithecus* and *Orronrin*. Estimated at up to 6 million years old, these individuals had small brains but erect posture.

D. The evolutionary tree for humans is now as complete as for any type of animals, and it fits a Darwinian pattern. Upright posture came first, presumably because it had survival value in a changing environment, then bigger brains and tool use.

E. New finds of hominid fossils still generate front-page news around the world. As Dubois predicted, these fossils now serve as the most well known evidence for evolution.

Essential Reading:

Bowler, *Evolution*, chs. 7–8.

Supplementary Reading:

Dart, *Adventures with the Missing Link*.

Eddy and Johanson, *Blueprints*, ch. 18.

Larson, *Summer for the Gods*, ch. 1.

Shipman, *Man Who Found the Missing Link*.

Questions to Consider:

1. How could nineteenth-century scientists draw such differing conclusions about evolution from the same fossil evidence?

2. Why has there been such widespread public interest in fossil evidence for human evolution?

Lecture Seven
Genetics Enters the Picture

Scope: Evolutionists were mired in doubts and disagreement at the dawn of the twentieth century. Biologists still believed that evolution happened, but there was no consensus among them on how it operated. All the options seemed inadequate, especially classical Darwinism. As often happens in science, answers came from an unexpected source.

Looking for evidence of sustainable evolutionary development though gross inborn mutations, rather than the minute variations posited by Darwin, two separate biologists simultaneously rediscovered the thirty-five-year-old work of Gregor Mendel. Mendelian genetics suggested ways for subtle inborn variations to sustain long-term evolutionary change. Laboratory studies in genetics pushed naturalists' fieldwork from center stage in evolutionary research.

Outline

I. By 1900, divisions among evolutionists over how evolution operated seemed irreconcilable.

A. Classic Darwinism, which envisioned the natural selection of minute, random, inborn variations of an essentially continuous nature, was widely dismissed as leading nowhere.

1. Under a continuous view of hereditary variations, as then prevailed, the characteristics of an offspring would be a blending of those of its parents.

2. Even if an individual with a beneficial variation was more likely to survive, it would likely breed with a "normal" individual, and their offspring would regress toward the species norm. Over time, continuous variations would be "swamped."

B. Lamarckism, the principal alternative, encountered increasing objections.

1. Variations are acquired during life. If the reproductive seed is drawn from across the body (via "pangenesis"), as most scientists (including Darwin) then believed, that seed could transmit those acquired characteristics.

2. Despite the plausibility of Lamarckism, proponents failed to produce experimental evidence that acquired characteristics could be inherited, while opponents, such as German cell biologist August Weismann, marshaled opposing evidence.

3. Rejecting pangenesis for the theory of an immutable germplasm transmitting hereditary information, Weismann argued that only inborn traits could be passed on. Stripped of all Lamarckian taints, this was the birth of neo-Darwinism.

4. Lamarckism survived as a scientific theory into the mid-twentieth century, particularly in the Soviet Union, but gradually lost influence in the West.

C. Around 1900, Dutch botanist Hugo De Vries offered mutation theory as a possible compromise explanation for the evolution of new species.

1. Mutation theory accepted Weismann's position that only inborn traits are inherited.

2. To overcome the concern that inborn variations would be swamped, De Vries postulated that mutations could be significant, discontinuous, and widespread enough to form abruptly a breeding population of a new variety or species.

3. De Vries saw natural selection operating to preserve beneficial mutations.

4. Although interest soon passed as scientists failed to find beneficial mutations, De Vries's idea called attention to the propagation and preservation of discontinuous variations. This laid the ground for rediscovering Mendel's work.

II. Mendelian genetics would provide the basis for reviving Darwinian theories of evolution.

A. During the 1860s, Gregor Mendel (an Austrian monk with an interest in natural history) experimented with the idea of new species as hybrids of old ones. He tested this by crossing distinctly different varieties of pea plants.

1. Rather than producing intermediate varieties, his crosses produced a remarkably regular re-emergence of the parent types.

2. When tall and short pea plants were crossed, the next generation was tall (not mid-sized as predicted by blended inheritance), but in the third generation, three-fourths were tall and one-fourth was short. The same discontinuous pattern appeared for other crosses.
3. Because Mendel's work was mathematical, dealt with discontinuous variations, and involved hybrids, it was largely ignored for thirty-five years.
4. As long as scientists studied apparently continuous variations, they did not see Mendel's pattern. When De Vries and other scientists accepted discontinuous variations, they rediscovered Mendel's work.

B. Although Mendel's laws were initially associated with major discontinuous variations (or mutations), rather than small continuous ones, their critical significance for salvaging Darwinism ultimately became clear.
1. The mutation theorists who rediscovered Mendel's laws explained them by positing the existence of two "genes" for each trait, with one gene from each parent. The dominant gene would be expressed; the recessive gene would lie dormant.
2. For example, when a pea plant with two tall genes was crossed with one with two short genes, each member of the next generation would be tall (if tall was dominant), but each would carry a short gene that could be transmitted to the third generation.
3. This physical process fit recent microscopic observations of meiosis, in which egg and sperm cells were formed with only half the chromosomes of a normal cell and then were brought together in a fertilized egg cell having the normal number.
4. There would be no blending of characteristics under Mendelian genetics. Beneficial variations would survive without any danger of being swamped.
5. Further, even recessive traits would not be lost permanently. They could reappear in a later generation and be propagated through selection if they were then beneficial.

C. Mutation theorists extrapolated this process to genetic mutations. They postulated that mutations would not be lost through continuous blending and could spread through a population if they were beneficial for survival.
1. In 1910, while studying fruit flies, American genetics pioneer Thomas Hunt Morgan became the first to observe a spontaneous mutation and watch it spread through a breeding population in a Mendelian fashion.
2. His research team later found that mutations could be induced by exposure to radiation and chemicals, suggesting a source for accelerated mutation.
3. With time, geneticists grew to appreciate that this natural process for propagating beneficial gross mutations could also propagate minor variations.
4. Morgan and other Mendelians initially saw mutation alone (without selection) as the source of new species, with natural selection acting only within the normal range of genetic variations in an existing species.

D. Although Mendelian geneticists at first operated in isolation from Darwinian naturalists, their ideas would come together in the neo-Darwinian synthesis of the 1930s.

Essential Reading:

Bowler, *Evolution*, ch. 9.

Supplementary Reading:

Allen, *Life Sciences in the Twentieth Century*, ch. 3.

Eddy and Johanson, *Blueprints*, chs. 5–8.

Mendel, *Experiments on Plant Hybridization*.

Questions to Consider:

1. Why was Mendelian genetics ignored in 1865? Why was it so quickly appreciated after its rediscovery in 1900? What does this change suggest about the nature of scientific discovery?
2. How did Mendelian genetics solve the problem of swamping and, thereby, pave the way for the revival of Darwinian theories of evolution? How did Mendelian genetics undermine Lamarckian theories of evolution?

Lecture Eight
Social Darwinism and Eugenics

Scope: Evolutionary thinking in biology spilled over into social thought. Even before Darwin published his theory in 1859, Herbert Spencer promoted the idea of a survival-of-the-fittest process driving social progress. With the rise of Darwinian biology, such thinking gained credence under the banner of "social Darwinism." Theories about how humans evolved increasingly influenced ideas of how people should live. Competition appeared beneficial.

Coupled with a rudimentary appreciation of genetics, social Darwinism fostered the eugenics movement, a social crusade advocating more children from genetically "fit" parents and fewer children from genetically "unfit" ones. Proponents typically equated fitness with intelligence, but they often favored physical strength, health, and beauty, as well. Some of their methods were voluntary, but many nations and most American states enacted at least some compulsory eugenic laws before the movement was discredited by Nazi practices during World War II.

Outline

I. Coined by its critics, the term "social Darwinism" gained currency during the Victorian era as a catch-all phrase to identify various utilitarian philosophies and policies that attributed human progress to unfettered competition among individuals.

- **A.** Valuing competition fit the spirit of the day. It predated Darwinian biology.
  - **1.** In the late 1700s, Adam Smith argued that economic progress depended on individual initiative. His faith in the natural harmony of human interactions gave him hope that all people would benefit from laissez-faire capitalism.
  - **2.** Embracing the idea of laissez faire, by 1800, Thomas Malthus noted that because of natural limits in resources, any social competition would have losers as well as winners. He saw that a "struggle for existence" fostered the general good by weeding out the weak.
  - **3.** Malthus's thinking inspired Darwin to conceive of natural selection as the engine of biological evolution, but he did not publish his views until 1858.
  - **4.** Beginning in the early 1850s, English philosopher Herbert Spencer popularized a Malthusian view of individual and group competition. He hailed the "survival of the fittest" as the only sure foundation for human progress.
  - **5.** With the advent of Darwinism in biology, Spencer's views of social development became known as social Darwinism even though Darwin did not fully endorse them.
- **B.** Social Darwinism encouraged laissez-faire capitalism and discouraged helping the "weak" in an era of widespread industrialization and urbanization.
  - **1.** Spencer maintained that government should never interfere in domestic economic or social affairs. Business regulation slowed progress, he said, while public health and welfare programs simply harmed people in the long run.
  - **2.** Under the banner of "root, hog or die," Yale economist W. G. Sumner argued that nature eliminates inefficiency and that any interference would backfire.
  - **3.** Such Gilded Age industrialists as Andrew Carnegie, John D. Rockefeller, and James J. Hill publicly justified their business practices in social Darwinist terms.
  - **4.** Opponents of public health and welfare programs drew on social Darwinist thinking in shaping American and European public policy throughout the late 1800s.
  - **5.** Biological Darwinists did not necessarily accept social Darwinism (with some, such as Alfred Russel Wallace, arguing that humans could guide their own evolution), but social Darwinists did use biological Darwinism to justify their views.

II. For many late nineteenth-century Europeans and Americans, the most important area of competition was between races and among nations. Social Darwinism was invoked to justify Western imperialism, colonialism, militarism, and scientific racism.

- **A.** Racism predated Darwinism, but biological evolution appeared to justify it.

1. Lamarckism posited a hierarchical view of progressive development, with more "civilized" races seen as more biologically advanced.
2. Despite Darwin's view of evolution as branching rather than linear, most nineteenth-century Darwinists saw a single line of human development, with Northern Europeans having evolved the farthest because of conditions in the locations they lived.
3. Both of these views inevitably blurred notions of cultural and biological evolution.
4. Darwin and Spencer believed that racial struggle contributed to human evolution by "superior" races replacing "inferior" ones where they mixed. Darwin subtitled his 1859 book "*or the Preservation of Favored Races in the Struggle for Life*."
5. At the time, such views justified European colonization of Asia and Africa. They led many European-Americans to believe that Indians and Negroes would die out in the United States.

B. For some, social Darwinism called for militaristic competition among nations.
1. Beginning in the late 1800s, Germany's leading Darwinian biologist, Ernst Haeckel, argued that nations and races advance through competition. An ardent nationalist, he advocated a strong, united Germany to dominate the world.
2. Haeckel's social Darwinism contributed to German militarism leading up to the First World War. Germany's defeat in that war embittered Haeckel and his followers.
3. Convinced of the biological superiority of the German people, some of Haeckel's followers contributed to the rise of Nazism and its policies of racial purity.

III. Combined with Mendelian genetics, social Darwinism led to the eugenics movement.

A. Shortly after Darwin published *Origin of Species*, his cousin, Francis Galton, conceived of applying its teachings to human development.
1. As in other species, Galton argued, fit humans produce fit offspring and unfit humans produce unfit offspring. As a thinking species, humans can use this understanding to accelerate the evolutionary process through selective breeding.
2. Galton defended his theory with surveys purportedly showing that ability and success ran in some families while inability and failure ran in others. He linked intelligence, beauty, and health with ability; ignorance, ugliness, and sickness with inability.
3. In 1883, Galton coined the term "eugenics" to designate polices and programs designed to encourage more children from the fit and fewer from the unfit.

B. Eugenics attracted widespread interest after the 1900 rediscovery of Mendelian genetics.
1. Genetics appeared to offer a physical basis for Galton's theories. Many experts saw such traits as mental illness and retardation, epilepsy, and criminality as the products of easily eliminated simple hereditary factors.
2. At a time when science was held in high esteem, eugenics offered a scientific methodology for the social sciences. Nature all but replaced nurture in social scientific thought. The intelligence quotient (IQ) was invented as an objective measure of intelligence.
3. Sociologists conducted public health surveys and compiled family pedigrees showing a hereditary basis for crime, poverty, anti-social behavior, and low IQ.
4. Although eugenics never gained broad popular support, many scientific, professional, and philanthropic organizations promoted its acceptance. These efforts influenced public policies throughout the United States and Europe.

C. "Positive eugenics" sought more children from the fit.
1. Winston Churchill, Theodore Roosevelt, and other prominent politicians openly worried that the professional classes were not reproducing in sufficient numbers. Progressive sociologist Edward A. Ross called it "race suicide."
2. Educational efforts taught students the importance of eugenic mate selection and the civic duty of having children. Pre-existing anti-miscegenation law was revived.
3. Eugenic societies held "fitter family" and "eugenic baby" contests.
4. Eugenic fitness was proposed as a prerequisite for marriage and adopted as a policy by some liberal Protestant churches. Some countries adopted tax and employment policies to encourage able citizens to have children.

D. "Negative eugenics" sought fewer children from the unfit.

1. Every American state and most Western countries adopted polices of sexually segregating certain supposedly dysgenic classes, typically the mentally retarded.
2. Thirty-five American states and many European countries instituted compulsory programs of sexual sterilization for the mentally ill and retarded, habitual criminals, or epileptics. Germany's program was later extended to include Jews.
3. During the period from 1900 to 1960, some 60,000 Americans were sterilized under compulsory state programs. Such programs were upheld as constitutional by the U.S. Supreme Court in 1927.
4. Partly on eugenic grounds, Congress curtailed immigration by non-Nordic stock.
5. Nazi Germany moved from eugenic sterilization to euthanasia. German geneticists actively supported racial purity programs. Biologists joined the Nazi Party at a higher rate than any other professional group.

E. Except for the Catholic Church, opposition to eugenics was disorganized and ineffective until the late 1930s, when Nazi practices discredited all such efforts.
1. Beginning in the 1930s, social scientists increasingly looked to environmental causes of human behavior. Nurture replaced nature in social scientific thought.
2. More slowly, geneticists recognized the complexity of human heredity. Simple eugenic remedies were abandoned as ways to deal with multi-factorial traits.
3. By the end of World War II, social Darwinism appeared morally bankrupt.

Essential Reading:

Bowler, *Evolution*, ch. 10.

Supplementary Reading:

Hofstadter, *Social Darwinism in American Thought*.

Kevles, *In the Name of Eugenics*.

Larson, *Sex, Race and Science*.

Paul, *Controlling Human Heredity*.

Questions to Consider:

1. Is it fair to blame Charles Darwin for social Darwinism? How much did biological Darwinism contribute to racism, imperialism, colonialism, and militarism?
2. Why did early twentieth-century public policy makers so readily accept radical scientific solutions (including eugenic sterilization) for traditional social problems (such as crime)? Did this reflect undue faith in science?

Lecture Nine
America's Anti-Evolution Crusade

Scope: Decades of popular concern over the theory of evolution erupted during the 1920s into a crusade by conservative American Protestants against teaching evolution in public schools. The crusade was part of their larger effort to defend traditional beliefs and values against liberalism in the church and secularism in society. Crusaders met immediate opposition from religious liberals and a broad array of secularists. The battle was joined over the theory of evolution because both sides viewed it as central to religious liberalism and scientific secularism.

The battle reached its public climax in 1925, when Tennessee's new law against teaching evolution was challenged by a schoolteacher named John Scopes. The nation watched as Christian politician William Jennings Bryan and agnostic lawyer Clarence Darrow dueled over the anti-evolution law in court. They helped make the issue into a flashpoint for public controversy.

Outline

I. Conservative Christians had never liked the Darwinian theory of human evolution. Their long-simmering concern boiled over during the 1920s into a crusade against teaching it in public schools.

- **A.** Several factors contributed to the timing of America's anti-evolution crusade.
  - **1.** Protestant fundamentalism had increased in reaction to religious liberalism in the major mainline Protestant denominations. Conservatives saw an evolutionary view of religion at the heart of the liberal heresy.
  - **2.** Darwinism was being revived in evolutionary science because of greater understanding of genetics.
  - **3.** Compulsory high school education was becoming commonplace; evolutionary teaching reached more students and families.
  - **4.** Evolutionary thinking was associated in the public mind with German militarism, laissez-faire capitalism, and eugenics.
  - **5.** The 1920s were a period of heightened social stress as reform and reaction competed for America's future. The Jazz Age battled with the "return to normalcy."
- **B.** Around 1920, several fundamentalist leaders began targeting the theory of evolution for public condemnation.
  - **1.** Leading the attacks were three Baptist ministers, William Bell Riley of Minneapolis, John Roach Straton of New York City, and J. Frank Norris of Dallas. Institutional centers of anti-evolutionism were the World's Christian Fundamentals Association, Chicago's Moody Bible Institute, and the Bible Institute of Los Angeles.
  - **2.** Mainline Protestant denominations became embroiled in bitter doctrinal disputes over teaching evolution in church colleges and from the pulpit. Conservatives demanded orthodoxy with respect to the special creation of humans in God's image.
  - **3.** Conservative Protestant denominations and independent Bible churches and schools reemphasized a literalistic interpretation of Genesis as foundational.
- **C.** Religious liberals fought back in defense of modern science and an evolutionary view of religious understanding.
  - **1.** Leading the defense were University of Chicago theologian Shailer Mathews and New York Baptist/Presbyterian minister Harry Emerson Fosdick. Most of the mainline Protestant denominations ultimately sided with the liberals.
  - **2.** Leading scientists and political figures with religious affiliations, such as Henry Fairfield Osborn, Robert Millikan, and Herbert Hoover, denounced anti-evolutionism.

II. In 1922, William Jennings Bryan transformed this religious dispute into a political battle.

- **A.** At age sixty-two, Bryan was a living legend.
  - **1.** He had been nominated for president by the Democratic Party at age thirty-six, the youngest presidential nominee of any major political party, and re-nominated twice more. The Populist Party also nominated him for president once.

2. Following his defeats, he remained in the public eye as a speaker and writer for progressive political causes and served as Woodrow Wilson's secretary of state until he resigned that post in protest of Wilson's drift toward entry in World War I.
3. His progressive politics and anti-militarism always had a moralistic religious tint, which became more pronounced over time. By the 1920s, he had become a leader of fundamentalist forces in the Presbyterian church.

B. In 1921, Bryan heard of an attempt by Kentucky Baptists to politicize the anti-evolution movement by seeking legislation to outlaw the teaching of Darwinism in public schools.
1. As a political progressive, Bryan welcomed legislative solutions to social problems.
2. As a conservative Protestant, Bryan deplored Darwinism as corrosive of religion.
3. As a left-leaning politician, he opposed social Darwinism, eugenics, militarism, imperialism, and laissez-faire capitalism.
4. As a rural populist from Nebraska, he was suspicious of elite institutions, such as science, and believed that the people had a right to control public education.
5. In 1922, he went to Kentucky in support of the Baptist measure to outlaw the teaching of evolution, then carried his crusade for such laws nationwide.

C. Bryan objected only to teaching the Darwinian theory of human evolution. He viewed the days of creation as symbolic of geological ages and acknowledged that "lower" animals may have evolved.
1. Bryan's concern always focused on people and what a belief in a "brute ancestry" might mean for human morality and religious faith.
2. After several near misses and a few partial victories for Bryan's crusade, in 1925, Tennessee became the first state to outlaw the teaching of human evolution in public schools. It was a misdemeanor subject to a fine of up to $500.
3. The law exceeded Bryan's proposal by covering all theories of human evolution, not just Darwinism, and imposing a criminal penalty. The Tennessee governor still viewed it as a symbolic measure, not an enforceable statute.
4. It gained immediate notoriety, with religious conservatives hailing it and most others scorning it. No one expected that teachers would be prosecuted under it.

III. The initial attention attracted by the new Tennessee statute expanded into a media frenzy when, six weeks after it became law, John Scopes was indicted for violating it.

A. From its bizarre beginnings to its inconclusive outcome, the Scopes trial was never a normal criminal prosecution.
1. Soon after Tennessee enacted its anti-evolution statute, the ACLU offered to defend any Tennessee schoolteacher willing to challenge the law's constitutionality in court.
2. Dayton civic leaders invited local science teacher John Scopes to accept the ACLU offer as a means to publicize their town. Scopes agreed to the scheme even though he was not a biology teacher and had never violated the statute.
3. Scopes's indictment made front-page news around the world. He was never arrested nor threatened with jail and spent much of the time until trial in media appearances.

B. Both sides in the larger controversy saw the pending trial as an opportunity to make their case to the public. It became a show trial for all concerned.
1. America's most famous trial lawyer and religious skeptic, Clarence Darrow, led a team of crack ACLU lawyers to Dayton to defend Scopes. Their stated goal was to debunk religious lawmaking and promote individual freedom.
2. Bryan joined the prosecution in an effort to articulate the case against teaching evolution and defend the right of a popular majority to control public education. He knew that the law (not Scopes) was actually on trial.
3. The media promoted this heavyweight bout as "the trial of the century" before it even began. It was broadcast over the radio, filmed for newsreels, and covered by more than 200 reporters from the United States and Europe.

C. The eight-day trial was largely anticlimactic as each side made its familiar arguments. Neither side disputed that Scopes had violated the law, and the court foreclosed other issues as irrelevant to the case.

1. When the judge refused to strike the statute as unconstitutional, the defense all but asked the jury to convict Scopes so that they could appeal the judge's ruling to a higher court. The jury did so, and Scopes was fined $100.
2. The trial's most memorable event was when Darrow invited Bryan to take the stand as a witness in defense of the anti-evolution statute. Darrow asked questions about biblical literalism that made Bryan and the Genesis account look foolish.
3. Following his conviction, Scopes was offered his job back but instead accepted a scholarship to study geology at the University of Chicago. He became a petroleum engineer in Venezuela and later managed an oil refinery in Louisiana.
4. Bryan died in Dayton less than a week after the trial, but his crusade continued.
5. Scopes's conviction was overturned on appeal, but the anti-evolution statute was upheld as constitutional. Other states and school districts imposed similar measures.

D. The trial left a bitter legacy of deep division over the teaching of evolution in public school. Each side had persuaded its followers of the critical importance of the issue.

Essential Reading:

Larson, *Summer for the Gods*.

Supplementary Reading:

Conkin, *When All the Gods Trembled*.

Numbers, *Darwinism Comes to America*, ch. 4.

Questions to Consider:

1. Why did a massive popular crusade against the teaching of human evolution in public schools erupt in the United States some sixty years after Darwin published his theory? What were the main points of contention?
2. How did a misdemeanor case in a small Tennessee town become America's "trial of the century"? Was all the media and public attention on it justified? What was the trial's lasting impact on the creation-evolution controversy?

Lecture Ten
The Neo-Darwinian Synthesis

Scope: By the 1940s, a consensus emerged among biologists on how the evolutionary process worked. It untied the laboratory research of geneticists and the fieldwork of naturalists to rout notions of acquired characteristics, vital forces, and external design from mainstream biology. Evolution, this synthesis maintained, was a purely materialistic process driven by the natural selection of random variation at the genetic level. In these respects, this so-called "modern," or "neo-Darwinian," synthesis was more fully Darwinian than Darwin's own conclusions.

Although this breakthrough was largely conceptual, it found its classic case in David Lack's 1947 interpretation of the evolutionary development of Darwin's finches on the Galapagos Islands. This famous sub-family of birds, which once inspired Darwin, had remained incomprehensible under selection theory. Lack's interpretation, as later developed by Peter and Rosemary Grant and featured in countless biology textbooks and works of popular science, became the best known example of natural selection at work among living organisms.

Outline

I. During the first quarter of the twentieth century, scientists remained deeply divided over how evolution operated. None of them saw a significant role for natural selection in the process.

- **A.** Field naturalists tended to follow Alfred Russel Wallace in stressing the role of geographical isolation and environmental adaptation in evolution but favored Lamarckian mechanisms as the cause of variation.
- **B.** Paleontologists interpreted the fossil record to show linear evolutionary development over time, as expected under Lamarckism, orthogenesis, or theistic evolution.
- **C.** Geneticists and other laboratory biologists rejected Lamarckism in favor of discontinuous Mendelian mutations feeding evolution with little role for the adaptive value of mutations or the selection of the fittest. This notion worked in laboratories but not in the wild.

II. Aspects of each view merged into a neo-Darwinian synthesis as scientists gained greater understanding of genetic and geographic factors.

- **A.** The first steps toward the neo-Darwinian synthesis were taken during the 1920s, when geneticists began appreciating complexity in the genetics of large populations.
  - **1.** Early Mendelians studied discontinuous single-gene traits (e.g., tall or short pea plants), thinking that single-gene mutations gave birth to new species or varieties. They had ignored the seemingly continuous variability of large populations.
  - **2.** Increasingly, they now recognized that multiple-gene interactions affect any one trait, such that single-gene changes might cause seemingly continuous variations in that trait. N. Nilsson-Ehle calculated that if ten genes affected one trait, then the trait might have 60,000 different variations.
  - **3.** This view dispensed with a blending view of inheritance for continuous variations and, thus, solved the problem that even beneficial variations would be swamped in reproduction. Minor nonfatal variations could survive in a population, and beneficial ones would spread through natural selection.
  - **4.** R. A. Fisher proposed that a large population of any species contains great genetic variability, which allows it to evolve gradually in response to environmental changes. Even harmful genes could survive if recessive and emerge as conditions warranted.
  - **5.** J. B. S. Haldane offered the example of the peppered moth, in which the population evolved in fifty years from mostly light-colored varieties to mostly dark-colored ones as increasing industrial soot in Britain gave selective advantage to darkness.
  - **6.** Genetic mutations circulate in a population even if they confer no benefit, allowing a species to build a fund of variability to be exploited by selection if conditions change. Gene mutations and recombinations add to variability in a population but do not trigger its evolution.

B. Theories about the evolution of large populations did not interest field naturalists, who saw speciation in the wild occurring mostly in small populations isolated on the fringe of larger populations. During the 1920s, geneticist Sewall Wright addressed this issue.

1. Through laboratory experiments with small populations, Wright found that intense inbreeding produced extreme variability in a species.

2. He showed mathematically that inbreeding could drive a small, isolated population to deviate from the parent population. If the deviation proved beneficial in the isolated locale, natural selection could generate rapid evolution.

3. In 1937, Theodosius Dobzhansky applied Wright's theory to wild populations to find that, given the reservoir of variability in a population, natural selection could cause gradual evolution under changed conditions and stability under constant conditions.

4. By the early 1940s, the influential British science writer Julian Huxley brought together these various insights from genetics and evolutionary biology into what he termed the "modern synthesis."

C. Led by Ernst Mayr in 1942, field naturalists agreed that the new genetics could explain the evolution of isolated populations without the need for invoking Lamarckism.

1. They stressed that speciation occurs only through an initial phase of geographic isolation. Without crossbreeding, each population could develop such separate traits that they could or would no longer crossbreed when brought back together.

2. These reproductively isolated variations, sub-species, or related species would have evolved to fit their separate environments in a process called "adaptive radiation."

3. If reunited with kindred types, competition would drive them even further apart.

4. Mayr concluded, "A new species develops if a population which has become geographically isolated from its parental species acquires during this period of isolation characters which promote or guarantee reproductive isolation when the external barriers break down."

5. Seen in this way, a species becomes a range of gene frequencies in a reproductively isolated population, not an ideally created archetype. Evolution occurs whenever the range shifts. It is a purely materialistic chemical process.

D. Led by George Gaylord Simpson in 1944, paleontologists concluded that this neo-Darwinian view of the origin of species did not conflict with the fossil record. Its gaps could be the result of rapid evolution in small populations, which would leave few fossils.

III. Evidence for the neo-Darwinian synthesis was largely theoretical and mathematical. Using the theory to account for large scale "macro-evolution" required extrapolation.

A. The best field evidence for neo-Darwinian evolution in action came in 1947 from David Lack's study of finches on the Galapagos Islands, the same birds that inspired Darwin. These birds differ primarily in the size and shape of their beaks.

1. Before Lack, naturalists were puzzled by the existence of thirteen distinct finch species that appeared to freely mix in a similar environment. Selection theory should allow only the fittest species to survive.

2. Lack propounded that food on various Galapagos Islands differs enough to have favored the evolution of different beaks from the same parental form through a selective process of adaptive radiation.

3. He also found that although different species now mingle on various islands, they do not readily crossbreed. Where similar species inhabit one island, they differ more than normal, suggesting that interspecies competition drives them further apart.

B. Lack's work became the classic case for neo-Darwinian evolution, featured in countless textbooks and documentaries ever since. It remains a case of "micro-evolution," but one involving the evolution of new species and genera.

1. Beginning in 1973 and continuing ever since, field biologists Peter and Rosemary Grant have studied the Galapagos finch population. They have watched average beak shapes and sizes evolve in response to changed conditions.

2. Similar studies of other isolated populations have been found to exhibit a similar pattern of micro-evolution, but the Grants' study remains the most well known.

Essential Reading:

Bowler, *Evolution*, ch. 11.

Supplementary Reading:

Lack, *Darwin's Finches*.

Larson, *Evolution's Workshop*, chs. 6 and 8.

Weiner, *Beak of the Finch*.

Questions to Consider:

1. How did the neo-Darwinian synthesis resolve outstanding questions in evolution theory and lead to the revival of Darwinian mechanisms as the driving force for evolution?
2. Explain why Lack's interpretation of Galapagos finches represents such a classic example of neo-Darwinian evolution in action.

Lecture Eleven
Scientific Creationism

Scope: Commemorating the centennial of Darwin's *On the Origin of Species* in 1959, scientists hailed the triumph of a consensus theory of evolution. They largely ignored the persistent anti-evolutionism that marked conservative Christianity in America and assumed that it would die. If anything, however, the rise of neo-Darwinism heightened tensions between traditional religious beliefs and modern scientific thought. Those tensions underlay the prenominal impact of *The Genesis Flood*, a 1961 book in which Virginia Tech engineering professor Henry Morris argued that scientific evidence supported the biblical account of creation.

Morris's brand of scientific creationism swept through America's conservative Protestant churches during the 1960s and 1970s, reviving belief that God created the universe and all species in the past 10,000 years. Rather than simply opposing evolution theory, believers now offered an alternative view for inclusion in public education. With the rise of the Christian Right in American politics, creationists got their way in many places until 1987, when the U.S. Supreme Court overturned creationist instruction as violating the separation of church and state.

Outline

I. The centenary of *Origin of Species* in 1959 marked a triumphant moment in evolutionism. Publications and ceremonies hailed Darwin's contribution in shaping the modern world.

- **A.** The neo-Darwinian synthesis had gained near universal acceptance among biologists by 1959, giving the impression that scientists fully understood how evolution worked.
- **B.** Acting to reverse the long-term impact of American's anti-evolution crusade on the content of public science education, in 1959, the federal government began funding high school biology textbooks that emphasized neo-Darwinian evolution.
- **C.** Neo-Darwinists Julian Huxley in Britain and G. G. Simpson in the United States popularized the expansion of the new synthesis into a humanistic worldview.
  - **1.** They saw science as the only source of truth and evolution as an ethical principle. They urged humanity to take hold of the evolutionary process.
  - **2.** For Huxley, evolution was a progressive force generating forms that were ever more able to transcend their environment. Taking this as an ethical goal, he valued the freedom to realize life's potentialities as the greatest good.
  - **3.** Simpson saw evolution producing beings of ever-greater awareness. For him, the goal became knowledge, which humans could use for the general good.

II. Evolutionists ignored societal shifts that by 1959 had closed large segments of the American population to the theory of evolution. Darwinism's public revival triggered a strong and enduring reaction among conservative Christians.

- **A.** Largely invisible to America's cultural elite, theologically conservative strands of American Protestantism steadily increased in size and influence from 1920 to 1960.
  - **1.** Militantly literalistic and Pentecostal Protestant sects existed on the fringes of society before 1920 but grew steadily thereafter. They often had untrained ministers.
  - **2.** As the clergy in America's mainline Protestant denominations became more liberal during the twentieth century, many conservative parishioners moved to denominations committed to biblical inerrancy.
  - **3.** The South, where the conservative Baptist churches dominated society and politics, gained economic, cultural, and political importance in the United States. More people moved South and Southern ways spread nationally.
  - **4.** As churches offering clear scriptural authority or ecstatic emotional experience grew, they developed their own colleges, schools, publishing houses, journals, camps, and evangelistic associations.

5. The secularization of Western society that emptied European churches so sapped the vitality of liberal American Protestantism that it did not counter evangelicalism, fundamentalism, and Pentecostalism. Many scientists left the church.

B. Darwinism remained an anathema to conservative Protestants, but they kept their objections within their own subculture until the 1960s, when the appearance of new federally funded biology textbooks ignited protests by parents and churches.

1. Citing the likes of Huxley and Simpson, conservatives objected to a supposedly atheistic theory being taught as scientific truth in public schools.
2. By the mid-1960s, fundamentalists were again protesting the teaching of evolution in public schools and demanding that "equal time" be given to their views.
3. These protests succeeded in limiting acceptance of the new texts, but recent rulings against religious instruction in public schools barred Bible teaching.

III. Mid-twentieth-century intellectual developments had driven conservative American Protestantism and evolutionary science even further apart than they had been during the 1920s.

A. On the science side, the materialism of neo-Darwinism was less amiable to reconciliation with religion than earlier neo-Lamarckian or theistic theories of evolution. Further, scientists cared less about reconciling science and religion.

B. On the religion side, expansion of conservative churches coupled with erosion of liberal churches had shifted American Protestantism toward biblical literalism. Conservatives showed less interest in reconciling modern science and scriptural interpretation.

C. Conservative Protestant theology on the age of the earth illustrates the rise of biblical literalism.

1. During the 1800s, in response to geologic evidence of past epochs, many evangelical theologians equated the days of creation in Genesis with geologic ages and accepted the idea of an old earth. Bryan still held these views in the 1920s.
2. During the early 1900s, evangelicals often reconciled science and scripture by positing a gap in Genesis to allow for unnumbered geologic ages (and fossils) between the original creation and the recent creation of modern animal life.
3. Before 1960, the leading advocate of a literal reading of the Genesis account was Seventh-Day Adventist science teacher George Price. He argued for a recent six-day creation, with a catastrophic flood shaping the earth's geology.
4. Each succeeding idea split the religious view further from mainstream science.

D. Baptist engineering professor Henry M. Morris revived Price's "flood geology" in 1961 and began spreading it widely. Under the name "scientific creationism," Morris's theory effectively co-opted the creationist banner within two decades.

1. As a young man, Morris became convinced that the entire Bible must be literally true or none of it could be trusted. He went on to study hydraulic engineering to learn how a catastrophic water action could affect the earth.
2. With theologian John Whitcomb, Morris published *The Genesis Flood* in 1961. It presented a scientific argument for creation within a biblical chronology and attributed the fossil record to the layer deposits of a single worldwide flood.
3. Virtually ignored by the scientific community, *The Genesis Flood* gained a wide audience in conservative Protestant circles. Morris followed it with a stream of books, articles, tapes, and lectures promoting his ideas to a variety of church audiences.
4. Since 1972, Morris's Institute for Creation Research (ICR) has widely promoted scientific creationism through books and pamphlets, films, lectures, debates, and research. ICR biology textbooks dominate the Christian school market.
5. During the mid-1970s, ICR prepared creationist textbooks (stripped of any reference to a creator) for the public school market. These texts drew the attention of secular scientists and educators and rekindled public battles over biology education.

IV. The battle over scientific creationism (or "creation science") in public education began with the legal argument that it was as scientific as evolution science and ended with the judicial conclusion that it was simply religious dogma.

A. Morris and his followers freely admitted that teaching creation promotes belief in a creator, but claimed that was the incidental result of teaching scientific evidence supporting the abrupt, non-evolutionary appearance of the universe, life, and species.

1. Teaching evolution also promotes a philosophical worldview, they added, and is not supported by any better scientific evidence than creation is.

2. Assuming this position, both could be given "balanced treatment" in public school biology courses without violating the constitutional bar against religious instruction.

3. This argument had wide appeal. Public opinion surveys found Americans evenly split on the question of origins and strongly in support of teaching both views.

B. Riding the crest of Religious Right political activism in the late 1970s and early 1980s, three states and many school districts adopted "balanced treatment" laws or policies.

1. Science, mainstream religion, and civil liberties groups challenged these laws and policies in court, arguing that they violated the separation of church and state.

2. One by one, each was struck down as unconstitutional, culminating in a 1987 U.S. Supreme Court ruling against Louisiana's Balanced Treatment Act. No law was needed to teach scientific evidence for or against evolution, the Court ruled; therefore, this law must have been passed to promote religion.

3. These rulings ended the teaching of scientific creationism in public schools, but the battle had awakened both sides and re-sensitized school officials to the issue. It fed the Christian academy and home-schooling movements.

Essential Reading:

Numbers, *The Creationists*, chs. 5–15.

Supplementary Reading:

Larson, *Trial and Error*, chs. 5 and 6.

Marsden, *Understanding Fundamentalism and Evangelicalism*.

Toumey, *God's Own Scientists*.

Whitcomb and Morris, *Genesis Flood*.

Questions to Consider:

1. Why did biblical literalism and conservative Protestantism survive and prosper in twentieth-century America? Did this involve a rejection of modern science?

2. Among twentieth-century American fundamentalists, how did belief that the earth was created within the past 10,000 years effectively displace the belief that the earth has passed through long geologic ages?

Lecture Twelve
Selfish Genes and Intelligent Design

Scope: Americans remain divided by the origins debate. Surveys indicate that half of them believe that God specially created the first humans. Most of the rest affirm that God guided evolution. Only about one in ten Americans accept the God-less theory of origins that dominates science. For many in the third camp, including the popular science writer Richard Dawkins, a purely neo-Darwinian struggle for survival among randomly mutating genes replaces purposeful design as the source of life's diversity. Others in this camp, such as paleontologist Stephen Jay Gould, question the adequacy of the neo-Darwinian synthesis to account for evolution—but remain confident that wholly materialistic mechanisms can do so.

Creationists counter that evolution remains "just" a theory and worry about the social and religious consequences of believing it. Alternative ideas (or at least scientific objections to materialism) belong in the classroom, they maintain. Even many Americans who reject scientific creationism agree that an intelligent designer should not automatically be ruled out as the source of life and individual species. In America, the debate over origins remains as intense as ever.

Outline

I. The American debate over organic origins continues at many levels. Evolutionary biologists debate how evolution works; social scientists debate its implications for human nature; the public debates if it works at all.

II. Virtually all academic biologists agree that species evolve from pre-existing species and most acknowledge only materialistic factors in the process. Disagreements are in its details.

- **A.** Failing to see sufficient gradualism in the fossil record to fit a neo-Darwinian pattern, paleontologists Stephen Jay Gould and Niles Eldredge offer a punctuated equilibrium model for evolution.
  - **1.** The fossil record displays long periods of stability or equilibrium for organisms punctuated by their rapid replacement by a related type, not the gradual branching pattern suggested by the individual selection of orthodox Darwinism.
  - **2.** Eldredge and Gould account for this by proposing that small, isolated populations of a species might evolve rapidly through individual selection and, if then better adapted, could rapidly replace the parental type through species selection.
  - **3.** Gould adds that developmental constraints in embryos might channel the course of variations independent of environmental factors, somewhat akin to orthogenesis.
  - **4.** Small genetic changes affecting embryos could open new channels of development akin to mutations, thereby causing sharp breaks and new directions in evolution.
  - **5.** Punctuated equilibrium accounts for the seeming discontinuity of the fossil record in a fundamentally Darwinian and purely materialist framework.
- **B.** The evolution of seemingly altruistic behavior has long been a source of disagreement among Darwinists and a refuge for theists.
  - **1.** Darwin maintained that selection operated at the individual level and struggled to explain why individuals sacrifice themselves for others. Social insects with sterile workers exemplified the problem, but human altruistic behavior (which some attributed to spiritual causes) was the real issue.
  - **2.** Neo-Lamarckian biologists accounted for altruism in terms of acquired instincts that helped groups (of which the individual was part) survive. Darwin ultimately fell back on such forms of neo-Lamarckian group selection.
  - **3.** Theistic evolutionists and others believing in supernaturalism saw God or spiritual forces as a source for such human traits as love, consciousness, and belief in God.
  - **4.** The revival of pure Darwinism in the neo-Darwinian synthesis during the mid-twentieth century rekindled scientific interest in altruistic behavior.
- **C.** As a result of the incorporation of genetics into the neo-Darwinian synthesis, modern Darwinists enjoyed an advantage over Darwin in explaining altruistic behavior. He could reduce selection no lower than the individual level; they could focus on genes.

1. To a Darwinist, individual selection fails to explain altruistic behavior even for social animals. For the survival and reproduction of any individual, self-interest trumps helping others so that self-interest should spread throughout the species.
2. If the gene becomes the focus of selection, then helping others with the same gene can help the gene to survive even at the expense of the individual. In 1964, W. D. Hamilton applied this idea to explain sterile insects helping their fertile sisters.
3. Applied to social insects, gene selection strikes many as a more rational explanation than somehow assuming that God bestowed altruism on insects. Once the approach is accepted for insects, it can be extended to all social animals, including humans.

D. Carrying gene selection to its logical conclusion, Richard Dawkins sees "selfish genes" as the basic units of selection for all evolution.
1. A gene is simply a chemical compound—a purely material substance without a will, soul, or purpose. It mechanically replicates itself, with chance variations randomly occurring in the copying process.
2. Genes survive in organisms, and genes producing reproductively successful traits in those organisms flourish. In a totally mechanistic process, "selfish genes" cause gradual evolution in their host or "robot" organisms. Their survival is our purpose.
3. Critics counter that the organism, not the gene, interacts with its environment. Evolution must involve organisms and environments, not just genes.

III. Continuing controversy surrounds the extension of neo-Darwinian biology to social scientific thought through sociobiology and evolutionary psychology.

A. Harvard naturalist E. O. Wilson pioneered the field during the 1970s based on his lifelong study of social insects, particularly ants.
1. Wilson's 1975 book, *Sociobiology: The New Synthesis*, explores the biological basis of social behaviors concerned with reproduction, as well as survival.
2. In higher animals, for example, Wilson argues that males gain by aggressively spreading their ample sperm while females gain by guarding their scarce eggs.
3. While acknowledging differences between humans and other animals, Wilson applies sociobiological techniques to explain human social behavior in his 1978 book, *On Human Nature*. He deals with human aggression, gender differences, and ethics.
4. Wilson tends to accept what evolution has produced as necessarily good and to warn that humans ignore biologically successful instincts at their peril.
5. Wilson's ideas received a hostile reception from mainstream social scientists, who saw human behavior as conditioned by the social environment rather than by biology.

B. By the 1990s, sociobiologic ideas in the form of evolutionary psychology were being used by a new generation of social scientists to explain an ever wider array of human behaviors, ranging from violence to love.
1. Aggressive behavior in young males, currently so self-destructive, could be held over from mating acts that once benefited in reproduction. Among chimpanzees, for example, the most sexually aggressive male produces the most offspring.
2. Belief in God, purpose, or an afterlife could make people more willing to sacrifice themselves for their kin, thereby preserving their own genes. Biological kin preference could account for racism and genetic nationalism.
3. Critics counter that education and individual choices influence human behavior. Even most sociobiologists concede that, because of their large brains, people enjoy a measure of control over their instincts not shared by other animals.

IV. As evolutionary biological and social scientists debate the merits of various materialistic explanations for the origins of species and behaviors, large segments of the American population reject naturalism as a premise for the discussion.

A. In setting its parameters for biology, the elite National Academy of Sciences asserts that science investigates only materialistic causes. Surveys consistently find that nine out of ten Americans believe in spiritual causes for life.

1. Typically, about 50% of those surveyed say that they believe God created humans in their present form within the past 10,000 years; 40% believe the human body evolved over time with God guiding the process; and 10% opt for purely naturalistic evolution.
2. Surveys of scientists find that most support naturalistic evolution, some accept a role for God in evolution, and almost none accept special creation.
3. This disconnect between scientific and popular opinion over the nature of science lies at the base of America's continuing controversy over creation and evolution.

B. Lost in the polarized conflict between materialistic evolution and special creation are those who accept that species evolve from species but see some role for God in the process. Broadly speaking, this is "theistic evolution."

1. Asa Gray's classic theory of theistic evolution held that God channeled evolution by guiding the process of variation. This intricate theory saw God intimately involved in evolution.
2. No such precise theories of theistic evolution command support today. The term is loosely used to identify anyone who invokes God at any point in organic origins.
3. For example, geneticist Francis Collins, director of the Human Genome Project, calls himself a "theistic evolutionist." He believes that God used the mechanism of evolution to create humans, but that such human traits as altruistic behavior and longing for God were divinely created.
4. Such Darwinists as Alfred Russel Wallace and David Lack also believed that certain human traits, such as love and consciousness, were specially created in evolved hominids to form humans. The Catholic Church accepts this position.

C. Between theistic evolutionists and special creationists are self-identified "progressive creationists." They believe that God intervened at various points in the geologic past to create the basic life forms that then evolved into the various species.

D. Half of all Americans do not accept any significant role for evolution in the generation of different kinds of plants and animals. At most, they accept the so-called micro-evolution of such nearly similar species as Darwin's finches on the Galapagos Islands.

1. For many Christians, Moslems, and other religious believers, God's revealed word in their scriptures is reason enough to believe in special creation.
2. During the 1990s, a loosely organized group of Christian scholars advanced the idea that species are simply too complex to evolve. While eschewing biblical arguments and chronologies, they saw species as the product of "intelligent design."
3. In this group, law professor Phillip Johnson stresses that science should not a priori exclude supernatural causes for natural phenomena. For him, gaps and abrupt appearances in the fossil record are best explained by special creation.
4. Biochemist Michael Behe claims that organic molecules are too irreducibly complex to have evolved through small, random steps. This is similar to the old argument that such organs as the eye are too complex to evolve in a Darwinian fashion.
5. Johnson and Behe have written popular books pushing their challenge to Darwinism. Their arguments join those of scientific creationists in pushing for limits on the teaching of evolution in public schools.

V. Nearly 150 years after the publication of Darwin's theory of evolution by natural selection, it remains central to the scientific and popular debate over organic origins. Scientists generally accept it and push its applications and implications. Many others see it as fatally flawed.

Essential Reading:

Bowler, *Evolution*, ch. 12.

Supplementary Reading:

Dawkins, *The Selfish Gene*.

Behe, *Darwin's Black Box*.

Gould, *Wonderful Life*.

Johnson, *Darwin on Trial*.

Larson, *Trial and Error*, ch. 7.

Questions to Consider:

1. In what way is Dawkin's selfish-gene theory an inevitable consequence of neo-Darwinism? Is sociobiology a logical consequence of Darwinian thinking?
2. What accounts for the continuing appeal of notions of intelligent design in nature? Is this appeal rational, emotional, or both? Is there a scientific basis for it? Is belief in the intelligent design of organisms incompatible with acceptance of the modern neo-Darwinian theory of evolution?

Timeline

1775	German geologist Abraham Werner begins teaching that the earth's features were formed through the gradual retreat of an ancient ocean.
1795	Scottish geologist James Hutton proposes that the earth's features are formed through ongoing processes of mountain uplift and erosion over a long time.
1795	French naturalist Georges Cuvier begins his work in paleontology and comparative anatomy and finds patterns in the extinction, appearance, and relationships of species over time.
1802	The French naturalist Lamarck outlines his theory of organic evolution through the inheritance of acquired characteristics.
1802	British theologian William Paley publishes his popular study of natural theology.
1809	Charles Darwin is born.
1830	English geologist Charles Lyell publishes the first volume of *Principles of Geology*, which posits that current geologic forces acting over long periods of time are sufficient to account for the earth's features.
1831–1835	Darwin serves as naturalist aboard H.M.S. *Beagle*, during which time he accepts Lyell's theory of geology and finds evidence of organic evolution.
1838	Darwin conceives of natural selection as a driving force for organic evolution through his reading of Thomas Malthus's *Essay on Population*.
1844	English writer Robert Chambers publishes his controversial treatise on evolution, *Vestiges of Creation*.
1851	English sociologist Herbert Spencer begins publishing a series of books outlining his theory of human progress through an individualistic struggle for survival.
1858	British naturalist Alfred Russel Wallace independently conceives of natural selection as a driving force for organic evolution and sends his essay on the topic to Darwin. Wallace's essay is published with one by Darwin.
1859	Darwin publishes *Origin of Species,* setting forth his theory of evolution in full.
1865	German zoologist Ernst Haeckel begins his efforts to reconstruct a materialistic history of evolutionary progress from the origin of life to the present.
1865	English scientist Francis Galton first publishes his eugenic theories of guiding human evolution through selective breeding.
1870s	The discovery of fossil evidence for the evolution of species in the past, notably a nearly complete series of ancient horse species and a toothed, feathered animal supposedly linking reptiles to birds.
1871	Darwin publishes *Descent of Man,* extending his materialistic theory of evolution to the development of humans.
1876	Alfred Russel Wallace publishes his treatise on the geographic distribution of species.
1882	German biologist August Weismann publishes *Studies in the Theory of Descent,* arguing that inheritance and variation occur in germplasm, which is fixed at conception.

1892 ..... On the island of Java, Dutch naturalist Eugene Dubois discovers the first known hominid fossils linking humans with other primates.

1900 ..... Dutch botanist Hugo De Vries rediscovers Mendelian genetics and applies it to his mutation theory of evolution.

1910 ..... American geneticist Thomas Hunt Morgan observes spontaneous inborn variations in fruit flies that are then passed on in a Mendelian fashion, suggesting a genetic basis for evolution.

1925 ..... South African paleontologist Raymond Dart discovers fossil remains of an upright-walking early human ancestor, *Australophithecus africanus.*

1925 ..... Tennessee teacher John Scopes is tried and convicted for violating America's first anti-evolution law.

1927 ..... The United States Supreme Court upholds compulsory state programs for the sexual sterilization of persons deemed eugenically unfit.

1937 ..... Ukrainian-born American geneticist Theodosius Dobzhansky publishes *Genetics and the Origin of Species*, which lays the foundation for the modern neo-Darwinian synthesis.

1940s ..... Nazi practices discredit eugenics.

1942 ..... Two major works articulate the modern neo-Darwinian synthesis: Ernst Mayr's *Systematics and the Origin of Species* and Julian Huxley's *Evolution: The Modern Synthesis*.

1947 ..... English ornithologist David Lack publishes *Darwin's Finches*, providing critical field evidence for the modern neo-Darwinian synthesis.

1949 ..... American paleontologist George Gaylord Simpson publishes *The Meaning of Evolution*, which presents Darwinism as a new foundation of morality devoid of transcendental religious values.

1953 ..... British biologist Julian Huxley publishes *Evolution in Action*, which proposes evolutionary humanism as a secular religion.

1959 ..... The centenary of the publication of *Origin of Species* marked by triumphal celebration of Darwinism.

1961 ..... British paleontologist Mary Leakey discovers fossil remains of a 2-million-year-old human species, *Homo habilis*, that lived among non-human hominids.

1961 ..... American engineer Henry M. Morris and theologian John Whitcomb publish *Genesis Flood*, which revives interest among conservative Protestants in scientific arguments for accepting the literal truth of the biblical account of creation.

1972 ..... Paleontologists Stephen Jay Gould and Niles Eldredge propose their punctuated equilibrium model of organic evolution.

1973 ..... Naturalists Peter and Rosemary Grant begin their three-decade study of finches on the Galapagos Islands that becomes the leading field study of evolution in action.

1975 ..... American naturalist E. O. Wilson publishes *Sociobiology*, which offers a basis in evolutionary biology for social behavior.

1976 ..... British science writer Richard Dawkins publishes *The Selfish Gene*, which popularizes the idea of evolution operating at the gene level.

1981	Arkansas and Louisiana enact statutes mandating balanced treatment for scientific creationism in public school biology courses.
1987	The United States Supreme Court strikes down the Louisiana creationism law as an unconstitutional effort to promote religious instruction in public schools.
1991	Law professor Phillip Johnson launches the religiously motivated "intelligent design" critique of organic evolution by publishing *Darwin on Trial*.
1990s	Paleontologists in East Africa uncover fossil evidence for several upright-walking, small-brained hominid species living up to 6 million years ago. A branching hominid family tree is extended into the remote past.

Glossary

Baconian science: a method of doing science, traditionally associated with the writing of philosopher Francis Bacon, that finds scientific knowledge coming through inductive reasoning based on observation and experimentation.

Catastrophism: a nineteenth-century geological theory articulated by Georges Cuvier, Louis Agassiz, and others that saw the earth's history divided into biologically distinct eras separated by worldwide floods or ice ages.

Creationism, scientific (or creation science): a twentieth-century development in conservative Protestant thought that seeks scientific evidence supporting a literal reading of the biblical account of creation in the first chapters of Genesis.

Darwinism: a theory of organic evolution developed by Charles Darwin and others stating that biological species develop from pre-existing species through the natural selection and accumulation of hereditary variations in individual organism.

Eugenics: a theory of applied science, popular during the early twentieth century, that sought to improve the human race by encouraging breeding by supposedly superior individuals and discouraging breeding by supposedly inferior ones.

Evolution, organic: the scientific theory that new species evolve from pre-existing species through gradual change rather than being abruptly created.

Evolutionary psychology: the view that various human emotions and behaviors, such as gender roles and aggression, are influenced by biological factors rooted in the evolutionary past.

Fossil record: the composite record of past life on earth preserved in remnants or traces of organisms, such as skeletons or imprints, embedded in rocks and soil.

Fundamentalism, Protestant: a strand of conservative Protestant Christianity characterized by a belief in the literal truth of the Bible and an eagerness to defend and propagate that truth.

Genesis account of creation: the description of origins set forth in the opening chapters of the Bible, which states that God created the physical universe, all biological kinds, and humans in His own image.

Hominid: a primate of a family of upright-walking, relatively large-brained animals of which modern humans, or *Homo sapiens*, is the only surviving species.

Intelligent design: the belief that only intelligent design, rather than materialist evolution, can account for the irreducible complexity of organic life.

Laissez faire: an economic and social doctrine that believes in human progress through rugged individual effort unfettered by governmental intervention in the economy or charitable welfare programs.

Lamarckism (or Lamarckian evolution): a theory of organic evolution developed by Lamarck and others stating that biological species develop from pre-existing species through the progressive accumulation of inheritable traits acquired in response to environmental conditions and internal developmental forces.

Materialism, scientific: the philosophic theory in modern science holding that physical matter in motion is the only reality, such that everything in the universe (including consciousness, emotions, and belief in God) can be explained by physical laws without invoking spiritual forces.

Mendelian genetics: the theoretical principles of heredity for sexually reproducing organisms first formulated by Gregor Mendel, which states that both parents contribute traits to offspring that do not blend but express themselves according to fixed laws of dominance or recessiveness.

Mutation theory: a theory of organic evolution developed by Hugo De Vries and others stating that biological species develop from pre-existing species through chance inheritable mutations that quickly create a distinct breeding population.

Natural selection: a scientific theory separately derived by Charles Darwin and Alfred Russel Wallace that accounts for organic evolution through the higher reproductive rates of individuals in a species that possess an inheritable variation rendering them better able to survive in their environment.

Natural theology: the belief that the existence and character of the creator is displayed in the creation, such that design in nature proves the existence of God and can provide a basis for theological understanding.

Neo-Darwinian (or modern) synthesis: a theory of evolution that sees a species as an array of similar individuals containing a range of genetic variations that can be acted on by natural selection to generate shifts in gene frequencies such that new species can result, especially in isolated populations or in response to environmental changes.

Neo-Lamarckism: variant theories of organic evolution developed in the late-nineteenth century that typically incorporated Lamarckian concepts of variation (including the inheritance of acquired characteristics) with Darwinian notions of natural selection to explain the development of new biological species from pre-existing ones.

Orthogenesis: a theory of organic evolution developed in the late nineteenth century stating that biological species develop from pre-existing species in a progressive pattern arising from internal developmental forces that operate independent of external factors.

Punctuated equilibrium: a version of Darwinian evolution theory proposed by paleontologists Stephen Jay Gould and Niles Eldredge beginning in the 1970s to account for the abrupt appearance and subsequent stability of species in the fossil record by supposing that new species develop in small isolated populations that then can spread rapidly through species selection.

Selfish genes: a version of neo-Darwinian evolution theory that sees genes (rather than individual organisms) as the basic unit of selection, such that organisms evolve as a means to facilitate the survival of their genes, which can account for seemingly altruistic behavior by individuals on behalf of their kin.

Social Darwinism: a loosely defined term used by critics to ridicule any late-nineteenth-century social and economic policies and practices that assumed human progress came through a competitive survival-of-the-fittest process among individuals, nations, or races.

Sociobiology: the view that Darwinian theories of evolutionary biology, featuring a competitive struggle for survival among individuals and successful reproductive strategies for individuals, provide a basis for understanding societal behavior patterns of individuals, including those of humans.

Theistic evolution: the view that God designed, guides, or intervenes in the evolutionary process to produce some or all species over time.

Uniformitarian geology: the theory that the earth's geologic features are the result of existing natural geologic forces (such as uplift and erosion) operating uniformly over eons of geologic history from the formation of the earth to the present time, without the need for supernatural or dramatically different interventions in the past.

Biographical Notes

Agassiz, Louis (1807–1873). Born in Switzerland, Agassiz first gained international fame for his pioneering study of fish fossils, research that brought the ancient seas back to life through the description of their inhabitants. His later study of glaciation led to the modern understanding of ice ages. Moving to the United States in 1846, Agassiz accepted a professorship at Harvard, where he trained a generation of American naturalists and published a steady stream of popular and scientific books. His 1859 *Essay on Classification* was perhaps the most comprehensive explanation of species ever compiled from a separate creation viewpoint. In it, he argued that because of their innate complexity, species must be fixed within definite limits and unchanging over time. Thereafter, he remained the leading scientific critic of evolution theory.

Bryan, William Jennings (1860–1925). A product of the American Midwest, Bryan was a populist politician and renowned orator. After two terms in Congress, the Democratic Party nominated Bryan for president in 1896, the youngest person ever so nominated by a major political party. His stands for workers' rights, business regulation, and monetary reform earned him the lasting support of many farmers, miners, and factory workers. After a narrow defeat in 1896, the Democratic Party re-nominated him in 1900 and again in 1908, but he lost by ever-wider margins. Serving as Secretary of State from 1913 to 1915, Bryan tried to keep the United States from entering the First World War. Seeing social Darwinism as a source for regressive social, military, and political policies, Bryan lobbied for laws against teaching the Darwinian theory of human evolution in public schools, culminating in the Scopes trial of 1925, in which he served as co-prosecutor.

Cuvier, Georges (1769–1832). French naturalist Georges Cuvier pioneered modern comparative anatomy and paleontology from his posts at the Museum of Natural History in Paris and the College of France. His study of comparative anatomy stressed the functional fit of animals to their environment and led to his classification of all animals into four viable body types. His study of paleontology both established the existence of vast numbers of extinct animals unlike any animals living today and identified fundamental breaks in the fossil record. Combining these views, Cuvier denied the possibility of evolution and postulated instead that the earth underwent a series of catastrophic extinctions, followed by the appearance of new species based on similar basic forms. Backed by impressive research in fossils and anatomy, Cuvier's theories gained a wide following among naturalists during the first half of the nineteenth century.

Darwin, Charles (1809–1882). Born into a wealthy, well-connected British family, Darwin was educated at Edinburgh and Cambridge universities, where he excelled in the study of natural history. From 1831 to 1836, he served as the volunteer naturalist aboard H.M.S. *Beagle* on its voyage around the world. The observations and collections that Darwin made during this trip provided the basis for a lifetime of private scientific research and earned him entry into the British scientific establishment. They also convinced him that species must evolve from other species, a theory that he worked on in secret for more than twenty years following his return to Britain. Finally publishing his complete theory of evolution by natural selection in 1859, Darwin transformed the biological sciences. Living a secluded life at his country home, Darwin continued to defend and extend his theory until his death.

Dobzhansky, Theodosius (1900–1975). Born and educated in the Russian empire, Dobzhansky emigrated to the United States in 1927 to work with the legendary American geneticist Thomas Hunt Morgan, who then led a team of researchers seeking to combine Darwinian evolution with Mendelian genetics. Dobzhansky's 1937 book, *Genetics and the Origin of Species*, was the first substantial synthesis of the two subjects. Utilizing mathematical models and experimental observations, his synthesis explored the evolutionary potential of existing genetic variability in wild populations. Rather than having to wait for random variations to occur, then selecting those that are beneficial, Dobzhansky showed that the inherent variability in the gene pool allows species to evolve rapidly through natural selection in response to environmental changes without the need for any new variations. Dobzhansky's work inspired a generation of geneticists, naturalists, and evolutionary biologists, culminating in the modern neo-Darwinian synthesis of modern biology.

Dubois, Eugene (1858–1940). A religious skeptic from the Catholic-dominated southern provinces of the Netherlands, Dubois devoted his scientific career to proving the theory of evolution. Following Ernst Haeckel, he studied the comparative anatomy of the larynx as a means to explore the evolution of human speech. Frustrated by the slow progress of this research, he resigned his post at the University of Amsterdam in 1887 and moved to the Dutch East Indies to look for fossil evidence of intermediate species in the evolution of humans from apes. The lack

of such evidence at the time stood as a major obstacle to popular acceptance of evolution theory. In 1891 on Java, Dubois succeeding in finding the first hominid fossils ever collected. He called his discovery *Pithecanthropus erectus* in honor of Haeckel's hypothetical ape-man. Like Haeckel, Dubois favored Lamarckian forms of evolution theory. This rendered his theoretic work of little lasting scientific significance, but for decades, *Pithecanthropus* remained the best fossil evidence for human evolution.

Galton, Francis (1822–1911). An independently wealthy gentleman-scientist, Galton gained fame as the "father" of eugenics. Born in Birmingham, England, Galton attended Cambridge University but never graduated from it. Instead, he traveled in Africa and gained entry to the elite Royal Society of London as an ethno-geographer on the basis of his travel writings. Following the publication of *Origin of Species* by his cousin, Charles Darwin, Galton became an ardent supporter of the theory of evolution and made his life's work the applications of its teachings to guiding the evolution of humanity through controlled breeding. He coined the term "eugenics" for this science and developed modern statistical methods to study it. Through his books, articles, and research, he championed the goal of more children from healthy, intelligent, and handsome parents and fewer children from unhealthy, unintelligent, and ugly ones.

Haeckel, Ernst (1834–1891). Born in Prussia and educated at Wurtzburg and Berlin, Haeckel was a political radical who saw Darwin's rejection of design in nature as a weapon to battle the established structure of German society and religion. Integrating Lamarckism with Darwinism, Haeckel saw biological races progressively formed in direct response to environmental factors, then screened by a competitive struggle that allowed only the fittest of them to survive. As a scientist, he studied evolutionary relationships in the embryonic development of species, finding similarities that long stood as important evidence for evolution. Pushing evolution theory back to the origin of life, he speculated about the physical factors that gave birth to life from inorganic compounds. As a philosopher, he was a crusading materialist whose ideological views of race influenced later Nazi thought.

Huxley, Thomas Henry (1825–1895). A prolific British science writer and lecturer, Huxley served during the Victorian era as the chief public promoter of Darwin's theory of organic evolution. The son of a schoolteacher, Huxley attended medical school on scholarship. He secured a surgeon's post on a British navy ship and gained entry into British scientific circles on the basis of the natural history observations and collections that he sent back to England. Following his navy service, he taught at the School of Mines in London, held a series of prominent posts in British scientific organizations, and gained fame as a witty and irreverent public voice for science. When Darwin announced his theory of evolution in 1858, Huxley saw it as the ideal vehicle for promoting materialism in Western science and meritocracy in British society. His efforts in defending the theory of evolution in public debates and popular essays earned him the nickname "Darwin's bulldog." In later life, he became active in efforts to secularize the British educational system and coined the term "agnostic" to describe his own views on religion.

Lamarck, Chevalier de (1744–1829). Born the eleventh son of a French nobleman and soldier, Lamarck's full name was Jean-Baptiste de Monet, Chevalier de Lamarck. After brief service in the French army, Lamarck devoted himself to the study of botany under royal patronage. After the French Revolution of 1789, Lamarck argued for the reorganization of biological studies on systematic, scientific grounds and was named curator of invertebrates at the National Museum of Natural History. Beginning in 1802, he published a series of works accounting for the evolution of new species through the inheritance of acquired characteristics. Although highly novel and widely known, Lamarck's theory did not gain a serious hearing by scientists until after Darwin published his alternative theory of evolution by natural selection in 1859. Thereafter, Lamarckism competed with Darwinism until Darwinism won out in the twentieth century.

Leakey, Mary Douglas (1913–1996). British-born paleontologist who, with her husband, Louis Leakey, set the standard in the hunt for hominid fossils for half a century. Beginning in the 1920s, Louis Leakey established East Africa as the center for hominid fossil discovery. Mary Douglas joined Louis Leakey as a field researcher in 1935 and married him a year later. Together, they pioneered techniques of systematic excavation and meticulous documentation that raised standards in the field. In 1961, Mary Leakey shook the human family tree with her discovery of *Homo habilis*, the earliest known species in the genus *Homo*. First with her husband and later her son, Richard, Mary Leakey contributed to a series of other hominid fossil finds.

Lyell, Charles (1797–1875). A British gentleman-scientist, Lyell revolutionized the study of geology through his three-volume *Principles of Geology*, first published in the early 1830s. Giving up the practice of law to study geology, Lyell expounded the view earlier proposed by Scottish geologist Joseph Hutton that, given enough time, existing geologic forces (such as volcanoes, earthquakes, and erosion) were sufficient to shape all the earth's

features. In doing so, he banished supernatural forces from geology and contributed to the increasingly naturalistic bent of British and American science. Lyell's evolutionary view of geologic history provided an intellectual foundation for Darwin's evolutionary view of biological history. Late in life and rich in scientific honors, Lyell became a critical early supporter of Darwin's theory of evolution.

Mendel, Gregor (1822–1884). An Austrian parochial school science teacher, Mendel discovered the laws of classical genetics. Mendel took an early interest in science and studied it at the University of Vienna in preparation for his planned career as a Catholic priest serving as a church schoolteacher. During the 1860s, in the course of his teaching at Brunn, Mendel conducted a series of breeding experiments with pea plants designed to test the inheritance of discontinuous traits. He found a regular pattern of dominant-recessive inheritance that became the basis for classical genetics. Mendel published his findings in a respected science journal, but their unexpected mathematical regularity led them to be ignored until 1900, by which time biological thinking had caught up with Mendel's experimental findings.

Morris, Henry M. (1918–). As a civil engineer during the 1940s, Morris developed an interest in the orderliness of nature. Already persuaded in the literal truth of the Bible, Morris became convinced that the Genesis accounts of a recent six-day creation and worldwide flood must be true. To study the matter further, he earned a doctorate degree in hydraulics from the University of Minnesota in 1950. For the next twenty-five years, Morris taught at state universities while writing a series of books on "flood geology," or his theory that Noah's flood could account for geologic features and the fossil record. He published the most influential of these books, *Genesis Flood*, with John C. Whitcomb, Jr., in 1961. It became highly popular in fundamentalist circles, reviving belief in a recent six-day creation and inspiring a political movement to secure balanced treatment for Morris's "scientific creationism" along with evolution in public schools. Since the late 1960s, Morris has led various Christian organizations that promote creation research and instruction.

Spencer, Herbert (1820–1903). One of the most controversial and influential English thinkers of the Victorian era, Spencer helped to lay the foundation for evolutionary thought in the social sciences. Beginning in the early 1850s, before Darwin announced the scientific theory of evolution by natural selection, Spencer published a series of influential sociological works attributing human progress to an evolutionary process driven by individualism. Change came through individual effort and could be inherited by the individual's offspring, Spencer maintained, in accord with his Lamarckian vision of evolution. In a bow to Darwinism, he added that competition then selected the fittest to survive and reproduce. Spencer advocated an extreme form of economic and social laissez faire, arguing that governmental and charitable welfare programs weakened society. Rejecting religion, he promoted a unification of all knowledge based on scientifically derived truths.

Wallace, Alfred Russel (1823–1913). A British naturalist and botanical collector, Wallace is best known for having independently deduced the theory of evolution by natural selection. From a working-class family, Wallace taught himself how to identify biological specimens at an early age. A radical thinker in religion and politics, Wallace accepted the idea of evolution as postulated by Lamarck and believed it could be proven by showing the geographic proximity of similar species. With the ulterior motive of studying bio-geography, Wallace set off as a commercial collector of exotic animals in the Amazon valley and Malay Archipelago from 1848 to 1862. In 1858, he conceived of natural selection as the mechanism driving evolution and sent an article outlining his idea to Charles Darwin. The receipt of this article moved Darwin to publish his own thoughts on the topic. Wallace's voluminous later writing centered on bio-geography, socialism, and spiritualism.

Wilson, Edward O. (1929–). Through his study of ants and other social insects, Wilson has shaped the frontiers of evolutionary biology over a fifty-year-long career at Harvard University. As an enormously popular writer, he has effectively communicated these ideas to the public. At the center of his thinking is sociobiology, or the view that evolutionary biology (with its emphasis on individual survival and reproduction) provides a basis for understanding societal behavior patterns in animals. Extrapolating from social insects and other animals to humans, Wilson maintains that some human behaviors, such as aggression and sexuality, are conditioned by our evolutionary development. Even behaviors that appear altruistic can derive from instincts developed through natural selection, he argues, because such behavior on behalf of relatives preserves an individual's genetic representation in the next generation. For Wilson, sociobiology suggests an evolutionary basis for human ethics.

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Supplementary Reading:

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