



**BONE HUNTER** Barnum Brown, when almost ninety, supervised construction of Sinclair Oil's lifesize dinosaur models, shown below being barged down the Hudson River to the 1964 New York World's Fair.

## BROWN, BARNUM (1873–1963) Dinosaur Fossil Collector

**N**amed after the great showman P. T. Barnum, indefatigable dinosaur digger Barnum Brown assembled his own version of “The Greatest Show on Earth”: a parade of giant dinosaur fossils wrenched from the cliffs and arroyos of the American West. Brown’s lasting contribution—hundreds of tons of dinosaur fossils—formed the nucleus of the American Museum of Natural History’s world-famous collection.

During the 1960s, Brown, nearly 90, could still be seen leading visitors around the crammed dinosaur halls, announcing, “Here’s another one of my children,” as he pointed out the bones of a saurian giant. But when he began his career in 1897, the museum had not a single dinosaur.

As a child in Carbondale, Kansas, Brown collected fossils from freshly plowed fields. He attended the University of Kansas, then moved to New York City, where he studied paleontology at Columbia University and began working at the museum while he was still a graduate student.

For his first field assignment, the museum’s director, Henry Fairfield Osborn, sent Brown to Como Bluff, Wyoming, to prospect its rich Jurassic deposits. Brown and his colleagues discovered new beds containing enormous quantities of fossils, including the *Apatosaurus* (then called *Brontosaurus*) that still dominates one of the museum’s huge dinosaur halls. However, Yale paleontologist Othniel C. Marsh was furious about his former sites being worked and began a bitter feud with Osborn that lasted to the end of his life.

During the early years of the 20th century, Brown dug up fossils all over the West. One of his greatest discoveries, the first ever and a nearly complete skeleton of *Tyrannosaurus rex*, was blasted out of tons of sandstone near Hell Creek, Montana, in 1902. The fossils were then hauled by horse-drawn wagon to the nearest railroad 130 miles away.

As his exploits became known, Brown became nationally famous as “Mr. Bones.” Crowds would meet his train and offer to help him find ancient monsters near their town. Now a celebrity, Brown dressed in expensive, fashionable outfits while exploring remote, dust-blown sites.

In 1909, Brown led an expedition along the Red Deer River in Alberta, Canada. The party navigated downriver on a large raft and found fossil deposits galore. “Box after box,” he wrote, “was added to the collection till scarcely a cubit’s space remained unoccupied on board our fossil ark.”

Over the next decades, he searched for fossils and prospected for oil in India, South America, Ethiopia, and the Greek islands. Brown’s second wife, Lilian, chronicled her adventures accompanying him on field trips in such books as *Bring 'Em Back Petrified* (1956) and *I Married a Dinosaur* (1950). When she first decided to join her bone-hunting husband in the field, the family maid expressed grave concern. “After all,” she warned, “who knows what the beasts died of?”

One of Brown’s most famous discoveries was the “great dinosaur graveyard” at the Howe Ranch, near the base of the Bighorn Mountains in Montana. After some preliminary work





BARNUM BROWN (left) with the reconstructed giant crocodile he named *Pseudosuchus sinclairii*, after his sponsor, oil magnate Harry Sinclair. Beside it is a modern croc skull.

in 1933, he convinced the Sinclair Oil Company to put up the money for major excavations at the site. The team's efforts soon paid off when they uncovered a vast bone deposit—in Brown's words, "a veritable herd of dinosaurs." More than 4,000 bones (about 20 dinosaurs) packed in 144 crates weighing 69,000 pounds were shipped to New York.

Sinclair Oil, which used a "brontosaurus" as its company logo, garnered a windfall of publicity from the public's interest in Brown's digs. During the 1930s and 1940s, the company gave free dinosaur stamps and booklets at its service stations, a promotion created and supervised by "Mr. Bones" himself.

In addition to being the world's greatest fossil hunter and a well-paid consultant to the oil industry, Brown had a clandestine career as a spy for the government—a story that was suppressed until 40 years after his death. He worked for the Office of Strategic Services, precursor of the CIA, which relied on his intelligence about the Aegean Islands as background for planning Allied invasion routes during World War II. During the 1940s, in between fossil-hunting expeditions, he assisted the Bureau of Economic Warfare.

In 1956, when he was 83, Brown explored a site at Lewiston, Montana, where he discovered and excavated a plesiosaur skeleton. Two years later he used a helicopter to prospect the Isle of Wight, where fossils abounded in the steep sea cliffs. After spotting skeletons from the air, he planned to strap himself into a bosun's chair and excavate while dangling above the English Channel.

While planning this expedition, he was approached by his old sponsor, the Sinclair Refining Company, to supervise the construction of life-size dinosaur models for the 1964 New York World's Fair. They were to be built in the town of Hudson, north of New York City, and transported to the fair via the Hudson River. Delighted at being offered a "new job" at the age of 89, Brown looked forward to startling Manhattanites with the bizarre sight of a bargeful of dinosaurs floating down the Hudson River.

Brown supervised the dinosaurs' construction but never did witness their journey to the fair. He died in February 1963, just a week short of his 90th birthday, and was buried beside his first wife, Marion. When Lilian died some years later, according to his daughter's memoirs, she "was buried on the other side of Barnum, who undoubtedly would have had a good chuckle over being sandwiched between his two wives."

See also BIRD, ROLAND T.; FANTASIA; OSBORN, HENRY FAIRFIELD; SINCLAIR DINOSAUR

**Crowds would meet the train when "Mr. Bones" arrived in dusty Western towns to help them round up their ancient monsters.**

## BRYAN, WILLIAM JENNINGS (1860–1925)

### Antievolutionist Crusader

During his lifetime, politician and great orator William Jennings Bryan won fame as a progressive reformer with a strong social conscience. Secretary of state under Woodrow Wilson, he had been the Democratic nominee for president three times. Bryan campaigned vigorously for women's suffrage, justice for the working poor, and curbs on corporate greed. He was also the architect of legislation prohibiting teaching evolution in the schools, thus leaving a legacy of continuing legal battles 60 years after his death.

Bryan has been vilified as an ignoramus and a demagogue who pandered to uneducated bigots in the backwaters of the United States. Movies and plays have portrayed him flailing and ranting as Clarence Darrow's adversary in the celebrated Scopes "Monkey Trial" of 1925, which was not his finest hour. Journalist H. L. Mencken depicted him as a religious fanatic, obstructing intellectual progress with a mulishly stubborn belief in the literal interpretation of the Bible.

In fact, Bryan had not always opposed evolutionary ideas, and had arrived at his reactionary position with the best of intentions for America's welfare. Convinced that the Darwinian theory, as many at the time understood it, was "a merciless law by which the strong crowd out and kill off the weak," Bryan preferred to believe "that love rather than hatred is the law of development." He also thought that "class pride and the power of wealth" were using Darwinism to justify exploiting the poor, just as European kings had once used the doctrine of Divine Right.

And his fears were justified. Industrial giants like John D. Rockefeller and Andrew Carnegie did indeed adopt Social Darwinist views about being "the fittest," their ruthlessness justified as part of a great law of nature. That this was a misreading of evolutionary theory occurred neither to Bryan nor the industrialists, since it was also taught by many biology professors of their day.

In addition, the Darwinian banner was being carried by militarists and, in Bryan's words, "was at the basis of that damnable doctrine that might makes right that had spread over Germany." He knew that during World War I, German intellectuals believed natural selection was irresistibly all-powerful (*Allmacht*), a law of nature impelling them to bloody struggle for domination. Their political and military textbooks promoted Darwin's theories as the "scientific" basis of a quest for world conquest, with the full backing of German scientists and professors of biology.

Bryan also perceived another evil resulting from the interpretation of Darwinism by the intellectuals of his day: an ill-conceived faith in eugenics as the wave of the future. It would paralyze the hope of social reform, Bryan realized, as "its only program for man is scientific breeding, a system under which a few supposedly superior intellects, self-appointed, would direct the mating and the movements of the mass of mankind—an impossible system!"

For these compelling reasons, as Stephen Jay Gould pointed out in *Bully for Brontosaurus* (1992), Bryan saw Darwinism as a many-faceted evil, quite apart from its conflict with biblical accounts of creation. Science had too easily lent respectability to political and social programs that went far beyond its proper sphere. Bryan "had the wrong solution," Gould wrote, "but he had correctly identified a problem!"

See also BUTLER ACT; *INHERIT THE WIND*; SCOPES TRIAL

**"Taxpayers have a right to say what shall be taught. . . . The hand that writes the check rules the school."**

—William Jennings Bryan

FLAG-DRAPED RELIGION was William Jennings Bryan's specialty. He was known as "The Great Populist" for his advocacy of overdue social reforms.



## BUFFON, GEORGES-LOUIS LECLERC, COMTE DE (1707–1788)

### French Naturalist

The orangutan, wrote the Comte de Buffon in the mid-18th century, "is a very singular brute, which man cannot look upon, without contemplating himself, and being convinced that his external form is not the most essential part of his nature."

## CLEVER HANS PHENOMENON

### Mystery of the “Talking” Horse

**E**volution of the capacity for thought and speech has long fascinated anthropologists, but recent “ape language” experiments sparked heated controversy. Can Koko the gorilla really communicate in sign language? Why did Nim Chimpsky’s longtime trainer decide he never really “spoke”? In these debates, scientists often cite the case of a famous “talking” horse who lived during the 1920s. His name was Clever Hans.

Billed as the smartest animal in history, Clever Hans could read, spell, do arithmetic, and work out musical harmonies. His trainer, Herr von Osten, posed mathematical and verbal questions, and the horse, with amazing accuracy, tapped out answers with his hooves.

Herr von Osten really believed in Hans. He swore he did not cheat by giving Hans the answers, and his sincerity was believable. To prove his point, he let strangers question the horse, and Hans still gave correct answers. Audiences were fascinated, and scientists baffled, until the mystery was unraveled by a psychologist named Oskar Pfungst.

In a series of systematic experiments, Pfungst rearranged elements of the question-and-answer proceedings. He soon discovered that if the human didn’t know the answer to the question, the horse was also stumped. But when he searched for deliberate sound or hand signals by the trainer, he found none. Yet he also determined that the horse was baffled when the questioner was hidden from view. Eventually, Pfungst concluded that the animal responded to very minute cues the questioner wasn’t even aware he was giving.

Hans performed best with men who began the session by leaning forward slightly in tense expectation, and then relaxed with barely perceptible movements when the horse had completed the correct number of taps—at which point Hans would stop. He was simply responding to human approval, not to the content of the questions.

Many of the “ape language” programs of the 1970s were greeted with initial enthusiasm but have since been shown to be tainted by the Clever Hans phenomenon. Involuntary human shaping of the animal’s responses proved to be a major flaw and embarrassment. Experimenters now strive to eliminate human cues, however unintentional. When ape language researchers work with bonobos in the Language Research Center at Georgia State University, for instance, the scientists wear welders’ masks to hide their eyes and facial movements. The “talking horse” of long ago is still telling us something.

See also APE LANGUAGE CONTROVERSY



A HORSE CALLED HANS astounded European audiences during the 1920s with his apparent ability to read, spell, and perform arithmetic calculations.

Biblical and anti-Christian, but utterly unscientific and impossible as well. But it has served effectively as the pseudoscientific basis of atheism, agnosticism, socialism, fascism, and numerous other false and dangerous philosophies over the past century.”

In 1981, Henry Morris obtained approval from the state of California for a graduate school run by his Institute for Creation Research, which offers degrees in science education, geology, astrophysics, geophysics, and biology—all from a creationist point of view. By 1986 he was able to move the school from the campus of Christian Heritage College in El Cajon, California, to its own campus. In its first catalogue, the institute’s philosophy of scientific creationism is spelled out:

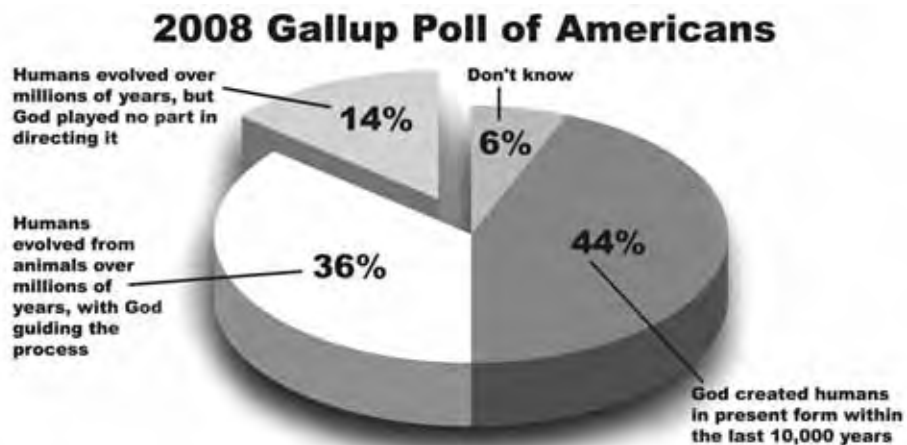
Each of the major kinds of plants and animals was created functionally complete from the beginning and did not evolve from some other organism. . . . The first human beings did not evolve from an animal ancestry, but were specially created in fully human form from the start.

See also FUNDAMENTALISM

## CREATIONISM, AMERICAN POLL ON Consistent Split in National Beliefs

Only about a third of Americans believe that Darwinian evolution is well supported by the evidence.

According to a 2008 Gallup poll, Americans are divided between those who believe that God instantaneously created humans in their present form less than 10,000 years ago (44%), those who favor an evolutionary process guided by God (36%), and those who believe evolution has occurred without any divine intervention (14%). Public opinion is almost equally divided between those who believe that human evolution is well supported by evidence and those who accept the biblical account of creation as literal and infallible. Since 1982, when the Gallup organization began surveying Americans on human origins, these percentages have remained remarkably stable, varying little from year to year. Among Western nations, the United States consistently ranks among the lowest in public support for the evolutionary paradigm of mainstream science.



## A CREATIONIST MUSEUM Evangelical Darwin-Free Dinosaurs

Ken Ham, a Christian evangelist with a passion for dinosaurs, raised \$27 million to build a lavish “biblically-based science museum” in Petersburg, Kentucky, 20 miles from Cincinnati. His Creation Museum, as it is now called, attracted about a half-million visitors within a year of its 2007 opening.

As director of the organization Answers in Genesis, Ham contends that every main-

stream science museum, zoo, and national park in America is brainwashing children with “evolutionist propaganda.” According to his website, secular science is based on a misplaced “faith in human reason,” while “creation science” is “based on the only Eyewitness’s revelation, as recorded in His own words.”

Ham previously worked at the Institute for Creation Research, which founded a Museum of Creation and Earth History in Santee, California, during the 1980s. That museum is now dwarfed by the Kentucky museum, which includes a mile and a half of outdoor trails on its 47 acres and 70,000 square feet of indoor exhibitions. Ham has expanded on many of the smaller museum’s concepts and themes, including the Six Days of Creation, Noah’s Ark, the Tower of Babel, and Flood Geology.

The Creation Museum promotes unquestioning acceptance of the Bible’s account of human origins (as interpreted by their ministry) as an antidote to “fallible human reason.” Visitors are taught that God made the Earth and all its plants and animals in six days, and that major geological features were subsequently shaped by a Great Flood. Evolution is a fallacy and delusion; humans were created in their present form by divine fiat 6,000 years ago. A typical museum label reads: “*Velociraptor*. Means ‘swift hunter.’ Height: 4 feet. Length: 11 feet. Created on: Day 6.”

A Hollywood theme park designer from Universal Studios was hired to build a section of Noah’s Ark and life-size dioramas that dramatize biblical scenes. In the museum’s Garden of Eden, dinosaurs are depicted living peaceably alongside Adam and Eve. Lions, tigers, and tyrannosaurs are shown as gentle vegetarians that never ate meat until humankind’s sins brought violence into the world.

While Ham’s ministry rejects almost every tenet of mainstream biology and geology, it embraces scientific evidence for the existence of dinosaurs. Dinosaurs have never previously appeared in Christian biblical imagery, probably because of their association with evolution. However, the Creation Museum’s exhibits teach that Noah’s ark had enough room for 16,000 “kinds” (not species) of animals, and that dinosaurs were indeed aboard. “Genesis says that the ark had two of every kind of creature that walked on the earth,” according to a museum spokesman, “so we’re taking the dinosaurs back from the evolutionists.”

See also CREATIONISM; FUNDAMENTALISM; INTELLIGENT DESIGN; NOAH’S FLOOD; “NOAH’S RAVENS”

## CREATIVE EVOLUTION

### Vitalist Principle

French philosopher Henri Bergson had a rich literary style, clothing his arguments in emotionally affecting language. His influential book *Creative Evolution* (1907) was a treatise on evolution that purported to refute Darwinism on the basis of Bergson’s intuitive feeling for a self-organizing principle he called the *élan vital*.

Scientists complained they had no way to work if Bergson denied them the possibility of finding causal explanations. Paleontologist George Gaylord Simpson argued in *The Evolution of Meaning* (1949):

Such theories do not explain evolution, but claim it is inexplicable and then give a name to its inexplicability: *élan vital*, omega, aristogenesis, cellular consciousness, holism. . . . As Huxley has remarked, ascribing evolution to an *élan vital* no more explained the history of life than would ascribing its motion to an *élan locomotif* explain the operations of a steam engine.



ANIMATRONIC DINOSAUR with cartoony spikes on its back greets visitors near the entrance to the evangelical Creation Museum in Petersburg, Kentucky.



DARWIN COLLEGE at Cambridge, England, founded in 1964 (left). This building, originally a granary, was later the home of Charles Darwin's son George, an astronomer and mathematician.

GROUCHO MARX takes over as dean of "Huxley College" (right) in the comedy *Horse Feathers* (1932). The school's football rival was "Darwin College," which at the time was equally fictitious.

Its first building was the "Old Granary," which had been converted into a private residence years before by Professor George Darwin, the distinguished astronomer and son of Charles. After his death, it was donated to the university by the Darwin family as the nucleus of the new college.

About 40 years before its actual founding, a fictional "Darwin College" was featured in the classic Marx Brothers comedy *Horse Feathers* (1932). The film's plot revolves around a football game between two rival schools: "Darwin College" and "Huxley College."

## DARWIN CORRESPONDENCE PROJECT

### Organizing Fifteen Thousand Letters

**D**arwin could not throw anything away. An inveterate collector of beetles and natural history objects since childhood, he also saved thousands of letters he received over the years. In addition, his family and friends kept nearly every scrap he wrote to them. As he developed his theories, he exchanged letters and requests for information with naturalists, travelers, and missionaries in every part of the world. About 15,000 letters to and from Darwin have become the core of one of the most ambitious scholarly projects ever undertaken.

In 1974, the American historian Frederick Burkhardt invited the Cambridge zoologist and literary scholar Sydney Smith to help with the immense task of gathering and organizing the thousands of letters for publication. A former president of Bennington College and president emeritus of the American Council of Learned Societies, Burkhardt gathered a team of scholars to preserve the correspondence and make it accessible to future generations.

The Darwin Correspondence Project has undertaken to retrieve, catalog, transcribe, annotate and publish both sides of the entire correspondence, of which about half were written by Darwin. It is located both at Cambridge University Library, England, its headquarters, and at the American Philosophical Society in Philadelphia. The late psychologist and Abraham Lincoln scholar C. A. Tripp contributed to the Project a program for immediately locating any word or phrase in Darwin's collected works and letters. In addition to their value as a history of Darwin's scientific work and as a snapshot of the time and culture in which he lived, many of the letters reveal the naturalist's humanity and sense of humor. Flashes of his wit are evident in his remark that a boring lecturer was "so very learned that his wisdom has left no room for his sense."

In the 1870s, the newly invented telephone became a fad among the well-to-do, and many rushed to have one installed. To our everlasting benefit, Charles Darwin refused to allow one in his home and continued writing and receiving letters to the end of his life.

**About 15,000 letters to and from Darwin have become the core of one of the most ambitious scholarly projects ever undertaken.**

## DINOSAURS, FEATHERED

### Are Birds Evolved Dinosaurs?

**W**hy do a chicken's feet resemble those of a bipedal dinosaur: trident-like toes, hind claw, and scales? The answer, supported by many recent discoveries in northeastern China, is that birds and dinosaurs are close cousins. Indeed, paleontologists have concluded that birds evolved from a diverse group of carnivorous running dinosaurs.

Some similarities have been obvious for many years. The first dinosaur remains found in America were neither skulls nor skeletons, but four-toed footprints preserved in stone, known as the "tracks of Noah's ravens." These petrified imprints were thought to represent similarities between bird's feet and those of some lizards. Famed 19th-century evolutionist Thomas Henry Huxley carefully compared the skeletons of birds and dinosaurs and concluded that the two groups were indeed closely related. Few followed up on Huxley's insight, but more than a century and a half later his views have been vindicated, to say the least. Birds are now thought to belong to a clade called Maniraptora, a branch of the theropod dinosaurs.

Until recently, the oldest known bird was a creature called *Archaeopteryx* ("ancient wing"), the 150-million-year-old fossil found in a Bavarian limestone quarry in 1861. While its wings sported fully developed feathers, *Archaeopteryx* also had a lizardlike jaw filled with teeth rather than a beak.

For years, birds were defined by their feathers, as well as by breastbones and wish-bones—and, often, winged flight. Some paleontologists thought that feathers must have appeared along with wings, but the question became: How could wings have evolved in the first place? After all, what good is half a wing? (See EXAPTATION.) Some experts thought that *Archaeopteryx* appeared too late in the fossil record to have been a founding avian.

In 1996 and '98, Chinese paleontologist Ji Qiang of the Chinese Academy of Geological Sciences published two previously unknown species of "feathered dinosaurs," *Sinosauropteryx* and *Caudipteryx*. The fossils Ji unearthed in Liaoning Province were surrounded by fine volcanic ash that had settled in an ancient lake, allowing detailed preservation of their downy plumage. They are about 130 million years old, younger than *Archaeopteryx*.

These dromaeosaurs, as they are called, represent a lineage of small, meat-eating, fast-running theropod dinosaurs, related to velociraptors, that had begun to develop feathers long before their descendants evolved the power of flight. Feathers may have been useful in regulating the animals' body heat. Stumpy arms, the precursors of wings, may have helped the creatures balance when running. Some dinosaur fossils have tested positive for beta keratin, the main protein in bird feathers.

During the 1990s and early 2000s, the fossil-rich Yixian Formation has yielded fifteen genera (different groups) of dinosaurs with preserved fossil feathers. Other birdlike dinosaurs and dinosaurlike birds have been found in Madagascar, Mongolia, Patagonia, and Spain. Many types of theropods may have had feathers, not just those that are especially similar to birds.

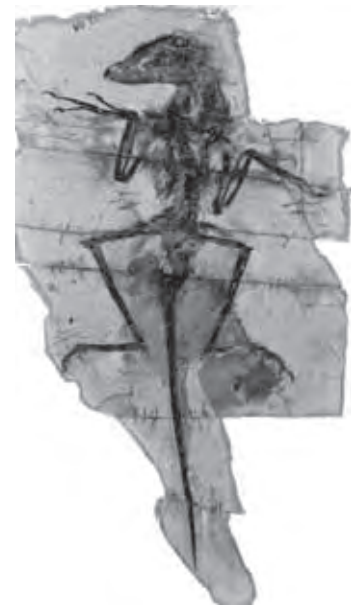
Thousands of specimens have been found in China recently, ranging from the size of pigeons to that of ponies, and with plumage ranging from fluff to feathers. In addition to all the fossils, in 2008 the bird-dinosaur link was given an unexpected boost. Molecular biologist Chris Organ of Harvard and colleagues compared collagen proteins from a 68-million-year-old *Tyrannosaurus rex* leg bone with those of living animals. The result: dinosaur proteins turned out to be most similar to those of ostriches and chickens, not lizards or alligators. The *Washington Post* headlined an account of the story: T. REX CLOSER TO GIZZARDS THAN LIZARDS.

See also *ARCHAEOPTERYX; CHINA, EVOLUTION IN; "NOAH'S RAVENS"*

## DIVERGENCE, PRINCIPLE OF

### "Keystone" of Darwin's Theory

**E**volution is often pictured as a family tree or branching bush, bristling with divergent forks. Each lineage repeatedly splits and differentiates, and lines splay out, in Alfred Russel Wallace's image from his Sarawak paper (1855), "like the twigs of a gnarled oak or the vascular system of the human body." Some of the early evolutionists, such as Ernst



THE FOSSIL OF A YOUNG FEATHERED DINOSAUR, *Microaptor zhaoianus*, was discovered in 1998 in China's Liaoning Province. About two feet long, it lived about 130 million years ago. Reconstruction courtesy of and © by Mick Ellison.



## EXTINCTION

### Destruction of Species

The history of the past few hundred years includes the extinctions of hundreds of species of plants and animals. Among them, quite a few—including the great auk, dodo, and passenger pigeon—were exterminated by humans who just didn't care. American bison were pulled back from the brink of extinction when only a few hundred were left alive, out of a population that had numbered 40 million. Between 1870 and 1875, buffalo hunters were slaughtering 2.5 million of them annually.

Extinction has always been a fact of life. According to ecologists Paul and Anne Ehrlich in their book *Extinction* (1981), 98 percent of all species that have ever lived have become extinct. There are probably about 10 million species alive on the Earth today, one million species in the Amazon basin alone, of which only 1.5 million have been discovered and given scientific names. Many are now disappearing before they are even discovered, particularly in the tropical rain forests.

Until the late 18th century, naturalists did not imagine that extinction was possible. Each species was believed to be a distinct idea in the mind of God, a link in an unbroken cosmic chain that allowed no gaps. When fossils of strange animals, like mastodons, were discovered, it was assumed that there must be some still living in the vast wilderness areas that had not yet been explored.

As more and more fossils were found (the first dinosaur teeth were discovered only in 1825) and more wilderness settled, the evidence of extinct creatures began literally to pile up. Late in his career, the eminent French anatomist Georges Cuvier had to admit that fossil bones were the remains of extinct species.

Paleontologists have documented several mass extinctions, which wiped out the majority of life on Earth, allowing new forms to radiate and develop. One such "mass dying" occurred after the Cambrian period, eliminating the once-numerous trilobites. Another took place at the end of the Permian period, eliminating most living things on the Earth. Still another was the famous and much-pondered Cretaceous extinction, which ended the 150-million-year reign of dinosaurs as the dominant form of life and ushered in the Age of Mammals.

Human activity, with its destruction of habitats as well as hunting, has been devastating, precipitating what has been called the sixth mass extinction. Although we have yet to see a new species evolve in nature—a very slow process—we often see them end, which can happen very quickly. As British naturalist Sir Peter Scott put it, speaking at a 1972 conference on breeding endangered species, "Living species today, let us remember, are the end products of twenty million centuries of evolution; absolutely nothing can be done when the species has finally gone, when the last pair has died out."

See also DINOSAURS, EXTINCTION OF; FULLER, ERROL; GREAT DYINGS; LONESOME GEORGE; RAIN FOREST CRISIS



IVORY-BILLED WOODPECKER,  
extinct since 1950



THYLACINE (TASMANIAN WOLF),  
extinct since 1936



YANGTSE RIVER DOLPHIN,  
extinct since 2007



QUAGGA,  
extinct since 1885

they have become important economic resources in Rwanda, Central African Republic, and Democratic Republic of Congo, attracting tourist dollars. Their celebrity status insures government measures for their continued protection, as they are much more valuable to the local economy alive than as hunting trophies. Yet they survive under problematic conditions: Constant exposure to humans may irrevocably disturb their normal behavior. Science's understanding of "natural" gorilla behavior, ecology and evolutionary adaptations may still forever be lost, even if the apes themselves are given a reprieve from extinction.

See also APES; "APE-WOMEN," LEAKEY'S; GARNER, RICHARD LYNCH; DIGIT; FOSSEY, DIAN

## GOULD, STEPHEN JAY (1942–2002)

### Paleontologist, Essayist, Science Historian

When five-year-old Stephen Jay Gould first laid eyes on the towering *Tyrannosaurus* skeleton in the American Museum of Natural History, he decided to spend his life studying fossils. The tyrant lizard, he later recalled, followed him home and into his nightmares. Decades before dinosaurs became a staple of American childhood, and almost alone among his peers in Queens, New York, young Gould never considered any other career but paleontology.

For most of his professional life, Gould was a professor at Harvard University and a curator of its Museum of Comparative Zoology. He had attended Antioch College, and studied paleontology at Columbia University. His thesis focused on variation and evolution in an obscure Bermudian land snail. Like Darwin with his barnacles, Gould pursued his later theorizing only after intense scrutiny of a single group of organisms.

He had hoped to find correlations between variation and different ecologies within the mollusk's range, but the snails' sizes, colors, and shell shapes varied quite independently of local environment. Impressed with the importance of nonselectionist factors in evolution, Gould became interested in structural constraints and limitations as organisms change.

Gould also became interested in distinguishing incidental features from adaptive ones. He and geneticist Richard Lewontin published an influential paper about "spandrels"—angular wall spaces on structural supports for medieval cathedral domes. Often these surfaces are decorated with paintings that have interested art historians. But when analyzing these paintings, they ignored the spandrel's humble origin as an unavoidable consequence of stress distribution—a structural byproduct of the dome's construction.

In their paper, Gould and Lewontin explain how slight changes in one feature can alter others without reference to adaptation—what Darwin had called "correlation of parts." Using spandrels as a metaphor, they pointed out that the human chin—often cited as "advanced" in comparisons with the chinless primates—holds no special correlation with higher intelligence. Chins, like spandrels, are the result of stress and growth factors in the human jawbone.

Gould's fellow graduate student at Columbia, Niles Eldredge, had studied thousands of trilobites that revealed a pattern that had impressed Thomas Henry Huxley a century earlier: The fossil record shows long periods of stability, punctuated by "bursts" of speciation. Darwin's explanation for this seeming absence of gradual transitions was that the fossil record was then too fragmentary and incompletely known to provide evidence of steady rates of change. It was like a book with pages and even whole chapters missing.

Looking at a much more complete fossil record more than a century later, Gould and Eldredge thought it was time to acknowledge that such episodic patterns in the rocks, separated by long periods of stability, probably reflect the reality of life's history. By the 1980s, "punctationalism" had become widely adopted and was fruitful in generating new insights and research.

Darwin was one of Gould's lifelong heroes, whose achievements he celebrated in such books as *Ever Since Darwin* (1977) and *The Panda's Thumb* (1980). Nevertheless, he was irreverent toward the orthodox Synthetic Theory of evolution that has prevailed in biology since the 1940s. Dissatisfied with

TWO PRODUCTS OF EVOLUTION contemplate one another. Stephen Jay Gould and a giraffe in Kenya, 1990.

Photo © Delta Willis.



the limits of its explanatory power, he often championed other possible mechanisms and approaches to supplement traditional natural selection—to the dismay of more conservative colleagues.

One of his approaches was to emphasize the hierarchy of levels on which evolution operates: biochemical, genetic, embryological, physiological, individual, societal, species, lineages. Sorting or selection on any of these levels, he believed, produces significant effects on the level above or below it—a largely unexplored area for future research.

He also believed that heterochrony—evolution that speeds up or retards stages in the individual's life cycle—was an important force in generating new species. A new species could result, for instance, if the adults remained stuck at an early stage of their development, which could be programmed by regulatory genes. The classic example of such “neoteny” is the axolotl—a salamander that retains its infant gills into adulthood and never leaves the water. Another possible example is that adult humans seem to preserve the characteristics of juvenile apes, such as a flattened face and greatly reduced eyebrow ridges, a condition known as pedomorphism.

Gould did not shrink from public controversy. He appeared before congressional committees on environmental issues, was a courtroom witness in the Arkansas *Scopes II* trial about teaching evolution in the public schools, and spoke out against pseudoscientific racism and biological determinism.

His fatal bout with cancer at the age of 60 cut off a brilliant intellect in its prime of productivity. During his last years, Gould raced to produce his magnum opus, *The Structure of Evolutionary Theory*, in which he defined his views over the whole range of evolutionary thought. He likened its intellectual edifice to a Spanish cathedral that had changed and evolved over the centuries, adding sections that were in tune with the fashions and temper of the times. The core structure of the cathedral remained in place, however much its extensions and facades might vary or become obsolete over the years. Gould viewed Darwinian evolutionary theory as sound, even as it changes and itself evolves.

See also BARNACLES; BIOLOGICAL DETERMINISM; CONTINGENT HISTORY; NEOTONY; PANDA'S THUMB; PUNCTUATED EQUILIBRIUM; SCOPES II

## GRADUALISM

### Slow and Steady Change

One key feature of Darwin's original theory was that evolutionary change must have proceeded by “slow, insensible degrees”—a progression of tiny changes adding up to produce new species over immense periods of time. It was Darwin's attempt to apply Sir Charles Lyell's uniformitarian geology to the world of life.

Lyell had been a voice of reason at a time when geologists invoked imagined violent and sudden catastrophes, convulsions, floods, and supernatural forces to explain the features of the Earth. Presently observable processes of wind, water, volcanoes, erosion, and deposition, Lyell thought, could account for them all.

Darwin went so far as to adopt “Nature makes no leaps” as an axiom, or basic assumption. But from the first his friend and supporter, Thomas Henry Huxley, thought it “unnecessary to burden the theory” with an unproven gradualism, which he later described as an “embarrassment” when he noticed that some patterns of fossils over time showed little change, and then relatively rapid replacement.

When critics asked why the fossil record, though it showed change over time, did not demonstrate this smooth succession of small, gradual transitions, Darwin replied that it was very “imperfectly” known and that subsequent discoveries would fill in the picture. In fact, many transitional forms have since come to light, though they are still comparatively rare.

By the 1970s, the concept of Darwinian gradualism came under increasing attack by biologists. Apparent discontinuities, or “jumpiness,” in the fossil record led to theories of “punctuated equilibrium” and intense scrutiny of Cambrian and pre-Cambrian fauna, since the basic body plans or phyla first appeared and proliferated during that time.

See also “HOPEFUL MONSTERS”; PUNCTUATED EQUILIBRIUM; UNIFORMITARIANISM



HANGING OUT WITH DARWIN, Stephen Jay Gould strikes a casual pose at Down House, now the Darwin Museum.

Photo © Delta Willis.

Top: A computer portrait of Gould by Pat Linse.

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Christian from Crete; an Armenian; a Methodist from the wilds of Arkansas; a Buddhist from China; a Brahman from Benares. Finally, a Salvation Army Colonel from Wapping.

[When I checked on the experiment after a couple of days] the cage of Higher Animals was all right, but in the other there was but a chaos of gory odds and ends of turbans and fezzes and plaids and bones and flesh—not a specimen left alive. These Reasoning Animals had disagreed on a theological detail and carried the matter to a Higher Court.

See also BARNUM, PHINEAS T.; TWAIN, MARK

## HAWAIIAN RADIATION

### Diversity from Isolation

If Charles Darwin had explored the Hawaiian Islands (rather than the Galápagos, which so impressed him) he would have seen much more striking examples of diversity among closely related species. Evolutionists after him have found in these volcanic islands, long isolated from the major continents, an extraordinary natural laboratory of adaptive radiation.

Most famous are the 23 remaining species of finchlike birds known as Hawaiian honeycreepers and the more than 500 different fruit flies that have evolved, diverging from island to island and adapted to different habitats or foods on the same islands.

During the several million years since their ancestors reached the islands, some honeycreepers evolved into seedeaters with heavy beaks; others developed straight, thin beaks for spearing insects; while still others diverged into parrot-beaked species and delicate nectar-feeders with long curving bills and tubular tongues for probing flowers. More than half of the original 47 honeycreeper species have become extinct during the past 1,500 years, since the advent of humans and imported predators. (Some were wiped out by the original Polynesian settlers and others only during the past few hundred years by Europeans.)

Under the former conditions of isolation, fruit flies (with their very short reproductive cycle) radiated far beyond the honeycreepers. Among the hundreds of species, some have become specialized for feeding on nectar or sugar; others eat decaying leaves; some are parasites on spider eggs; and some live only in a single valley on one island. They show a spectacular diversity in their body shapes, but even among those that appear pretty much the same (even to other fruit flies), they can be told apart by their sounds and behavior.

Hawaiian fruit fly populations have evolved scores of different courtship behaviors by which to recognize members of their own species, including elaborate airborne “dances.” During the late 1980s, researchers also found the “songs” of Hawaiian fruit flies are as amazingly varied as their bodies. Some species make pulsing cricketlike sounds, while others sound more like cicadas than flies. Like body shapes or genes, these “songs” are providing more clues about how the various species diverged and spread throughout the islands.

See also ADAPTATION; DARWIN'S FINCHES; DIVERGENCE, PRINCIPLE OF; ISOLATING MECHANISMS

RAPID EVOLUTION of honeycreepers from fairly recent common ancestors has produced scores of closely related but divergent species in the Hawaiian Islands. Honeycreepers with sharp, heavy beaks can penetrate bark, while delicate, elongated, curved beaks evolved in nectar-feeders. Species with parrotlike beaks crush seeds and pits.



The 23-acre park is open to the public free of charge. A large cluster of fossil bones has been left unexcavated and undisturbed, so the visitor can see the natural state in which the profusion of fossils occurs in the asphalt. It is not unusual to see a sparrow or squirrel wander from the park into the pit today and become entrapped in the gooey tar, the sad spectacle of a fossil in the making.

The extensive collections from Rancho La Brea (more than 565 species) are stored and exhibited in the George C. Page Museum of La Brea Discoveries in the park. Opened in 1977, the Page Museum features life-sized outdoor sculptures of mastodons, seemingly trapped in the actual tar deposits. Visitors can also observe the museum's scientists and technicians as they meticulously extract fossil treasures from the ancient tar deposits.

## LAETOLI FOOTPRINTS

### Earliest Fossil Man-Tracks

Mary Leakey described it as “perhaps the most remarkable find I have made in my entire career.” The veteran paleoanthropologist was referring neither to a fossil hominid skull nor a stone tool, but to a trackway of petrified footprints she had excavated in 1978 near an ancient volcano in Tanzania. When she first came across the hominid prints Leakey was sceptical, but later she became convinced that she had found the earliest prints of man's ancestors, evidence that hominids three-and-three-quarter million years ago walked upright with a free-striding gait, just as we do today.

These earliest human footprints were found at a site called Laetoli, in a wooded area about 25 miles south of Olduvai Gorge, where Mary Leakey, her husband, Louis, and son Richard had made so many important fossil discoveries. They were actually found by Paul I. Abell (1924–2004), a chemistry professor from the University of Rhode Island, who had a special interest in paleoclimates and for 17 years spent his sabbaticals helping the Leakeys search for hominid fossils. Working with Mary Leakey's team, he was the first to chance upon a hardened footprint in volcanic ash that turned out to be part of an 80-foot trail left by a pair of adult hominids and a child several million years ago.

Preserved in the hardened volcanic mud are tracks of various animals, including spring hares, guinea fowl, elephants, pigs, rhinos, buffaloes, hyenas, antelopes, baboons, and a saber-toothed cat. Among these are the tracks of three hominids—a large individual walking slowly north, a smaller one following behind, and a youngster. The young one seemed to have been following alongside them, at one point turning to look around to the left.

Like nearby active volcanoes in East Africa today, the ancient volcano Sadiman—very near the prints—occasionally belched out clouds of gray ash over the surrounding countryside. This ash sets hard as cement when it is first dampened slightly, then dried in the sun. A brief shower moistened the ash layer; tiny raindrop craters can be seen in its surface. Then the sun came out and hardened it, leaving this extraordinary record of an upright-walking hominid group, from almost four million years ago.

See also LEAKEY, MARY

## LAMARCK, JEAN-BAPTISTE ANTOINE DE MONET, CHEVALIER DE (1744–1829)

### Naturalist, Evolutionist

Pioneer evolutionist Jean-Baptiste Antoine de Monet (later known as the Chevalier de Lamarck) came from a long line of horse soldiers, imbued with honor, bravery, tenacity, and a desire for glory. When Lamarck traded a military career for one in science, he had simply found a new field of combat, and to this day “Lamarckians” remain embattled.

His war-weary father, determined to shield his 11th child from becoming cannon fodder, sequestered him with the Jesuits as a priest-in-training. But at 19, young Jean-Baptiste fled his school to join a regiment defending a German town at the start of the Seven Year War. Within a few days, Lamarck distinguished himself in the thick of battle. Seizing a field com-



FOOTPRINTS IN VOLCANIC ASH were made four million years ago by three upright hominids—possibly a male, female, and child. Other tracks nearby include those of saber-toothed cats.



## SALTATION

### Evolutionary Leaps

**T**he word “saltation,” derived from the Latin, means jumping or leaping from place to place, and is used to describe the peculiar locomotion of grasshoppers and kangaroo rats.

In evolutionary studies, “saltation” means rapid change, where species seem to evolve by macromutations, rather than through a slow series of intermediate forms.

When Charles Darwin first expressed his theory of evolution, he adopted this timeworn cliché as part of the evolutionary process: *Natura non facit saltum* (Nature makes no leaps). His friend Thomas Huxley thought that was an unnecessary burden for the theory to carry. Although he was a staunch defender of the general truth of evolution, Huxley’s reading of the fossil record presented some puzzles about evolutionary rates. Many species appeared to be stable, showing little change over long periods, while certain groups seemed to change and diverge fairly rapidly. Recent “punctuational” theorists incline more to Huxley’s view.

Of course, from the vantage point of a human life span, evolution is excruciatingly slow—whether change takes place over millions of years or in mere thousands.

See also “HOPEFUL MONSTERS”; PUNCTUATED EQUILIBRIUM

“MY THINKING PATH” was how Charles Darwin described his Sandwalk, which he strolled several times a day, pondering his scientific problems.



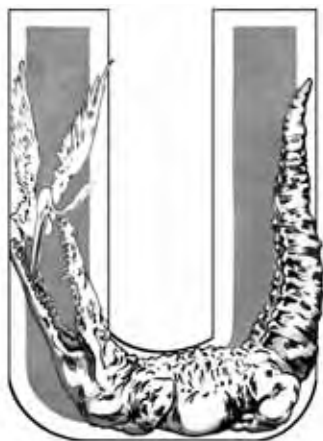
## SANDWALK

### Darwin’s “Thinking Path”

**O**ne of the first things Charles Darwin did when he and his wife settled in Downe village, in the Kentish countryside, was to construct a circular path through the fields and woods on his property. He called it the “Sandwalk,” his “thinking path,” and had the gardener sprinkle its length with sand.

This was to be no idle bit of landscaping, but an essential tool for his work. Each morning and each afternoon for over 40 years, he took his turns on the Sandwalk, sometimes accompanied by his little terrier. Scientific friends such as Thomas Huxley or Sir Joseph Hooker, when they visited, would join him for theoretical discussions on his walks, or to talk about, in Hooker’s words, “old friends, old books, and things far off to both mind and eye.”

Darwin was in the habit of placing a small pile of flints at the crossroad of the Sandwalk, the number of flints depending on the difficulty of the problem he was pondering. If it was a “three flint problem,” he would knock a flint off with his walking stick each time he made a circuit; when the flints were gone, it was time to return home. (His method was strikingly similar to the “three pipe problems” of Sherlock Holmes.)



## UNIFORMITARIANISM

### Slow, Steady Change

In the early 19th century, the top geologists of England and France, among them the great Georges Cuvier, were convinced catastrophists. They believed the geology of the Earth could be explained by such biblical catastrophes as the Great Flood, or “Noachian Deluge” as they called it. Some even attempted to calculate the dimensions of Noah’s Ark; Captain Robert FitzRoy of the *Beagle*, for instance, held a pet theory that mammoths became extinct because the door of the ark was too small to admit them!

Charles Lyell (1797–1895) published a revolutionary book, *Principles of Geology* (three volumes, 1830–1833), in which he theorized that the great features of the Earth had been produced by small causes working at a uniform rate over immense periods of time. These could still be observed at work today, such as water carrying sediments or wearing down rocks.

When Charles Darwin left on his voyage aboard HMS *Beagle*, he took the newly published first volume of Lyell’s *Principles* with him. It had a profound effect on his geological observations. In 1832, when the ship stopped over at Montevideo, on the Río de la Plata, he received the second volume by mail. “I am become a zealous disciple of Mr. Lyell’s views, as known in his admirable book.” Darwin wrote a friend in 1835, “Geologising in South America, I am tempted to carry parts to a greater extent even than he does.”

Actualism, the concept that ordinary present processes operated in the past, is the keystone of what we usually call uniformitarian thinking; it was not original with Lyell, though he made it widely popular. (In the mid-18th century Buffon, for instance, had written that “in order to judge what has happened, or even what will happen, one need only examine what is happening.”)

Few noticed that Lyell spliced actualism with other ideas that seemed to be logical extensions but, in fact, were not. Gradualism and other theories were tied onto actualism like tin cans to a dog’s tail. They had no necessary connection or unity, but Lyell’s skillful presentation made them an accepted part of the package later called uniformitarianism. (A master of argument, Lyell had trained as a barrister before switching to geology.)

Modern geology is uniformitarian in accepting the actualist notion that the study of processes observable today can tell us what happened in the past, in postulating an immense age for the Earth, and in concluding that many great geologic features are the products of slow, steady forces causing gradual change over very long periods.

However, geology is also catastrophic in deducing radical changes in the atmospheric gases, in attributing global mass extinctions to fairly rapid shifts in climate, and in tracing some of these in turn to meteoric impacts. There has also been a shift toward the discontinuous, or jumpy, view of evolutionary events known as punctationalism.

Today’s earth scientists claim Lyell’s *Principles of Geology* as their founding document but view it as a mixed bag of catastrophic and uniformitarian elements.

See also ACTUALISM; GRADUALISM; LYELL, SIR CHARLES; STEADY-STATE EARTH

## WALLACE, ALFRED RUSSEL (1823–1913)

### Codiscoverer of Natural Selection

After publication of the *Origin of Species* in 1859, evolution by natural selection, biology's great unifying concept, became famous as "Darwin's theory." First announced and published jointly the previous year, it is actually the Darwin-Wallace theory. Nevertheless, Charles Darwin often called it "my theory," while Alfred Russel Wallace, his partner and coauthor, graciously insisted, "It [is] actually yours and yours only."

Wallace carried modesty to extremes, even calling his own book on evolution *Darwinism* (1889). Had he been more ambitious and less generous, evolutionary science might have become known as "Wallaceism."

An explorer, zoologist, botanist, geologist, and anthropologist, Wallace was a brilliant man in an age of brilliant men. Famous not only as cocreator of the natural selection theory, he was the discoverer of thousands of new tropical species, the first European to study apes in the wild, a pioneer in ethnography and zoogeography (distribution of animals), and author of some of the best books on travel and natural history ever written, including *A Narrative of Travels on the Amazon and Rio Negro* (1853) and *The Malay Archipelago* (1869). Among his remarkable discoveries is "Wallace's Line," a natural faunal boundary between islands (now known to coincide with a junction of tectonic plates) separating Asian-derived animals from those evolved in Australia.

Born in 1823 in Usk, England, a small town near the Welsh border, Wallace was raised in genteel poverty. His first employment was helping his brother John survey land parcels for a railroad. While still in his twenties, he served a stint as a schoolmaster in Leicester, where he met young Henry Walter Bates, who shared his passion for natural history. On weekend bug-collecting jaunts, the would-be adventurers discussed such favorite books as the *Voyage of HMS Beagle* (1845) and dreamed of exploring the lush Amazon rain forests of Charles Darwin's ecstatic descriptions.

Another book also inspired them: Robert Chambers's anonymously published *Vestiges of Creation* (1844), a controversial, literary treatise on evolution. Scorned by scientists, *Vestiges* championed the idea that new species originate through ordinary sexual reproduction rather than by spontaneous creation. Wallace and Bates decided they would comb the exotic jungles to collect evidence that might prove or disprove this exciting "development hypothesis" (only later known as evolution). When Darwin had embarked on his own voyage of discovery some 20 years earlier, he had had no such clear purpose in mind.

Science was not yet a well-established profession, and naturalists were often dedicated amateurs from wealthy families. When Darwin went on his circumglobal voyage, his father paid all expenses, even providing a servant to assist with his work. Wallace's achievements are all the more remarkable, for he had to finance his expeditions by selling thousands of natural history specimens, mainly insects, for a few cents apiece. When his exploring and collecting days were over, Wallace struggled to support his family on author's royalties and by grading examination papers. (He said in *My Life* (1905) that the "capability of a man in getting rich is in an inverse proportion to his reflective powers in direct proportion to his impudence.")

Bates and Wallace reached Pará, at the mouth of the Amazon, in May 1848; they collected and explored the surrounding regions for several months, then decided to split up. Wallace went up the unknown Rio Negro, leaving Bates to explore the upper Amazon regions. From 1848 until 1852, Wallace collected, explored, and made numerous discoveries despite malaria, fatigue, and the most meager supplies.

When he finally returned to rejoin Bates downriver, he found that

BRILLIANT, ECCENTRIC, and utterly his own man, Alfred Russel Wallace independently developed the theory of evolution by natural selection.





his beloved younger brother had traveled across the world to join the adventure and had just died of yellow fever in Bates's camp. Grief-stricken, exhausted, and suffering from malaria himself, Wallace boarded the next ship for England. With him went his precious notebooks and sketches, an immense collection of preserved insects, birds, and reptiles, and a menagerie of live parrots, monkeys, and other jungle creatures.

In the middle of the North Atlantic, as Wallace suffered a new attack of malaria, the ship suddenly burst into flames. He wrote in *My life*, "I began to think that almost all the reward of my four years of privation and danger was lost." He was able to rescue only a few notebooks as he dragged himself into a lifeboat; everything else burned or sank beneath the waves. In *Travels on the Amazon and Rio Negro*, he recalled:

How many times, when almost overcome by the ague, had I crawled into the forest and been rewarded by some unknown and beautiful species! How many places, which no European foot but my own had trodden, would have been recalled to my memory by the rare birds and insects they had furnished to my collection! . . . And now I had not one specimen to illustrate . . . the wild scenes I had beheld!

The measure of Wallace's enormous courage and resilience showed itself shortly after returning to England. With the insurance money he received for part of his lost collections, he immediately set out on a new expedition—this time to the Malay Archipelago (1854–1862).

Wallace mastered Malay and several tribal languages, for he was intensely interested (as Darwin never was) in "becoming familiar with manners, customs and modes of thought of people so far removed from the European races and European civilization." A self-taught field anthropologist, he made pioneering contributions to ethnology and linguistics and developed "a high opinion of the morality of uncivilized races." He later recalled with satisfaction that while he lived among them he never carried a gun or locked his cabin door at night.

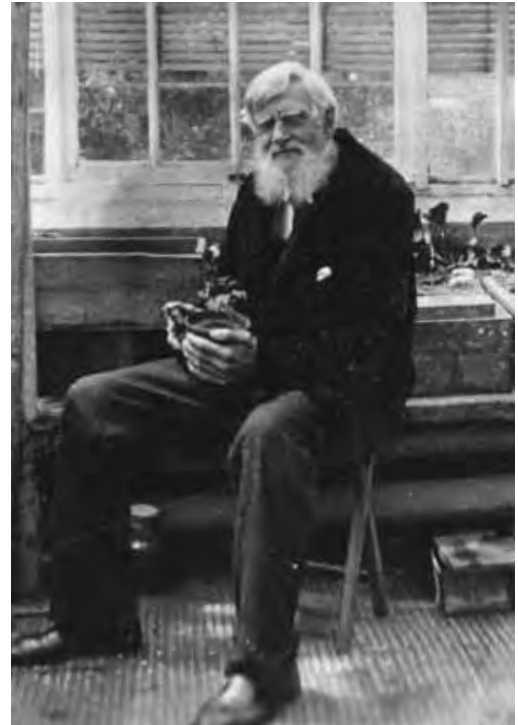
In the Moluccas he tracked orangutans through the deep forest, shot several for the British Museum's collection, and raised an orphaned infant orang in his field camp. Since local tribesmen regarded the red-haired apes as "men of the woods," they were horrified when he shot and skinned them, convinced he would next want to add their own skulls to his collection.

Wallace collected natural history specimens with an extraordinary passion. As he recounts in *The Malay Archipelago* (1869),

I found . . . a perfectly new and most magnificent species [of butterfly]. . . . The beauty and brilliancy of this insect are indescribable, and none but a naturalist can understand the intense excitement I experienced. . . . On taking it out of my net and opening the glorious wings, my heart began to beat violently, the blood rushed to my head, and I felt . . . like fainting . . . so great was the excitement produced by what will appear to most people a very inadequate cause.

Wallace came to the idea of evolution not through artificial selection of domestic animals, as Darwin did, but through his observations of the natural distribution of plants, animals, and human tribal groups and their competition for resources. Like Darwin, he was influenced by Thomas Malthus's *Essay on the Principle of Population* (1798), which he had read some years before.

In 1855, while in Sarawak, he composed "my first contribution to the great question of the origin of species." Combining his knowledge of plant and animal distribution with Sir Charles Lyell's account of "the succession of species in time," he came up with a conclusion about when and where species originate. ("The how," he wrote, "was still a secret only to be penetrated some years later.") His paper, titled "On the Law Which Has Regulated the Introduction of New Species," stated that "every species has come into existence coincident



**NATURALIST, EXPLORER, anthropologist, and founder of zoogeography, Alfred Russel Wallace was also the first European to observe orangutans in the forest.**



YOUNG WALLACE set off for the Brazilian rain forest on a quest to find evidence for or against the idea of evolution.



both in space and time with a pre-existing, closely-allied species." This preliminary conclusion, he knew, "clearly pointed to some kind of evolution."

Published in an English natural history journal in September 1855, Wallace's "Sarawak Law" was generally ignored by the scientific world. When he expressed his disappointment in a letter to Darwin, "He replied that both Sir Charles Lyell and Mr. Edward Blyth, two very good men, specially called his attention to it." Writing years later, Thomas Huxley said, "On reading it afresh I have been astonished to recollect how small was the impression it made."

In February 1858, Wallace was living on Ternate, one of the Moluccan Islands, and was suffering from a sharp attack of intermittent malarial fever, which forced him to lie down for several hours every afternoon. From his combined accounts in a 1903 article and in *My Life*, his 1905 autobiography, here are Wallace's recollections about his independent discovery of natural selection:

It was during one of these fits, while I was thinking over the possible mode of origin of new species that somehow my thoughts turned to the "positive checks" to increase among savages and others described . . . in the celebrated *Essay on Population* by Malthus . . . I had read a dozen years before. These checks—disease, famine, accidents, wars, etc.—are what keep down the population. . . . [Then] there suddenly flashed upon me the idea of the survival of the fittest . . . that in every generation the inferior would inevitably be killed off and the superior would remain.

Considering the amount of individual variation that my experience as a collector had shown me to exist . . . I became convinced that I had at length found the long-sought-for law of nature that solved the problem of the origin of species. . . . On the two succeeding evenings [I] wrote it out carefully in order to send it to Darwin by the next post.

It was this article, "On the Tendency of Varieties to Depart Indefinitely from the Original Type" (1858), that sent Darwin into a panic, convinced his friend Charles Lyell's warning that he would be "forestalled" by Wallace "had come true with a vengeance."

Lyell and Sir Joseph Hooker, attempting to rescue their friend's threatened prior claim, arranged to have Wallace's paper published along with some of Darwin's early drafts. The announcement of the Darwin-Wallace theory of evolution by means of natural selection was read at the Linnean Society and published in its journal in 1858; the following year Darwin completed the *Origin of Species* and rushed it into print.

Wallace was informed of these developments while still in the Moluccas, and he wrote that he happily and graciously approved. When he returned to England in 1862, Darwin was still anxious about Wallace's reaction, and was relieved to discover his "noble and generous disposition." Later Wallace maintained that even if his only contribution was getting Darwin to write his book, he would be content. But the fact remains that Wallace was not given an opportunity to exercise his nobility or generosity, since the joint publication was decided without anyone consulting him.

In addition to the chronicles of his travels, Wallace turned out a remarkable series of books, all landmark studies in evolutionary biology: *Contributions to the Theory of Natural Selection* (1870), *Geographical Distribution of Animals* (1876), *Island Life* (1880), and *Darwinism* (1889). In *The World of Life* (1910), he describes the living Earth as a single, complex system, an idea that seems, in some sense, to have foreshadowed the Gaia hypothesis:

There are now in the universe infinite grades of power, infinite grades of knowledge and wisdom, infinite grades of influence of higher beings upon lower. . . . This vast and wonderful universe, with its almost infinite variety of forms, motions, and reactions of part upon part, from suns and systems up to plant life, animal life, and the human living soul, has ever required and still requires the continuous co-ordinated agency of myriads of such intelligences.

Unlike the cloistered, tactful Darwin, in his later years Wallace was imprudently outspoken about his religious and political beliefs. Outraged colleagues wanted to dismiss him as a "senile crank" for his strong advocacy of utopian socialism, pacifism, wilderness conservation, women's rights, psychic research, phrenology, and spiritualism, as well as his

campaign against vaccination. Wallace replied he was not “brain-softening” with age, but had held many of these beliefs for 30 years.

Spiritualism strongly influenced his ideas on human evolution, causing him to differ with Darwin in 1869 on whether natural selection could explain “higher intelligence” in man. Wallace thought the human mind was supernaturally injected into an evolved ape from “the unseen world of Spirit.” He also rejected Darwin’s concept of “sexual selection,” which he dismissed as merely a special case of natural selection. Although the two men remained friendly and mutually respectful, they never really understood each other’s perspective. [See SPIRITUALISM; “WALLACE’S PROBLEM.”] Nevertheless, Wallace was called upon to be an honored pallbearer at Darwin’s funeral at Westminster Abbey.

In 1876, Wallace helped introduce a Spiritualist paper at the British Association’s scientific meetings, which apparently touched off the notorious Slade affair. [See SLADE TRIAL.] He testified for the defense at the trial of Henry Slade and often defended other professional “spirit-mediums” who were accused of conducting fraudulent “psychic experiments.” In 1881, Wallace joined the Society for Psychic Research.

He headed the Land Nationalisation Society in 1882 and openly declared himself a Socialist in 1890. Some of his admirers had recommended he be appointed director of the proposed new park at Epping Forest, but Wallace immediately lost the position by stating that he would keep the woodland exactly as it was for future generations, allowing no restaurants, hotels, or other concessions.

When Darwin started a petition among scientists to get Wallace a civil pension, botanist Sir Joseph Hooker and others objected to appealing for government funds on behalf of “a public and leading spiritualist.” However, Darwin and Huxley prevailed and Wallace got his pension. (Huxley, though differing with Wallace on many issues, assured him in 1866 that he would never seek “a Commission of Lunacy against you”!)

In his last book, *Social Environment and Moral Progress* (1913), Wallace cataloged the horrors of the urban poor, colonial exploitation, and unchecked greed: “It is not too much to say that our whole system of society is rotten from top to bottom, and the Social Environment as a whole, in relation to our possibilities and our claims, is the worst that the world has ever seen.” He was deeply saddened and outraged, as he wrote in *The Wonderful Century* (1898), by “reckless destruction of the stored-up products of nature, which is even more deplorable because more irretrievable.”

He was furious when apologists for the status quo told him society needed no safety net for its poor or infirm, since, according to the “law” of natural selection, they ought to be eliminated. “Having discovered the theory,” he fumed in his 1913 book, “it is rather amusing to be told . . . that I do not know what natural selection is, nor what it implies.” Eugenicians who sought to regulate human breeding for selective improvement he considered “dangerous and detestable,” and he warned that lawmakers were “sure to bungle disastrously” any legislation on the subject.

Influenced by the socialist Henry George, Wallace urged a policy of land nationalization and an economy in which “all shall contribute their share either of physical or mental labor, and . . . every one shall obtain the full and equal reward for their work. [Then] the future progress of the race will be rendered certain by the fuller development of its higher nature acted on by a special form of selection which will then come into play.”

What “special form of selection” might be the salvation of humanity? Wallace argued that human populations produce many more males than females, but in his day young men were dying by the millions. Alcoholism, dangerous occupations, and particularly the frequent wars left Europe with a huge proportion of unattached women. But under a just and nonmilitaristic social system, Wallace predicted, the number of males would rise dramatically, until they greatly outnumbered women: “This will lead to a greater rivalry for wives, and will give to women the power of rejecting all the lower types of character among their suitors.” The



well-educated, enfranchised, responsible “women of the future [will be] the regenerators of the entire human race . . . in accordance with natural laws.”

Wallace’s special hope for the salvation of mankind, then, was none other than “sexual selection,” one of Darwin’s favorite mechanisms for explaining the evolution of man—which Wallace had always insisted did not exist! However, Wallace added a twist to Darwinian sexual selection: an explicit acknowledgment of the large evolutionary effects of a slight change in sex ratio, a surprisingly modern way of thinking about populations.

During the 1970s and 1980s, Alfred Russel Wallace became a hero among disaffected academics and independent scholars. They saw in him a brilliant scientist, working outside the establishment, scrabbling for a living, snubbed by those with wealth and position, persecuted for unpopular social views—possibly even deprived of his rightful place in history. Yet Wallace was morally triumphant as a great human being and fearless truthseeker, cheerful, optimistic, and productive into his ninetieth year.

In 1985, the British Entomological Society, of which Wallace was once president, launched a series of major expeditions to study the insects of the world’s tropical rain forests. They called it “Project Wallace.”

See also BATES, HENRY WALTER; BEETLES; GAIA HYPOTHESIS; HAMPDEN, JOHN; PHRENOLOGY; “SARAWAK LAW”; SEXUAL SELECTION; *VESTIGES OF CREATION*; WALLACE’S LINE

## WALLACE’S LINE

### Landmark in Zoogeography

**A**lfred Russel Wallace (1823–1913), the talented English naturalist who codiscovered the theory of evolution by natural selection, has often been the forgotten man in the Darwin-Wallace theory. But there is another monument to his brilliance that stands alone, and can still be seen today on every geologist’s and biologist’s map of the world: Wallace’s Line.

WALLACE’S LINE is an inferred natural boundary between animals evolved from Asian precursors (western side) and those of Australian (eastern side). A century after Wallace proposed it, geologists confirmed that his line is near the edge of the Indo-Australian plate.

