Starting in the 1830s, British naturalist Charles Darwin suggested and developed some ideas about evolution that revolutionized the field of biology. Biological evolution, or evolution, is a change in the genetic composition of a population that gives rise to new life forms from common ancestors. Darwin’s thinking was influenced by the ideas of several other people who worked before and during his time.

Challenge

How did Darwin build on his and others’ work to develop his ideas about natural selection and evolution?

Materials

For each student

3 sticky notes

Student Sheet 4.1, “Scientists, Ideas, and Events that Influenced Darwin”

Procedure

1. As you read, follow the “Read, Think, and Take Note” strategy. To do this:
   - Stop at least three times during the reading to mark on a sticky note your thoughts or questions about the reading. Use the list of guidelines on the next page to start your thinking.
   - After writing a thought or question on a sticky note, place it next to the passage in the reading that prompted your note.
   - Discuss with your partner the thoughts and questions you had while reading.

Charles Darwin
Reading

Before Darwin

In the early 1800s, naturalists had begun to consider the idea that species of living things are not fixed, a revolutionary idea at the time. Instead, they suspected, species have undergone changes ever since they first evolved on earth.

In France, Jean-Baptiste Lamarck was one of the naturalists considering changes in species. In 1809 (the year Charles Darwin was born), Lamarck published *Zoological Philosophy*, a book that presented one of the first theories of evolution. He suggested that when the environment changes, organisms must also change in response if they are to survive. He favored a mechanism for evolution proposed by earlier scientists that was based on use and disuse of organs. He stated that, for example, if giraffes continually stretched their necks to reach high treetops for food, their necks could lengthen over their lifetime, and their offspring could inherit these changes. If an animal did not use a particular organ, the organ would become smaller from one generation to the next or disappear entirely. Lamarck’s theory would say, for example, that because snakes could slither through the grass, the legs of snake species gradually became smaller and smaller.

Lamarck was ignored or attacked by most of his colleagues for his theory of use and disuse because he had no evidence for his mechanism, and many of his ideas were pure speculation. Today, his theory is not accepted because scientists’ investigations of heredity have shown that acquired characteristics (characteristics that develop during life, that are not inherited), such as strong muscles due to exercise, are not passed through from the body to the genes, and are not, therefore, passed on from parents to offspring.
Darwin’s Observations on the Galapagos Islands

In 1831, one of Darwin’s college professors recommended him to Captain Robert Fitzroy to join the voyage of the HMS Beagle, a survey ship that would travel all over the world. Appreciating Darwin’s education and impressed by his wealthy background, Fitzroy accepted the 22-year-old Darwin on board.

While at sea Darwin read the first volume of Charles Lyell’s recently published *Principles of Geology*. The main point of Lyell’s book was that the geology of the earth in its present form helps explain the geologic past. Lyell proposed that large-scale geologic change results from small changes over extremely long periods of time. For example, the slow erosion of rock over many years can lead to the formation of a canyon. In addition, he, as had others, thought that the earth was much older than several thousand years.

Over the five years of the voyage, Darwin observed and collected a variety of animals, plants, and fossils to bring back to England. His work on the voyage included explorations on land in South America where he noted geological formations, and several weeks studying the organisms on the Galapagos Islands, about 970 km off the coast of Ecuador. Those 10 islands, as Darwin observed, were all formed from volcanic rocks and all had similar soil, climates, elevation, and size. He also noticed that the plants and animals on the islands had adapted to all kinds of environments.
Darwin made extensive observations of the Galapagos plants and animals. He wondered why the species on each island differed from each other but were much more like each other than species elsewhere.

Among the organisms Darwin brought back to England were the now-famous Galapagos finches. Darwin had collected a number of birds that he assumed were blackbirds, grosbeaks, and woodpeckers because they varied so much in beak structure, tails, and body form. Showing his collection to England’s bird experts, he was surprised to learn that his birds were all members of 13 closely related species of finches. He had seen one group of finches often climbing around the flowers of cactus trees, while another group tended to flock together and feed on seeds on the ground. For each species of finch the birds’ beaks were suited to the food sources available on the island they lived on. Although Darwin examined many other groups of organisms, including mockingbirds and tortoises, the finches became best known because they showed how a diverse group of species could evolve through natural selection from a common ancestor that originated on the mainlands.
Variety and Artificial Selection through Breeding

Back in England as he thought about the patterns of organisms on the islands—different from and yet similar to those on the mainland—Darwin began to develop his ideas about biodiversity. From pigeon breeders he learned that selective breeding could be used to produce a great variety of pigeons in a relatively short period of time. A breeder would cage two individual pigeons with a desirable trait together to mate in order to obtain offspring that inherited and reinforced that trait. These improved offspring were then selected for further breeding, and the breeder would continue the process for generations. Meanwhile, another breeder would be mating his pigeons for another desirable trait. People had applied such artificial selection for thousands of years in breeding better crops and animals. Dogs, cows, corn, and tulips are just some of the organisms modified by humans through selective breeding.

Darwin became so fascinated with this that he began to breed pigeons at his home. In observing characteristics of tails, heads, beaks, and necks, he was once again astonished by the variety he could bring out among the pigeons, an astonishment similar to when he understood the variations among finches on the Galapagos. He also learned that if he crossbred varieties of pigeons, some offspring would resemble the birds he first started with when he began breeding. Darwin considered how this great variety might arise in nature. He wrote in his autobiography:

After my return to England, it appeared to me that by following the example of Lyell in Geology, and by collecting all facts which bore in any way on the variation of animals and plants under domestication and nature, some light might be thrown on the whole subject. I soon perceived that selection was the keystone of man’s success in making useful races of animals and plants. But how selection could be applied to organisms living in a state of nature remained for some time a mystery to me.

Darwin’s breakthrough came in reasoning that the selection produced artificially by humans might occur in all sorts of species, as a result of changes in the environment. Also in his autobiography he wrote:

In October 1838, that is, fifteen months after I had begun my systematic inquiry, I happened to read for amusement Malthus on Population, and being well prepared to appreciate the struggle for existence which everywhere goes on from long-continued observation of the habits of animals and plants, it at once struck me that under these circumstances favorable variations would tend to be preserved, and unfavorable ones to be destroyed. The result of this would be the formation of new species. Here, then, I had at last got a theory by which to work.

Thomas Malthus

A British economist who proposed in an essay in 1798 that human population growth will always exceed the amount of food available to feed the population, Malthus argued that the geometric growth of the human population would lead to starvation and suffering by the poorer members of society. He suggested that individuals in the population compete with each other for limited resources. Those successful in competing would survive, while those who failed were doomed to starvation.
The Origin of Species

Darwin spent the next 20 years gathering more facts for the theory of natural selection. While he planned to write a large work on the theory, he spent time on many other projects as well. In 1858, however, another world-traveling naturalist, Alfred Russel Wallace, sent Darwin a summary of his own theory of evolution in which he drew conclusions similar to Darwin’s. Wallace requested that Darwin, who was a respected naturalist, send the paper to the Linnaean Society, a group of influential naturalists of the day. Through Lyell and others, a meeting of the Linnaean Society was organized to present both men’s work together. Soon after, in 1859, Darwin published his thorough and detailed explanation of natural selection in his book *On the Origin of Species.*

In *On the Origin of Species,* Darwin laid out his evidence that all living species change through a series of steps, as characteristics slightly more favorable to surviving in a particular environment are preserved successively over time. An accumulation of enough of these changes would give rise to a new species. In addition to recognizing that all species diverge and change through evolution, Darwin proposed that these changes take place through what he called **natural selection.** He reasoned that if breeders could use artificial selection to create dramatic changes in species over short periods of time, natural processes could lead to change over very long periods. As Darwin saw it, natural selection explained the differences in closely related species. The Galapagos finches provided an example of how an original small population could evolve into a number of different species. Because they are most closely related to South American finches, it appears that these finches first arrived on the islands from the mainland, perhaps as a result of storms that blew them off course.

Likely scattered among the 10 islands, individuals in the population encountered new food sources and habitats, which differed from island to island. The beaks of individual finches from the mainland would have had a certain amount of variation in their shapes and sizes. Those individuals with beaks that could feed easily on available food sources survived longer, reproducing more offspring that inherited the genes for similar traits. Over an unknown number of generations, this resulted in finches with different beaks in different habitats, depending on whether the type of food available was seeds, insects, or fruit. Long, pointed beaks, for example, were well suited for digging seeds out of cactus fruits. Short, wide beaks were best for eating seeds from the ground. Thin, sharp beaks were suited to catching insects. At the same time, other changes in characteristics, such as body size, tail shape, and behavior were also accumulating in the populations. Gradual accumulations of these changes through natural selection eventually led to the separation of a population into different species.

**Alfred Russel Wallace**

**Considered the co-discoverer** of natural selection, Alfred Russel Wallace is also known for his accomplishments in the field of biogeography. One of his key contributions was to divide the world into seven major biogeographical areas. The name “Wallace’s Line” was given to the divide between Southeast Asia and the Australia and New Zealand region because the plants and animals in the two areas were very different even though they were geographically close to one another.
In *The Descent of Man*, published in 1871, Darwin identified another mechanism for evolution, which he called sexual selection. **Sexual selection** refers to differential reproduction resulting from variation in the ability to obtain mates. For example, female peacocks tend to preferentially mate with males that have showy tail feathers. Darwin distinguished this type of selection from natural selection because these features are not necessarily adaptive for the conditions of life; they promote reproductive success in a very different way that in some cases may even conflict with natural selection. For example, the showy tail display of a male peacock attracts potential female mates leading to increased reproduction, but may also attract predators, reducing survival.

Darwin’s famous work drastically changed the field of biology. His story reflects how science progresses and theories are developed. Theories are complex and require support from a large body of evidence from many independent sources. **Evidence** is information used to support or refute a claim. Darwin made careful observations and thought about the patterns he saw while also thinking about ideas he learned by reading and talking to other scientists. His breakthrough came in putting these ideas together and providing a detailed description for how natural selection and sexual selection could give rise to diverse life forms from common ancestors. Since its development, a large body of evidence has been gathered to support the theory of natural selection, which provides a logical, scientifically tested explanation for the evolution of life.

**Analysis**

1. Look carefully back at the reading and write a five-to-eight sentence summary about who influenced Darwin’s thinking and how they did so.

2. What did you learn from Darwin about how a scientific theory is developed?

3. a. What kinds of traits evolve through natural selection? Give a few examples.
   
b. What kinds of traits do not evolve through natural selection? Give a few examples.

**KEY VOCABULARY**

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<thead>
<tr>
<th>biological evolution</th>
<th>natural selection</th>
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<td>evidence</td>
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