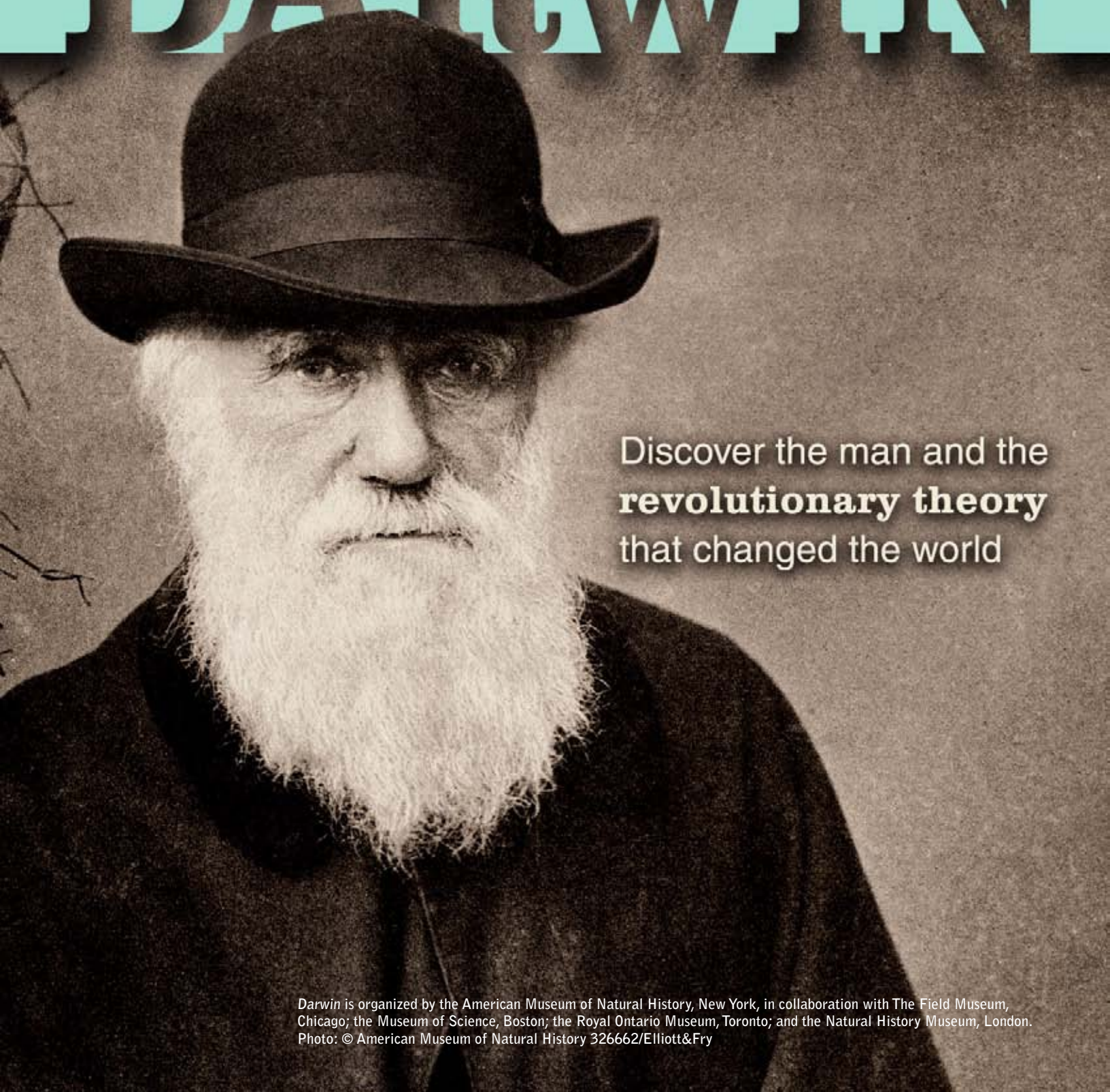


The Field Museum Education Department Presents

Educator Guide & Walking Map

The Field Museum's Education Department develops on-line educator guides to provide detailed information on field trip planning, alignment with Illinois State Learning Standards (ILS), as well as hands-on classroom activities to do before and after your visit to the Museum.

DARWIN



Discover the man and the
revolutionary theory
that changed the world

Darwin is organized by the American Museum of Natural History, New York, in collaboration with The Field Museum, Chicago; the Museum of Science, Boston; the Royal Ontario Museum, Toronto; and the Natural History Museum, London.
Photo: © American Museum of Natural History 326662/Elliott&Fry

Charles Darwin was just 22 years old, an amateur naturalist studying for a career in the clergy, when he set sail aboard the HMS *Beagle* in 1831. It was a voyage that would change Darwin's life, shake nineteenth-century Europe to its core, and lay the foundations of all modern biology.

Now visitors can join Darwin on his voyage of discovery in the most in-depth exhibition ever presented about the man, the scientist, and the theory. Visitors will encounter many of the unique animals Darwin observed in exquisite detail, including live South American horned frogs and a green iguana, mounted birds, insects, fossils, and much more. Darwin's letters, notebooks, and personal belongings paint an intimate portrait of a man as devoted to his family as he was to nature, and a scientist whose fascination with plants and animals led him to the process—natural selection—by which evolution works.

Before you visit the exhibition, spend some time viewing the information on the Web site to begin planning your visit. We also recommend our quick fun facts and pre-activities to introduce your students to the complexities of the exhibition and focusing on one or two sections within the exhibition to study in depth. Each section has an introduction, guiding questions, answers to guiding questions, suggested pre-activities, field trip activities, and post-activities to help guide your students' experience.

Visit us on-line at <http://www.fieldmuseum.org/darwin/>.



Visitors get a close-up look at a four-foot-long green iguana (*Iguana iguana*) from South America, just one of the live species on display in **Darwin**.
Photo:© Roderick Mickens, AMNH

Guide Contributions

American Museum of Natural History © 2005

Adapted for The Field Museum by Richard A. Kissel, Science Program Developer; Elizabeth Babcock, Director of Education and Library Collections; Monica García, Manager of Teacher Programs and Partnerships

- **Darwin's greatest tool was his ability to observe and analyze.** Darwin made great discoveries using basic scientific tools like a magnifying glass and notebook. But his most powerful tool was his mind. His intense curiosity about the diversity of species and their range of adaptations to different environments led him to a new understanding of the world around us—and our place in it.
- **Scientific knowledge changes over time, as scientists test, refine, and add to what is already understood about the world.** Before Darwin, 18th-century naturalists saw order in nature, and a few even recognized that some form of evolution occurs. Darwin's breakthrough was his discovery of the underlying mechanism, which he named natural selection. New scientific tools and new fields of study, such as molecular biology and genetics, have greatly advanced our understanding of how this process works and have provided significant corroboration for Darwin's theory.
- **The evidence that Darwin collected during the five-year voyage (1831-1836) of the HMS *Beagle* led to his theory that species adapt to different environments and change over time.** At the time, most people believed that all plant and animal species on Earth had been created in a fixed form, but evidence convinced Darwin otherwise. Among the many species he observed were ostrich-like rheas that differed in form as he made his way up the coast of South America, and Galápagos tortoises that were adapted to life on individual islands. Darwin came to realize that these different species had originated from a common ancestor and adapted to their local environments over time.
- **Darwin developed his theory of natural selection after years of rigorous observation, testing, and analysis.** Scientific theories develop as scientists collect evidence about the natural world, form hypotheses that explain what they've observed, use their hypotheses to make predictions, test these predictions with further observations and/or experiments, and generate explanations that survive the testing process. Aware that his ideas would shake the world, Darwin spent four decades at Down House, his rural retreat outside London, testing and strengthening his theory.
- **All life, including humans, evolved from a common ancestor through the process of natural selection.** Over the course of biological evolution, populations branch off from one another, stop interbreeding, and become separate species. These species continue to adapt and change over time. Darwin called this process “descent with modification,” and grounded it in the evidence that: 1) all organisms differ among themselves (variation); 2) organisms pass traits on to their offspring (inheritance); 3) some organisms—being better adapted—survive and reproduce more frequently than others (selection); and 4) vast periods of time are involved.
- **Modern evidence supports and expands upon Darwin's theories.** Genetic sequences, in combination with morphological studies of organisms, have been used to construct evolutionary family trees that illustrate the relationships between diverse species, and provide very strong support for common ancestry.
- **Modern biology, and society in general, benefit from our understanding of the process of natural selection.** Numerous scientists are investigating the natural world today—whether fighting viruses, decoding DNA, or analyzing the fossil record—have found Darwin's theory of natural selection essential to their work. For example, scientists studying flu viruses can anticipate which new varieties might evolve to become most harmful in the near future. They can then create vaccines designed to help the body's immune system ward off most of the upcoming year's varieties, a process that has saved countless lives.



A reproduction of the first-known sketch by Charles Darwin of an evolutionary tree describing the relationships among groups of organisms.

Photo: © By permission of the Syndics of Cambridge University Library



This wooden writing box filled with mementos collected by Darwin's wife to remember their first daughter, Annie, who died when she was only 10 years old, is just one of the many personal items featured in **Darwin**.

Photo: © Craig Cheseck, AMNH

The Illinois Learning Standards (ILS) define what students in all Illinois public schools should know and be able to do in the seven core areas as a result of their elementary and secondary schooling. The classroom assessments are resources to help teachers determine local performance expectations for the Illinois Learning Standards (ILS) at each grade level. For more information on the ILS, visit www.isbe.state.il.us/ils/Default.

Use of materials in this educator guide in combination with a field trip to the exhibition will help you link learning experiences to the following Illinois Learning Standards (ILS). Teachers will need to identify descriptors and benchmarks to individual lesson plans, larger units of study, and to specific subject area. This exhibition, while suitable for all students regardless of grade level, maps closely to concepts studied in later elementary, middle school, and high school.

English Language Arts:

Goal 1: Reading; Goal 2: Literature; Goal 3: Writing; Goal 4: Listening; Goal 5: Research

Mathematics:

Goal 6: Number Sense; Goal 7: Estimations & Measurement

Science:

Goal 11: Inquiry & Design; Goal 12: Concepts & Principals; Goal 13: Science, Technology, & Society

Social/Emotional Learning (SEL):

Goal 1: Develop self-awareness and self-management skills to achieve school and life success

Social Science:

Goal 14: Understand political systems, with an emphasis on the United States; Goal 16: Understand events, trends, individuals and movements shaping the history of Illinois, the United States and other nations; Goal 17: Understand world geography and the effects of geography on society, with an emphasis on the United States; Goal 18: Understand social systems, with an emphasis on the United States.

Adaptation: A feature that contributes to an organism's success and survival in its environment.

Artificial Selection: Human-guided breeding and cultivation that perpetuate only those forms having certain desirable inheritable characteristics, ensuring that certain traits, or features, are represented in successive generations.

Biodiversity: The variety of organisms considered at all levels, from genetic variants belonging to the same species through arrays of species; includes the variety of ecosystems, which comprise both the communities of organisms within particular habitats and the physical conditions under which they live.

Botany: The study of plants.

Community: The organisms of an ecosystem.



Fossils, mounted specimens, and illustrations of the uniquely American modern animals and groups Darwin saw on the Galápagos Islands, such as these blue-footed boobies (*Sula nebouxi excise*) are featured in the exhibition.

Photo: Stephen C. Quinn © American Museum of Natural History

Down House: Darwin's home from 1842-1882, located 16 miles outside London. There, Darwin formulated his ideas of evolution by means of natural selection.

Ecosystem: The organisms living in a particular environment, such as a lake or forest, and the physical part of the environment that affects them. The organisms alone are called the community.

Entomology: The study of insects.

Evolution: The accumulation of inherited changes in populations of organisms over the course of generations. Evolution explains how species change over time and evolve into new species, and how what we see today may differ from the past. Evolutionary theory explains the diversity of life through the process of descent with modification.

Extinction: When a species dies out forever. Small numbers of species are going extinct all the time, but mass extinction events are responsible for wiping out much of the species diversity in the past.

Family Tree: A diagram showing the evolutionary relationships of species.

Food Web: A model that shows all the possible feeding relationships within a community.

Fossil: The remains or traces of organisms that were once alive. Fossils can include bones, trackways, skin impressions, etc.

Galápagos Islands: A group of volcanic islands in the Pacific Ocean west of the mainland of Ecuador.

Geology: The study of the earth—past and present—and the processes that shape it.

Heredity: The passing of traits from one generation to the next. A trait is a notable feature or quality.

HMS *Beagle*: The vessel that carried Darwin around the world. It departed Plymouth harbor on December 27, 1831 and returned to England on October 2, 1836.

Homology: A similarity in structure, physiology, or behavior in two species due to inheritance from a common ancestor, whether or not the function is the same (e.g., the bones in the human arm and a bat's wing are homologous structures).

Inheritance: The genetic transmission of characteristics from parents to offspring.

Mass Extinction: When a large proportion of species go extinct within a relatively short time (several million years) across much of the world. There have been at least six mass extinctions in the four billion years since life began.

Morphology: The study of the form and function of an organism.

Natural Selection: The driving mechanism of evolutionary change: organisms that are better adapted to their environment are more likely to survive and therefore more likely to pass along their successful features to their offspring. The concept of natural selection was proposed by Charles Darwin in his book *On the Origin of Species* (1859).

So, how does natural selection work? It's as easy as one, two, three!

1. No two organisms (except identical twins) are exactly alike. This is called individual variation. Individuals inherit traits, or features, from their parents. Inherited variation comes from the mixture of genetic information from parents, and very occasionally from new mutations (copying errors of DNA).
2. There is a limit to the number of individuals that can survive in any particular environment, but natural population growth tends to exceed that number.
3. Those individuals that have traits that allow them to survive better and reproduce more frequently will tend to pass more of these characteristics to the next generation.

For example, saddleback tortoises (as seen in the *Darwin* exhibition) have longer necks and can reach high food more easily. On islands that lack food close to the ground, animals with this trait have a better chance of surviving and reproducing compared to their short-necked cousins. So over time, the long-necked tortoises are *naturally* selected compared to the short-necked tortoises in this environment. This is an example of how a population or species can evolve. Natural selection is the process by which species evolve over time.

Naturalist: A person who collects and observes plants, animals, and rocks.

Sandwalk: The trail at Down House where Darwin would take his daily walks.

Selection: See the definition of Natural Selection above.

Species: A population or series of populations of closely related and similar organisms.

Theory: An explanation of some phenomenon of the natural world that is well supported by the evidence at hand.

Variation: Differences in structure or character among individuals of a population.

Zoology: The study of animals.



Live orchids, like those with which Charles Darwin experimented to provide more evidence for natural selection, are featured in **Darwin**.

Photo: Craig Chesek © American Museum of Natural History

Welcome to *Darwin*! This exhibition tells the story of Charles Darwin, the man and the scientist, and how the evidence he gathered during and after the voyage of the HMS *Beagle* led to the development of the theory of evolution through natural selection. It goes on to explore contemporary evolutionary biology, its applications in medicine and conservation, and how this theory is the foundation for all modern biology.

In this spectacular exhibition, you will view the most complete collection of Charles Darwin's manuscripts, artifacts, memorabilia, and other rare personal belongings. This extraordinary portrayal reveals Darwin's endless curiosity, exceptional power of observation, and scientific genius. Family photographs and letters reveal a different side of this famous scientist: Darwin as a family man—a husband and father of 10 children. Trace the historic five-year voyage on the HMS *Beagle* that brought him to the Galápagos Islands, and experience some of the unique animals Darwin encountered on his journey, such as live South American horned frogs and a green iguana. This unique in-depth exhibition includes hands-on interactive displays and interviews with contemporary scientists. Follow the development of Charles Darwin's ideas at Chicago's world-famous Field Museum.



Ornate horned frogs (*Ceratophrys ornate*) similar to the ones observed by Darwin during his travels to South America, are just one of the live species featured in the exhibition.

Photo: © Joe McDonald, Clyde Peeling's Reptiland



In Darwin's time, most people—even scientists—thought that species had existed in their current form since the world began. Only recently had geologists begun to understand that the earth was millions (in fact, we now know, billions) of years old. The evolution of species had been suggested by only a handful of thinkers—Darwin's grandfather among them. In this section of the exhibition, visitors will see classic illustrations and mounted animal skeletons representing the Victorian view of a well-ordered, unchanging nature.

One of Darwin's original microscopes is just one of the many personal items on display in an elaborate reproduction of Darwin's study from Down House.
Photo: © Denis Finnin, AMNH

Guiding Questions

1. What is morphology?
2. Before Darwin, how did most naturalists view the world's biodiversity?
3. In science, why is observation so important?

Pre-Activity

1. Show students a random collection of objects, such as an assortment of office supplies (e.g., a pen, a pair of scissors, a stapler, a pencil, etc.) or other objects used daily in the classroom. Have them make five observations about each object. Then ask them if they see any order to the objects. Can they categorize the objects and make groups and subgroups? After they have constructed a categorization for the objects, show the students images of different types of organisms. Ask them to make five observations about each organism, and like they did with the objects, ask them to categorize the organisms based on the features they observed.

Field Trip Activities

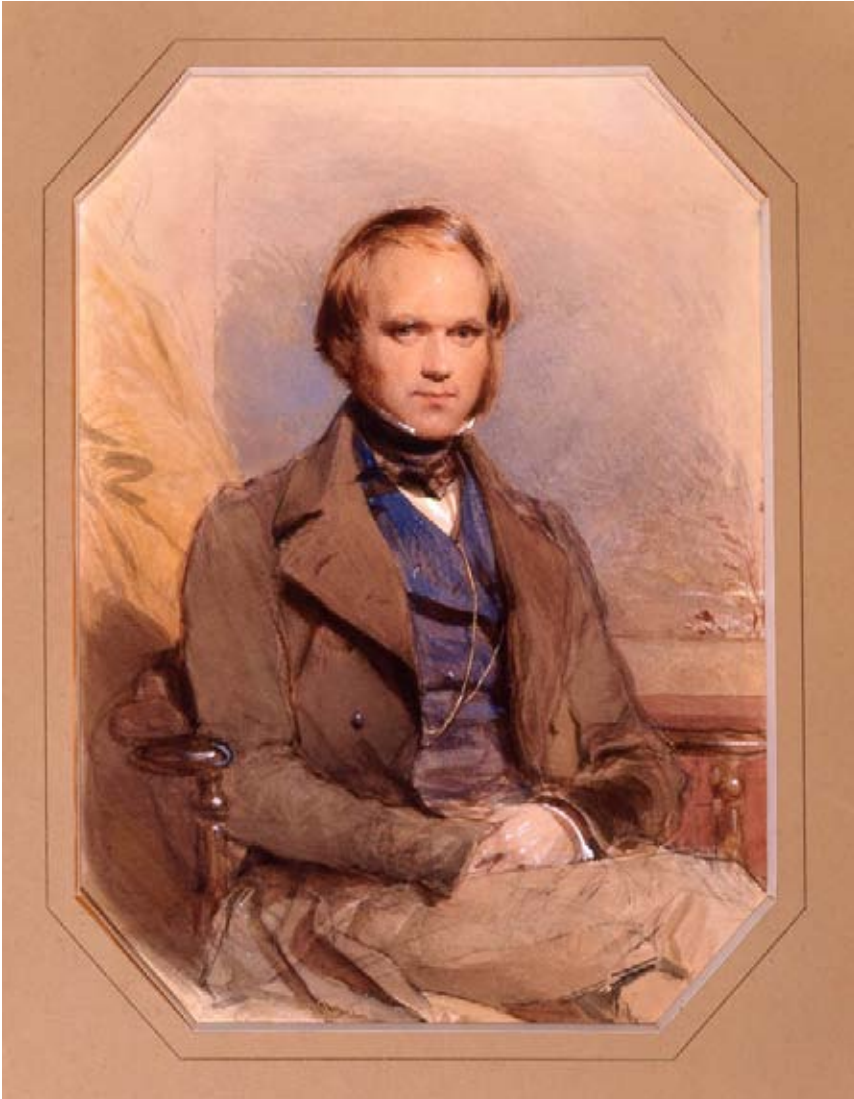
1. As you enter *Darwin*, you'll see a magnifying glass that Darwin himself used. Ask students to find three other tools in the exhibition that Darwin used. For what purpose were they used?
2. The centerpiece of *The World before Darwin* gallery is a case filled with many different animals skeletons. Ask students to each pick out a skeleton, and then make five observations about the skeleton. What do their observations tell them about the animal? Did it walk, swim, or fly? Did it eat meat or plants? Observation is the first step to finding the answers!
3. Explore the *Evolving Planet* and *What is an Animal?* exhibitions to many more types of animals—past and present—and observe the diversity of forms that exist.

Post-Activity

1. Ask students to discuss the observations they made about the different skeletons during the field trip. Did students all make the same observations, or were they different? Did they come to similar conclusions about the animal's lifestyle, or were their conclusions different? This exercise will show that different observations will lead to different conclusions. That's why different scientists have different ideas about our world!

Answers to Guiding Questions

1. Morphology is the study of the form and function of an organism.
2. Before Darwin was born, species were not linked in a single "family tree." Species were thought to be unconnected, unrelated, and unchanged since the moment of their creation. This reflected the broader view that the world is stable and unchanging.
3. Observation is important to any scientific investigation. To answer questions about the world in which we all live, scientists closely observe nature to find answers. Observation skills are critical because: 1) observation generates questions to answer; 2) through direct observation, we collect information; 3) information is fodder for developing possible explanations (hypotheses). Careful observation is key in science!



A portrait of 31-year-old Charles Darwin by George Richmond in 1840.
Courtesy of the Darwin Heirlooms Trust
Photo: © English Heritage Photo Library

Born into a wealthy family, Darwin had little interest in school, but he was an avid naturalist, a collector and observer of plants, insects, and rocks. In this section of the exhibition, visitors will see artifacts and photos from Darwin's prominent family—the Darwins on his father's side, the Wedgwoods on his mother's—the book his grandfather, Erasmus Darwin, wrote on his own idea of evolution, and some of the beetles and other insects Darwin joyfully collected in his youth, along with his notes about them.

A film on Darwin's life and work is narrated by the scientist's great-great-grandson, Randal Keynes. Drawing on archival photographs and new images of Darwin's journals, manuscripts, and homes, the film introduces visitors to Darwin's life, including his early observations of nature, his journey on the HMS *Beagle*, his subsequent years of research, and the impact of his theory on science and culture.

Guiding Questions

1. What is entomology?
2. What is geology?
3. What is a naturalist?

Pre-Activity

1. As a young naturalist, Darwin had many mentors and role models, such as Reverend J. S. Henslow. Ask students to write a short essay on a role model in their lives.

Field Trip Activity

1. One of Darwin's favorite hobbies as a child was the collecting of beetles. In the *A Young Naturalist* gallery, ask students to pick any two beetles. Have them draw the beetles and answer the following two questions: 1) How are these two beetles different? 2) How are these two beetles similar?
2. Find the cast of rocks layers. Reading rock layers is like reading the pages of a book; the rock layers tell a story. What does the cast show?
3. To learn more about geology and the Earth's 4.5 billion year history, visit the *Evolving Planet* and *Earth Science* exhibitions!

Post-Activity

1. Young Darwin was greatly influenced by the work of geologists Charles Lyell and James Hutton, who helped show that the Earth is not only much older than most people thought, but that it was constantly changing over time. To help students understand just how old the Earth is, print out and distribute the PDF available at http://www.amnh.org/education/resources/rfl/pdf/dino_10_time.pdf and guide your students through the activity.

Answers to Guiding Questions

1. Entomology is the study of insects.
2. Geology is the study of the earth—past and present—and the processes that shape it.
3. A naturalist is a person who collects and observes plants, animals, and rocks.



During his five-year voyage to the Galápagos Islands, Darwin studied the unique species of the area. This section of the exhibition explores some of his findings.
Photo: © Denis Finnin, AMNH

The section opens with the original letter that changed Darwin's life: an invitation to serve as a naturalist aboard the HMS *Beagle* as it set out to map the oceans and islands of South America and the South Pacific. Some of the personal items Darwin took along, including a one-shot pistol and his Bible, are featured here, along with a 26-inch scale model of the 90-foot ship.

Surrounded by an ocean soundscape, visitors enter the centerpiece of the exhibition: a circular room featuring many of the wonders Darwin saw on his five-year trip—including some of the actual specimens he collected—and tracing his mental journey from a curious amateur observer to a scientist pondering the patterns and connections in what he saw. Live animals play a starring role here: three ornate Argentinean horned frogs and a four-foot-long South American green iguana. Visitors will also see fossils and mounted specimens of the uniquely American plants and animals that fascinated Darwin: rheas, giant sloths, and armadillos (including the cast of a huge fossil glyptodont, an extinct armadillo-like creature the size of a cow); Galápagos tortoises with different shell shapes adapted to their specific islands; mockingbirds, penguins, and blue-footed boobies, and much, much more. Notes and letters Darwin sent to friends and family give visitors a glimpse of his excitement, his thought processes...and his problems with seasickness.

Guiding Questions

1. What and where are the Galápagos Islands?
2. What are fossils?
3. What is paleontology?
4. What is adaptation?

Pre-Activities

1. Explain that adaptations are features that contribute to an organism's success and survival in its environment. View the *Natural Selection* video at http://www.fieldmuseum.org/evolvingplanet/precambrian_14.asp and ask students to identify three adaptations shown in the video (the adaptations are: 1) long legs for fast running; 2) longer hair for more warmth; and 3) green coloration for camouflage). Then have students break into small groups; give each group a picture of a plant or animal that lives today (e.g., giraffe, tiger, hummingbird, cactus) and have students identify three traits that help the organism survive in its environment.

Field Trip Activities

1. Ask students to choose one of the live animals in the exhibition and draw it. Have them identify two interesting features of the creatures and then write about how those features help the animal survive.
2. Print out and make copies of a map of the HMS *Beagle* voyage found at <http://www.amnh.org/education/resources/rfl/pdf/beaglevoyage.pdf>. Give each student a copy of the map in the exhibition and ask them to label the stops on the map with the name of the country and the year Darwin arrived there. Have them pick three stops and describe the observations he made at each place.
3. The diversity found at the Galápagos Islands is a just a glimpse at the diversity of life on the planet. Have students explore the *Messages from the Wilderness* exhibition to see a whole host of different animals—and the environments in which they live! How are animals on the Galápagos different from those in North America? Are there any similarities? Do you have any explanations for those differences?
4. And adaptation isn't just a thing of the present. Encourage students to visit *Evolving Planet*. In the gallery with the Cambrian sea, have students watch the animated seascape and identify three animals. For each of the animals, identify two features that help that animal survive in its environment. You could do the same with the dinosaurs, which are also featured in *Evolving Planet*.
5. Explore other habitats and life forms of the Pacific Ocean and its islands in the *Traveling the Pacific* exhibition.

Post-Activities

1. Give students a list of different types of environments; for each environment, include as many details as possible (e.g., land or water, hot or cold, wet or dry, etc.). After explaining that adaptations are features that contribute to an organism's success (i.e., survival) in its environment, have students make a hypothetical animal that would live in that environment, detailing three adaptations that help it survive in the environment.
2. Charles Darwin traveled the world, collecting all types of animals, plants, and fossils. From China to Africa to Peru to Wyoming, Field Museum scientists travel around the world, too! Visit their field sites and see them dig up dinosaur bones and more at <http://www.fieldmuseum.org/expeditions/>. Have students select one Field Museum scientist and write a one-page narrative of their research and discoveries.

Answers to Guiding Questions

1. The Galápagos Islands are a group of volcanic islands in the Pacific Ocean, west of the mainland of Ecuador.
2. Fossils are the remains or traces of organisms that were once alive. They can include bones, trackways, skin impressions, etc.
4. Paleontology is the science that investigates extinct organisms and the history of life on Earth by studying the fossil record.
5. An adaptation is a feature that contributes to an organism's success and survival in its environment.

Returning to England, Darwin settled in London and began the real voyage of his lifetime—an intellectual journey that continued for years as he examined the specimens he had brought back from his trip and began writing up his research. A number of these specimens are on display here, from lichens to finches, along with the notebooks in which he analyzed them and letters to colleagues that show the development of his thinking. It was in London that Darwin’s revolutionary ideas began to unfold, as dramatically illustrated in the first evolutionary tree Darwin sketched in his notebook. Fascinating displays point out not only the concepts Darwin explored but the evidence on which he based his theory.

The London years were also the period when Darwin wooed and won his cousin, Emma Wedgwood, whose family is best known for their superb pottery. (The exhibition includes—early on—the famous Portland Vase given by Josiah Wedgwood to Erasmus Darwin, Charles’s grandfather.) Visitors will be charmed by Charles and Emma’s love letters, and by Darwin’s personal notes debating with himself whether or not to marry.

At Down House, where Darwin spent the next 40 years, he continued to refine his theory while studying barnacles, pigeons, and plants. He wrote of his ideas at last to the botanist Joseph Hooker, saying it was “like confessing a murder.” Still, he didn’t publish his theory until a similar one advanced by Russel Wallace forced his hand.

Visitors will find themselves transported to Down House through a large-scale, time-lapse video of the sandwalk path Darwin created on its grounds. Darwin often strolled here, observing, experimenting, and contemplating as he walked. Near it is a painstaking reconstruction of Darwin’s study, with many objects brought from Down House itself. In the study visitors will see Darwin’s microscope and other research tools, the walking stick he used on the sandwalk, specimen bottles, and more. Also on display is one of the few existing manuscript pages from *The Origin of Species*, along with a first edition of the published book.

Down House was also where Darwin did his research and where the couple raised their children; ten were born to Emma, though two died as infants. Of all Darwin’s treasures shown here, the one that may have been dearest to him is a small wooden writing box filled with keepsakes of his daughter Annie, who died of tuberculosis at the age of ten.



An elaborate reproduction of Charles Darwin’s study from Down House is one of the centerpiece attractions of **Darwin**.
Photo: © Denis Finnin, AMNH

Guiding Questions

1. What is the Down House?
2. What is the sandwalk, and why was it important to Darwin?
3. Where is London?

Pre-Activity

1. In London and at the Down House, Darwin's ideas were beginning to unfold. He studied a host of different organisms, including lichens, barnacles, and finches. Have students visit <http://animaldiversity.ummz.umich.edu/site/index.html> and become familiar with these life forms.

Field Trip Activities

1. Ask students to locate three types of organisms that Darwin studied during his years in London and at Down House. What did he learn from these organisms, and how did his study of them contribute to his theories on evolution?
2. Ask students to explore the recreation of Darwin's study at Down House. What tools or equipment do you see? What can you infer about how Darwin did science? Have students share their ideas as a group.

Post-Activity

1. Ask the students to imagine that, in 100 years, a museum decides to make an exhibition about them. If the exhibit were to feature artifacts to tell their story, what types of artifacts would they be? What story do you hope they share, and why?

Answers to Guiding Questions

1. Down House was Darwin's home from 1842-1882; it is located 16 miles outside London. There, Darwin formulated his ideas of evolution by means of natural selection.
2. The sandwalk is the walking trail at Down House. Darwin would take his daily walks along the trail, collecting his thoughts on his revolutionary ideas.
3. London is located on the southern portion of England, north of the English Channel.



Skull of *Australopithecus africanus*.

The final sections of the exhibition deal with the science of evolution and the refinements it has undergone since Darwin's time, as new research methods are developed and new information gained. Visitors can learn more about the workings of natural selection and some of its recent applications in a science theater video that includes two segments from the PBS series, *Evolution*. Displays delve into the meaning of "theory" in science and the controversial subject of "social Darwinism." And several prominent biologists discuss their views on reconciling science and faith.

Several interactive stations in this section help visitors understand concepts that are central to evolution, such as homologies (similarities in structure that indicate two species evolved from a common ancestor), adaptation to the environment, and natural selection. The current understanding of our own ancestry—a family tree depicting



Skull of *Homo neanderthalensis*.



Skull of *Homo sapiens*.

Photos: © 2006 The Field Museum, A114414_11d, A114414_08d & A114414_02d, Photographer John Weinstein

Guiding Questions

1. What is evolution?
2. What is homology?
3. How are today's scientists still influenced by the work of Charles Darwin?

Pre-Activity

1. Science is changing all the time! Scientists discover new evidence, and that evidence may force them to alter their existing ideas. The ancestors of whales, for example, were once tied to an extinct group of mammals called mesonychids, but scientists now think that whales evolved from a type of even-toed hoofed mammal (artiodactyls). Before Darwin's revolutionary idea of natural selection, Lamarck thought that evolution occurred by organisms passing acquired traits onto their offspring. Have students research these and other such topics in science (e.g., medicine, topics related to dinosaurs, etc.) to see how scientists have changed their ideas in those topics.

Field Trip Activities

1. Have students explore the *Nowhere to Hide* interactive. What insects survive when the leaves are green? What happens to these insects when you change the color of the leaves? Why?
2. Ask students to watch the *Natural Selection* video. What are the five components of the underlying mechanism of natural selection? [Answer: variation, inheritance, selection, time, and adaptation] Define each in two to three sentences.

Post-Activities

1. With their new understanding of natural selection, have students write a short narrative that follows the history of a group of imaginary organisms, showing how certain traits allow some members of the group to survive and pass on those traits to their offspring. The narrative should follow through three generations, and it should include the five components (variation, inheritance, selection, time, and adaptation) seen in the *Natural Selection* video of Darwin.
2. Have students reflect on how one person—Charles Darwin—was able to make an incredible contribution to our understanding of the world.
3. The work of Darwin lives on at The Field Museum! Visit the state-of-the-art Pritzker Laboratory for Molecular Systematics and Evolution and explore how Field Museum scientists are studying DNA to unravel the evolutionary relationships of frogs, birds, and other organisms. On-line at http://www.fieldmuseum.org/research_collections/pritzker_lab/pritzker/lab_projects/project_frame.html.

Answers to Guiding Questions

1. Evolution is the accumulation of inherited changes in populations of organisms over the course of generations. Evolution explains how species change over time and evolve into new species, and how what we see today may differ from the past. Evolutionary theory explains the diversity of life through the process of descent with modification.
2. Homology is a similarity in structure, physiology, or behavior in two species due to inheritance from a common ancestor, whether or not the function is the same (e.g., the bones in the human arm and a bat's wing are homologous structures).
3. Numerous scientists are investigating the natural world today—whether fighting viruses, decoding DNA, or analyzing the fossil record—have found Darwin's theory of natural selection essential to their work. For example, scientists studying flu viruses can anticipate which new varieties might evolve to become most harmful in the near future. They can then create vaccines designed to help the body's immune system ward off most of the upcoming year's varieties, a process that has saved countless lives.

Part II: Resources for Teachers and Students



This caricature of a young Charles Darwin riding a giant beetle was drawn by fellow beetle collector Albert Way in 1832.
Image: © By permission of the Syndics of Cambridge University Library

Scientists from the BOTANY, GEOLOGY, and ZOOLOGY DEPARTMENTS at The Field Museum study evolution everyday! Together, they take an interdisciplinary approach in their research programs, combining fossil and living organisms together to extract information of broad evolutionary significance.

The Field Museum collections of fossils and meteorites are world-renowned, drawing researchers from around the globe to study them. The scientists in the Geology Department, together with colleagues at local universities, form one of the nation's largest concentrations of paleontologists.

Follow The Field Museum scientists at <http://www.fieldmuseum.org/expeditions> as they travel around the world to study life's evolution—past and present:

Lance Grande examines a 50-million-year-old ecosystem from Wyoming.

On-line at <http://www.fieldmuseum.org/expeditions/lance/about.html>.

Richard Kissel excavates a 12,000-year-old mastodon from our own backyard!

On-line at http://www.fieldmuseum.org/expeditions/interactive_main_content.html.

Peter Makovicky studies dinosaurs from China, South America, and North America.

On-line at http://www.fieldmuseum.org/expeditions/pete_expedition/petehome.html.

Jennifer McElwain studies fossil plants from Greenland to better understand climate change and organisms' responses.

On-line at http://www.fieldmuseum.org/research_collections/geology/geo_sites/greenland/index.html.

Greg Mueller examines the mushrooms, puffballs, bracket fungi, and boletes of Costa Rica.

On-line at http://www.fieldmuseum.org/expeditions/greg_expedition/about.html.

Bruce Patterson works in Africa on the maneless lions of Tsavo.

On-line at <http://www.fieldmuseum.org/expeditions/tsavo/about.html>.

Janet Voight dives to the depths of the ocean for her research on hydrothermal vents and the life that they support.

On-line at http://www.fieldmuseum.org/expeditions/janet2_expedition/about.html.

The Field Museum's Pritzker Laboratory for Molecular Systematics and Evolution is a multi-user core facility dedicated to the genetic analysis and preservation of the world's biodiversity. The lab serves as a research and training facility for the curatorial staff, postdoctoral associates, and undergraduate and graduate students who conduct basic research in molecular evolution and systematics. Explore their work at the sites listed below.

Shannon Hackett uses DNA research to create a family tree for birds—living dinosaurs!

On-line at http://www.fieldmuseum.org/biodiversity/scientist_feature9.html and http://www.fieldmuseum.org/research_collections/pritzker_lab/pritzker/lab_projects/project_frame.html.

Mark Westneat studies the evolutionary relationships of coral reef fishes.

On-line at http://www.fieldmuseum.org/research_collections/pritzker_lab/pritzker/lab_projects/project_frame.html.

Meet all of the scientists that work with the Pritzker Laboratory and see how they are using the information from molecules to better understand life's amazing diversity.

On-line at http://www.fieldmuseum.org/research_collections/pritzker_lab/pritzker/people/people_frame.html.

Join The Field Museum in exploring, celebrating, and protecting our planet's amazing web of life!

Have students explore the Museum's efforts at <http://www.fieldmuseum.org/biodiversity/ybc.html> and http://www.fieldmuseum.org/research_collections/ecco.htm.

Related Exhibitions at The Field Museum!

DARWIN

What did the world look like through the eyes of a 500-million-year-old trilobite? What could you see and hear in the swampy forest that was Chicago...300 million years ago? How would it feel to touch the face of our early human cousins? ***Evolving Planet*** takes visitors on an awe-inspiring journey through 4 billion years of life on Earth, from single-celled organisms to towering dinosaurs and our extended human family. Unique fossils, animated videos, hands-on interactive displays, and recreated sea- and landscapes help tell the compelling story of evolution—the single process that connects everything that’s ever lived on Earth.

Around 65 million years ago, a mass extinction wiped out at least half of all species, including all dinosaurs. Except birds! Come face to beak with the dinosaurs of today in the ***World of Birds*** and ***North American Birds*** exhibitions, and see how they live in ***Bird Habitats***.

From tiny rodents to mighty whales, mammals come in all shapes and sizes today! In ***World of Mammals***, follow the mammal family tree to see how we mammals are all related to each other. And then visit the ***Mammals of Asia***, ***Mammals of Africa***, and ***Africa*** exhibitions to see the incredible diversity of mammals inhabiting these continents. You’ll take an overseas trip without leaving the Museum!

Lizards and turtles and snakes, oh my! See what makes these and other reptiles—and amphibians—so unique in the ***Reptiles*** and ***Amphibians*** exhibition.

See animals like you’ve never seen them before. Explore the ***What is an Animal?*** and ***Animal Biology*** exhibitions to see the many unique adaptations that they’ve evolved, including their many shapes, sizes, and colors. To see animals in their habitats, visit ***Messages from the Wilderness***.

Orchids and beetles fascinated Darwin late in life. Explore the amazing diversity of plants and insects in the ***Plants of the World*** and ***Insects*** exhibitions!



Just for Educators!

Darwin (Grades 4-12)

Step inside the world of Charles Darwin—naturalist, explorer, and reluctant revolutionary. Join a Field Museum scientist on a guided tour that chronicles Darwin's life and discoveries, then explore natural selection and its impact on the theory of evolution. Be one of the first educators to model unique hands-on activities and construct a classroom timeline marking the development of the theory of evolution. Earn 3 CPDUs. Boxed dinners will be provided.

Wednesday, June 20, 2007, 5:00pm-8:00pm

\$20, members \$18

Understanding Animal Form and Function (Grades K-12)

Some animals look so strange to us that it's hard to believe they're real. But even the weirdest creatures look the way they do because it helps them survive. It's natural selection! Explore the differences and similarities between animal bodies—past and present. What can the shape, size, and other features of an animal's body tell us about its biology and evolutionary history? Learn several ways to link modern animals in *What is an Animal?* with their fossil relatives in *Evolving Planet*. Model hands-on activities that can be used with your students! Earn 3 CPDUs. Boxed dinners will be provided.

Wednesday, October 17, 5:00pm-8:00pm

\$30, members \$25

The Harris Educational Loan Center

Key to Darwin's theory of evolution by means of natural selection was the study of fossils. Teachers and parents can put real fossils in the hands of their students and children by borrowing one of these Experience Boxes for their classroom or home: *Dinosaurs and Other Mesozoic Creatures*; *Dinosaurs and their Times: Cretaceous*; *Dinosaurs and their Times: Jurassic*; *300 Million Years Ago in Illinois*; *Hominid Evolution*. See page 27 for more items!

Visit <http://www.fieldmuseum.org/harrisloan> to register and reserve your materials, or call 312.665.7555.

Home School teachers, parents and families: \$60, members \$30

School rates: Individual teachers: \$30 per year; Register 10-19 teachers: \$20/teacher;

Register 20 or more teachers: \$15/teacher

Footprints of the Past (Grades 1-4)

Students will explore the fascinating creatures that have roamed the Earth and compare them to the creatures that we see today.

Mondays-Fridays, 10:00am-12:30pm

\$4 per student

The Great Fossil Hunt (Grades 3-8)

Students will learn about the process of fossilization as they unearth and prepare dinosaur bones for display, discovering what fossils can tell us about the past.

Mondays-Fridays, 10:00am-12:30pm

\$4 per student

The Life of Earth (Grades 5-7)

Students will explore this amazing planet we call Earth and how it has evolved to take the form we see today.

Mondays-Fridays, 10:00am-12:30pm

\$4 per student

Evolution 101 (Grades 9-12)

Join us for an in-depth look at the basics of evolution and its importance to scientific research. Tour Evolving Planet and other exhibitions to understand first-hand how evolution works in nature.

Mondays-Fridays, 10:00am-12:30pm

\$4 per student

High School Press Preview

High School journalists—join us for a private tour and dialog with the actual exhibition designers and scientists. You can even enter a publication contest by submitting your newspaper article on the exhibition! This program is free to middle and high school journalism staff accompanied by advisors/chaperone, and includes entrance to the museum for the day as well as your ticket to the accompanying exhibition.

Friday, October 19, 2007, 9:00am-12:00pm

Pre-registration required. Call 312.665.7506 for more information.

Lecture

Darwin: Discovering the Tree of Life

Dr. Niles Eldredge, Curator, Division of Paleontology, American Museum of Natural History
Charles Darwin's ideas resonate deeply in Western culture today, and his theories still lie at the heart of modern scientific evolutionary research. Hear an engaging account of Darwin's life by Dr. Niles Eldredge, lead curator of *Darwin*, with emphasis on the intellectual journey that led Darwin to his theory of evolution.

Thursday, June 14, 2007, 6:00pm

*General seats \$9, students/educators \$8, members \$5 (includes a viewing of **Darwin**)*

Adult Field Trips

Introduction to Rock Identification and Fossil Collecting

Travel to the abandoned mines near Mazon Creek to collect rock and fossil specimens and learn about the basics of rock identification, fossil as indicators of ancient environments, and how a geologist uses these specimens to interpret the area's geologic story.

Saturday, September 29, 2007, 8:00am-3:00pm

\$70, members \$49

Pre-registration required.

Fossil Hunting at Larson Quarry

Reconstruct the Illinois landscape of 425 million years ago when a shallow, subtropical sea covered the area. You'll learn about the organisms that lived in this ancient environment and discover techniques for finding the fossils that time left behind.

Saturday, October 13, 2007, 7:00am-1:30pm

\$65, members \$45

Pre-registration required.

Film Screening

Margaret Mead Film Festival

The Margaret Mead Film & Video Festival is the longest-running showcase for international documentaries in the United States, encompassing a broad spectrum of work, from indigenous community media to experimental nonfiction. Each year the Traveling Festival brings highlights from the Mead Festival to sites throughout the United States and abroad, providing access to innovative work from around the world.

• **Featured Film: *Flock of Dodos***

Who are the dodos in the current debate over evolution versus intelligent design? Marine biologist turned filmmaker Randy Olsen travels the country in search of an answer. He starts with his 82-year-old mother who is neighbors with the top lawyer for intelligent design in Olson's home state of Kansas, which is the epicenter of the controversy. This film gets beyond the tedium of the "debate" of who's right and who's wrong. Instead, it explores how those who embrace each side are "communicating" their ideas to the public.

A panel discussion will follow the screening.

Saturday, October 27, 2007

Free with basic admission

2:00pm film screening, 3:30pm panel discussion

Family Field Trip

Fossil Hunt at Mazon Creek

Do you like to hunt for fossils? Come with us to the world-famous Mazon Creek site, and discover what Illinois was like more than 300 million years ago! Plan on a one-quarter mile walk to fossil locations. For families with children ages 8-17.

Saturday, August 25, 2007 OR Saturday, September 15, 2007, 8:00am-3:00pm

\$40, members \$30

Pre-registration required.

Family Workshops

Darwin, The Beagle, and the Box

What methods did Darwin use to collect and sort his findings while traveling on the HMS *Beagle*? Families are invited to not only learn about Darwin's collecting techniques, but to create a specimen box of their own in this fun and informative family workshop. For families with children ages 6-12.

Saturday, September 15, 2007, 10:00am-11:30am

\$16, members \$11

Pre-registration required.

Two of Us

What is evolution? Join us in this four-week excursion through the wonders of The Field Museum! Come and learn how all life on Earth is connected. Travel 4.5 billion years in only four weeks! You and your little one will travel the Museum's exhibition halls, sing songs, hear stories, touch objects, and make art projects. For each 3-5 year old child with paid attendance, one parent or adult chaperone attends for free. Ideal for homeschoolers!

Tuesdays, September 4 - 25, 2007, 10:00am-11:00am

\$32, members \$23

Pre-registration required.

Gallery Programs

Darwin Discovery Days

Celebrate the opening of *Darwin* with fun-filled activities for the whole family! Stop by our hands-on *Mass Extinction* interpretive station and learn what factors helped shape life on Earth. Listen to a special reading of *Life on Earth: The Story of Evolution* by Steve Jenkins and enjoy a first-person interpretation of Darwin by storyteller Fox Ellis.

Saturday and Sunday, June 16 and 17, 2007, 11:00am-2:00pm

Free with basic admission.

Scientists at The Field

Meet a Field Museum scientist and see rarely displayed specimens from our collections. Featured scientist Mary Beth Prondzinski will highlight botany specimens from the Galápagos Islands.

Saturday and Sunday, June 16 and 17, and Saturday, September 8, 2007, 11:00am-2:00pm

Free with basic admission.

Interpretive Station: Mass Extinction Game

Examine extinct organisms and learn how life on Earth has been shaped by five prehistoric mass extinctions, each wiping out more than 50% of species on the planet.

Select weekends. Please check the kiosk on the day of your visit for a list of activities.

Free with basic admission.

Kraft Story Time

Take a seat in one of our exhibition halls, hear a story, and make an art project to take home, all in 20 minutes! Featured titles in June include *Life on Earth: The Story of Evolution*, by Steve Jenkins; *Each Living Thing*, by Joanne Ryder; *Tree of Life: The Incredible Biodiversity of Life on Earth*, by Rochelle Strauss and Margot Thompson.

Weekends in June; 1:30pm

Free with basic admission.

Visit us at on-line <http://www.fieldmuseum.org/harrisloan>, or call 312.665.7555

Experience Boxes

Fossils show that life changes over time. Discover the history of life on Earth—and how that life has changed through time—with...

Dinosaurs and Other Mesozoic Creatures

Use fossils, fossil replicas, and timeline charts to learn about dinosaurs and other Mesozoic plants and animals. Pre-K and higher.

Dinosaurs and Their Times: Cretaceous

Place models of various Cretaceous Period dinosaurs—*Tyrannosaurus*, *Maiasaura*, and *Triceratops*—in a classroom diorama. Kit includes casts of a *Tyrannosaurus* tooth and claw. Especially recommended for Pre-K through first grade.

Dinosaurs and Their Times: Jurassic

Jurassic Period dinosaur models—*Apatosaurus*, *Diplodocus*, *Brachiosaurus*, *Stegosaurus*, and *Allosaurus*—are placed in a classroom diorama. Kit includes casts of an *Allosaurus* tooth and claw, posters, and books. Pre-K and higher.

Studying African Wildlife

Learn how scientists study Africa's many ecosystems and wild animals by using tools such as rain gauges, soil probes, or stopwatches. Videos show scientists working in the field. K-8.

And don't stop there; adaptations are everywhere! Explore how different mammals have adapted to different diets with...

Bite, Tear, or Chew

Compare skulls of a carnivore, an herbivore, and an omnivore. Find out how teeth reveal what an animal eats. K-8.

Humans evolve, too. Discover your own ancestry and learn about the evolution of the hominid family tree with...

Hominid Evolution

Explore how early hominids became bipedal; developed larger bodies and brains; and developed tools, language, and agriculture. Includes casts of early stone tools and exact replicas of early hominid skulls. 9-12.

Exhibit Cases

See animal adaptations up close and personal! Fill your classroom with all different types of birds, mammals, reptiles, amphibians, fungi, and plants. Just some of the 150+ exhibit cases are...

Goldfinch	Blue Racer Snake
Goshawk Hawk	Six-Lined Lizard
Snowy Owl	Tiger Salamander
Red-headed Woodpecker	Mushrooms
Flying Squirrel	Carnivorous Plants
Red Fox	Skunk Cabbage

Darwin's study of finches and their adaptations contributed to his ideas on natural selection. Study the adaptive features of bird beaks with...

Bird Beaks

Examine the ways in which these seven different bird species use their beaks as tools, and identify their food choices based on each beak shape. Great for discussing adaptation! 9-12.

Audio/Visual

Field Trip through Time

Travel through the 3.5 billion year history of life on Earth as you explore highlights of our exhibitions on evolution (Video; 10 minutes). Day care/Pre-K.

Books

Evolution

The questions of life on Earth. A how-and-when book about the beginning of life on our planet. K-8

Eyewitness Science: Evolution

Explore the theory of evolution, how it works, and how we know. K-8.

Printed Material

Bird Beak Poster

Beaks as tools? See the many adaptations for different diets found in bird beaks.

Evolving Planet Educator Guide

Fossils provide evidence of evolutionary change over time. Find activities for a field trip and the classroom that related to *Evolving Planet*, the Museum's 27,000-square-foot exhibition on the history of life on Earth.

Sue Educator Guide

Perhaps the Museum's most famous resident, explore activities that relate to the world's largest, most complete skeleton of *Tyrannosaurus rex* ever

(Titles in **Bold** are Highly Recommended)

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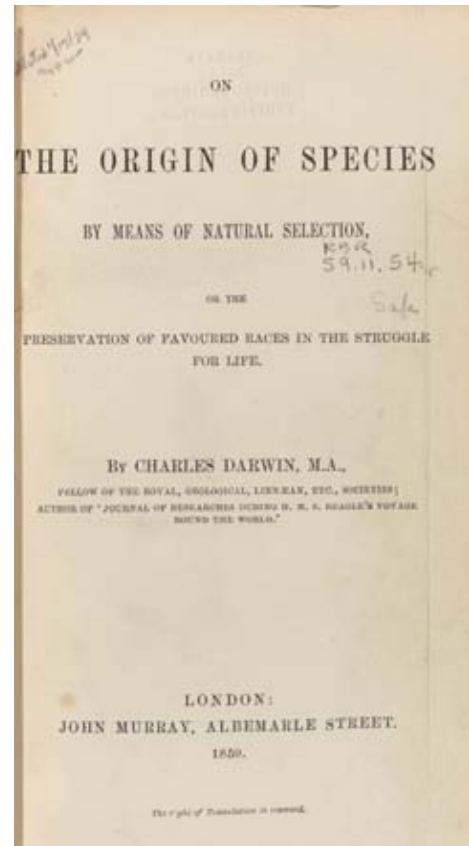
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An original manuscript page (title page of a published copy shown here) from Charles Darwin's *The Origin of Species*. Photo: © American Museum of Natural History, Department of Library Sciences

Sites for Educators

The Field Museum: *Darwin*

<http://www.fieldmuseum.org/darwin>

The Field Museum: *All About Evolution*

<http://www.fieldmuseum.org/evolvingplanet/allabout.asp>

The Field Museum: *Evolving Planet*

<http://www.fieldmuseum.org/evolvingplanet>

American Museum of Natural History: *Resources for Learning*

<http://www.amnh.org/resources>

Scholastic: *Animals, Adaptation, and the Galápagos Islands: Discover with Darwin*

<http://teacher.scholastic.com/activities/explorations/adaptation>

Geological Time

<http://pubs.usgs.gov/gip/geotime/contents.html>

University of California Museum of Paleontology: *Understanding Evolution*

<http://evolution.berkeley.edu/evosite/evohome.html>

PBS Evolution Series: *Educator Site*

<http://www.pbs.org/wgbh/evolution/educators>

American Association for the Advancement of Science: *Evolution on the Front Line*

http://www.aaas.org/news/press_room/evolution

National Science Teachers Association

<http://www.nsta.org/evresources>

National Center for Science Education

<http://www.ncseweb.org>

Sites for Students

The Field Museum: *Expeditions @ The Field*

<http://www.fieldmuseum.org/expeditions>

University of California Museum of Paleontology: *Understanding Evolution*

<http://evolution.berkeley.edu/evosite/evohome.html>

The American Museum of Natural History: *Ology*

<http://ology.amnh.org>

1809 - Charles born to Susannah and Robert Darwin in Shrewsbury, England.

1817 - Susannah Darwin died.

1818 - Charles became a boarder at Shrewsbury School.

1825-27 - Charles studied medicine at Edinburgh University, Scotland.

1828-31 - Charles studied to become a minister at Cambridge University, England.

1831-36 - Charles sailed around the world as a naturalist on the HMS *Beagle*.

1839 - January: Charles married his cousin Emma Wedgwood.
May: Publication of *A Naturalist's Voyage*.
December: Birth of William, the first of Emma and Charles's ten children.

1842 - The Darwin family moved to Down House, Kent.

1844 - Charles wrote a 230-page essay on the origin of species.

1846 - Charles began his study of barnacles that would last eight years.

1848 - Charles's father, Robert Darwin, died.

1851 - Daughter Annie died.

1859 - Publication of *On the Origin of Species*.

1871 - Publication of *The Descent of Man*.

1876 - Charles wrote his autobiography.

1881 - Publication of *The Formation of Vegetable Mold through the action of Earthworms*.

1882 - Charles died at Down House. He was buried in Westminster Abbey beside Sir Isaac Newton.

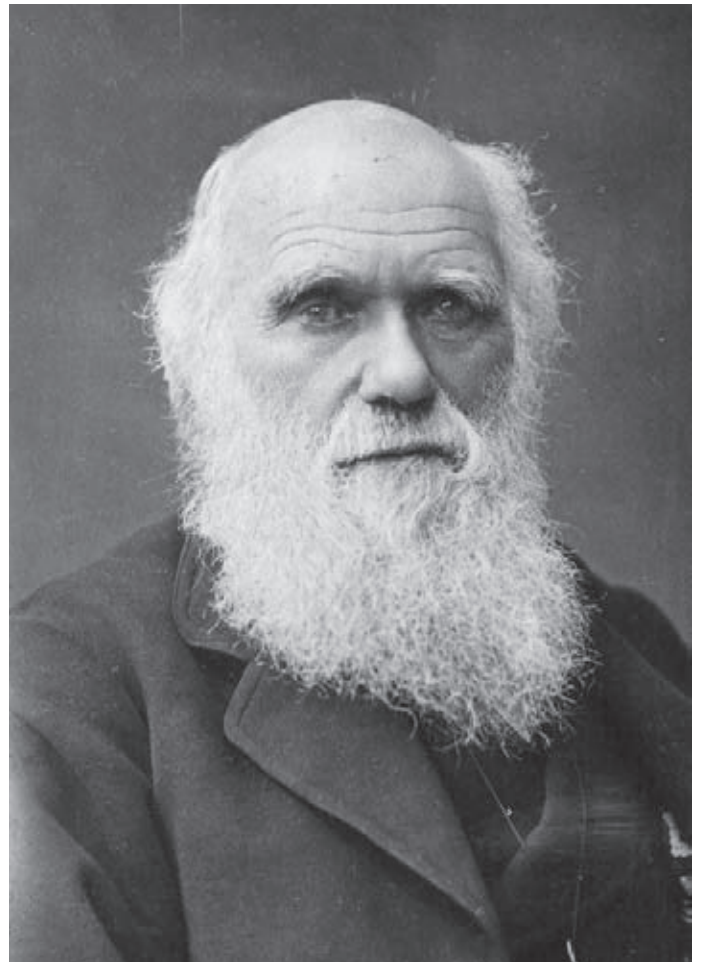


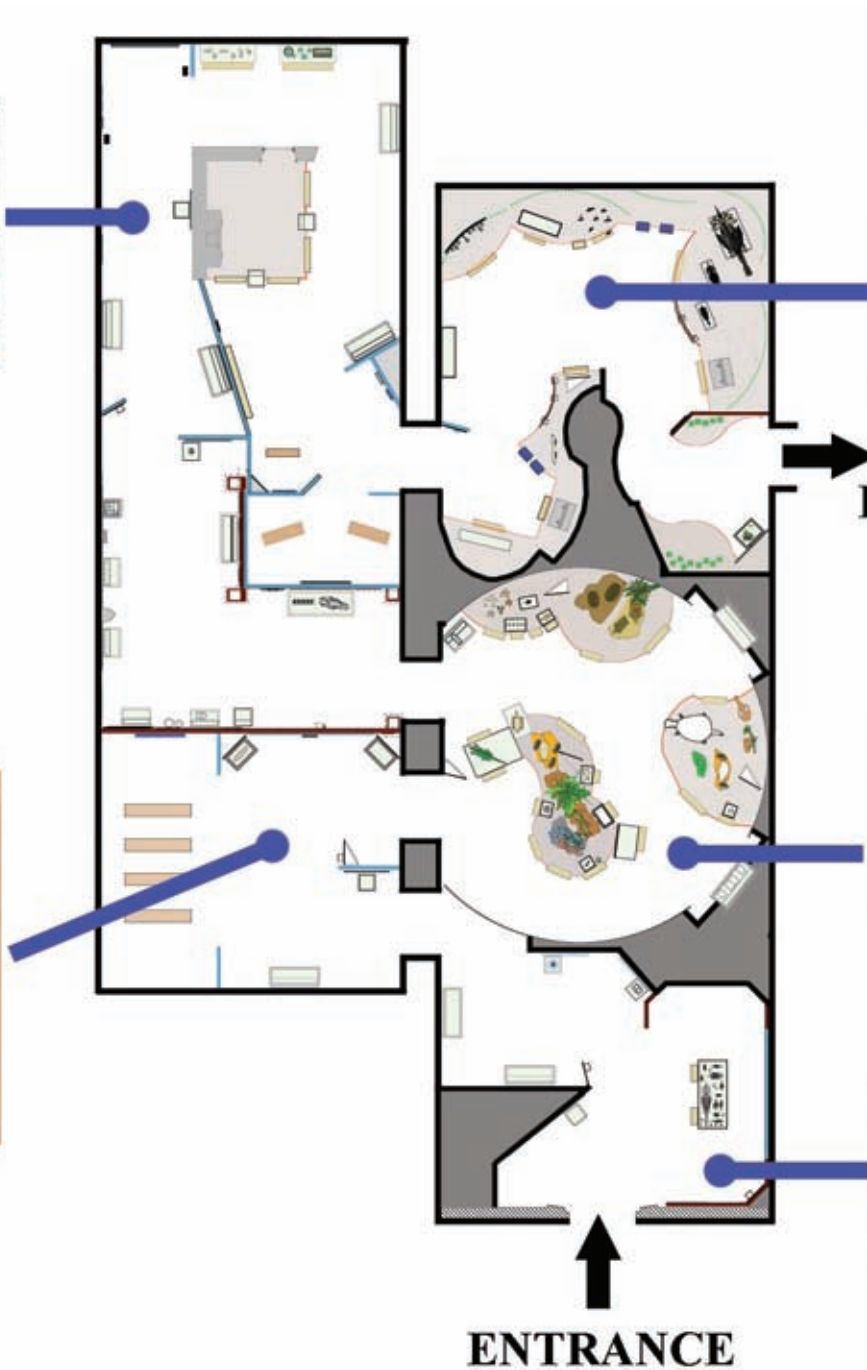
Photo:© Richard Milner



The Idea Takes Shape



A Young Naturalist



Evolution Today



A Trip Around the World



The World Before Darwin

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