



## The Making of a Theory: Fact or Fiction

### OVERVIEW

This activity supports the viewing of the film [The Origin of Species: The Making of a Theory](#). Before and after watching the film, students discuss and evaluate several statements about Charles Darwin, Alfred Russel Wallace, and the specific evidence that led each of them to the theory of evolution by natural selection. This activity serves as an anticipation guide to focus students on several key concepts covered in the film. It can also be used as a pre- and post-assessment.

Additional information related to pedagogy and implementation can be found on [this resource's webpage](#), including suggested audience, estimated time, and curriculum connections.

### KEY CONCEPTS

- Charles Darwin and Alfred Russel Wallace *independently* discovered the natural origin of species and formulated the theory of evolution by natural selection based on distinct sets of observations and facts.
- The natural origin and evolution of species provide scientific explanations for both the diversity and unity of life as well as the sequence of changes found in the fossil record.
- Natural selection acts on variation among individuals within populations. The differential survival and reproductive success of individuals with different traits causes populations to change from one generation to the next.
- By comparing organisms living today with the fossil records of extinct organisms, it is possible to reconstruct an evolutionary history and infer lines of evolutionary descent.
- Observations of the natural world raise questions. Scientific explanations provide answers to such questions, which can then be tested using additional observations and evidence.
- Communication among scientists plays a crucial role in scientific discoveries.

### STUDENT LEARNING TARGETS

- Evaluate claims based on information and evidence presented in a film.
- Participate in a collaborative discussion of evidence and its interpretations.

### PRIOR KNOWLEDGE

In order to answer the questions before watching the film, it is helpful for students to:

- have heard of Darwin and Wallace
- be familiar with the terms “evolution” and “natural selection”

For students who have not been exposed to these concepts, the film can serve as an introduction.

### TEACHING TIPS

- There are multiple ways to structure this activity. A few examples are as follows:
  - Students can complete the “Before” section (5–10 minutes) and then watch the film (30 minutes) in class. They can finish the “After” section the next day in class, then have a class discussion.
  - Students can complete the “Before” section in class, then watch the film as homework. They can complete the “After” section the next day in class, then have a class discussion.
- After students have completed the activity, you may have them consider additional questions, such as:

- What are the key facts and observations presented in the film that led Darwin and Wallace to the *natural origin of species* — in other words, the idea that species descend from other species?
- What is the evidence for *natural selection* as a mechanism of evolution?
- How did different observations, from different places, lead to the same conclusions?
- One point you might want to highlight for students is that the glyptodont/armadillo showed variation over time, whereas the mockingbirds and tortoises showed variation over space. Ask students how each of these types of evidence helped Darwin reach his conclusion about the origin of species.
- The [film activity for The Making of a Theory](#) provides more supporting resources for the film.
  - The “Educator Materials” contain additional information about the events leading up to the formulation of the theory of evolution by natural selection and about Wallace’s and Darwin’s lives. Consider providing students with a copy of the background information in the document to read in preparation for watching the film.
  - The “Student Handout” contains more questions that can be used to probe students’ understanding of the key concepts addressed in the film.

## PROCEDURE

### Before Watching the Film

Have students work in pairs to complete the section labeled “Before Watching the Film” in the “Student Handout.” Let them know that they are not supposed to know all the answers at this point. They should just record their best guess for each statement based on what they already know. They should also record their reasoning in the space provided after each statement.

### During the Film

Have students record information and evidence for or against each claim, as given in the film, in the section labeled “After Watching the Film.”

### After Watching the Film

Have students work in pairs to discuss the accuracy of the statements based on information presented in the film. They should record their evaluations for each statement in the “After Watching the Film” section.

Depending on available time, have a class discussion about each of the statements and whether they are true or false. Make sure that students support their claims with information and evidence from the film.

## ANSWER KEY

Students should assess each statement based on the information presented in the film. Some additional information not in the film is included below and can be used for supporting background and discussion.

1. Most Europeans living around Darwin and Wallace’s time, including most European scientists, believed in special creation, meaning that God created each species on Earth in its present form.

**True.** The film mentions that in Darwin’s time, most Europeans, including Darwin himself, believed that God had created Earth and all of the organisms living on it in their current forms. Although the ancient Greeks, non-Western cultures, and even some naturalists in Europe had put forth ideas about evolution prior to Darwin’s and Wallace’s work, these notions were often marginalized by the prevailing dogma of special creation.

Darwin and Wallace made observations of the natural world. The evidence they collected did not support the idea that God created species in their present form and unchanging. Their observations and evidence were instead consistent with a natural origin of species.

In his autobiography, Darwin wrote:

*The old argument of design in nature, as given by Paley, which formerly seemed to me so conclusive, fails, now that the law of natural selection has been discovered. We can no longer argue that, for instance, the beautiful hinge of a bivalve shell must have been made by an intelligent being, like the hinge of a door by man. There seems to be no more design in the variability of organic beings, and in the action of natural selection, than in the course which the wind blows.*

(Excerpt from *The Autobiography of Charles Darwin*)

Soon after the publication of *On the Origin of Species*, most scientists accepted the notion that life had evolved, but some remained skeptical about natural selection. Today, the theory of evolution by natural selection is a foundational principle of biology.

2. Before he set sail on the HMS *Beagle*, Darwin was training to be a clergyman, or minister. He was asked to join the voyage to provide company for the *Beagle's* captain.

**True.** As mentioned in the film, before embarking on his voyage, Darwin was planning to be a clergyman. He was studying at Christ's College at Cambridge. During that time, he became an enthusiastic naturalist, collecting beetles and taking classes from botany professor John Stevens Henslow. Henslow was the one who passed on the offer to Darwin to be the naturalist and traveling companion of Commander Robert FitzRoy, captain of the HMS *Beagle*. Darwin's primary job on the voyage was to provide upper-class company for FitzRoy, who wanted a naturalist and a dining companion. Darwin was well-suited for the position since he was well-educated, was an amateur naturalist, and came from an aristocratic background. For Darwin, the voyage was an extraordinary opportunity to obtain specimens for his collection, but he did not set out to understand the origin of species. The mission of the survey ship HMS *Beagle* was to chart the South American coast.

3. The observation that fossils of extinct organisms are found where similar organisms live today can be explained by the fact that species don't change over time.

**False.** In the film, we see that Darwin discovered the fossil remains of large glyptodonts, which are very similar to, though much larger than, present-day armadillos. The living tree sloths and armadillos appeared to have succeeded earlier related species, but they are not the same species. The clustering of similar species in space (that became different over time) suggested that each species had descended with modification from common ancestors.

The fossil record was a critical piece of evidence for Darwin's formulation of evolutionary theory. But Darwin realized that the fossil record was imperfect. In *On the Origin of Species*, he predicted that the fossil record should contain fossils of creatures with transitional features. Many transitional fossils have been identified today.

*Lastly, looking not to any one time, but to all time, if my theory be true, numberless intermediate varieties, linking closely together all the species of the same group, must assuredly have existed; but the very process of natural selection constantly tends, as has been so often remarked, to exterminate the parent-forms and the intermediate links. Consequently evidence of their former existence could be found only amongst fossil remains, which are preserved, as we shall attempt to show in a future chapter, in an extremely imperfect and intermittent record.*

(Excerpt from *On the Origin of Species*, Chapter 6: On the Absence or Rarity of Transitional Varieties)

4. Darwin was eager to share his ideas about evolution with the rest of the world, so he wrote and published his book, *On the Origin of Species*, in just two years after returning from his voyage on the HMS *Beagle*.

**False.** As mentioned in the film, Darwin knew that his ideas about evolution would be shocking to most people because they contradicted special creation. So, after returning from his voyage on the HMS *Beagle*, Darwin spent years quietly and methodically amassing scientific evidence in support of his ideas, while sharing his observations and conclusions with only a few close friends. He also published many important papers on his other observations of the natural world, including ones on organisms such as barnacles, plants, and pigeons. It wasn't until 20 years after returning from his voyage that Darwin finally felt compelled to publish *On the Origin of Species*. He did so because Alfred Russel Wallace had sent him a summary of his own ideas about evolution, natural selection, and the origin of species.

Wallace had written to Darwin asking him to publish his (Wallace's) theory if he viewed it favorably. Darwin asked two of his friends and colleagues, geologist Charles Lyell and botanist Joseph Hooker, to review the manuscript. Lyell and Hooker decided that the fairest course of action would be to publish Wallace's essay and Darwin's work simultaneously. They announced that both Wallace and Darwin had independently reached the same conclusions.

5. The observation that the more similar two species are, the closer they tend to live geographically is evidence that species descend from other species.

**True.** As shown in the film, Wallace extensively traveled the Malay Archipelago for eight years, collecting specimens and recording their locales. During this time, Wallace noted that similar species were found in similar geographical areas. For example, certain species of butterflies were found only in the Americas, whereas other types were found only in Asia; the same was true for many other animals. Through this research, Wallace surmised that species descend from similar, nearby species.

Wallace later noticed a clear divide running through the Malay Archipelago with respect to the distribution of species. The animals on the western islands were similar to those found in Asia, while the animals on the eastern islands were more similar to those found in Australia. Wallace had effectively discovered the boundary of two converging continental plates that, over time, had juxtaposed two distinct island systems. This meant that the eastern islands had once been connected by land to Australia, and the western islands had once been connected to Asia. As a result, the species distribution that Wallace observed was consistent with the idea that species come from pre-existing, nearby species.

In 1855, while in Sarawak on the Malaysian island of Borneo, Wallace wrote a paper on the geographic distribution of species entitled "On the Law Which Has Regulated the Introduction of New Species." He proposed that "every species has come into existence coincident both in time and space with a pre-existing closely allied species." Wallace described that species have evolved over time, with some species becoming extinct and new species evolving from earlier forms. Wallace is often referred to as the father of modern biogeography.

6. The finger bones inside manatee and whale flippers are evidence that these living species are modified forms of older species.

**True.** The film shows that Wallace wondered why "imperfections," such as finger bones in whale flippers, existed. Whales don't grasp and manipulate objects with their flippers, so why would they need finger bones? Why would seemingly useless structures be present if every species was specially created? Both Wallace and Darwin searched for a scientific explanation for these questions. They concluded that the presence of such structures was consistent with the theory of descent with modification, as the finger bones in whale flippers represented modified forms of structures present in a common ancestor. Modified forms often also have modified functions. For example, the human arm, whale's flipper, and bat's wing are

adapted for different purposes but share the same basic bone structure, indicating that these organisms descended from a common ancestor.

7. Darwin and Wallace made observations of the natural world, including that individuals within a species have variations that affect how well they compete for limited resources.

**True.** The film shows that Wallace realized that individuals within a species compete for survival. Individuals within a species with variations in their traits that provide them with an advantage in a given environment are more likely to survive and produce more offspring. Over time, these advantageous variations accrue in the population. Darwin independently made similar observations.

In 1798, Thomas Malthus, an English clergyman and economist, published *An Essay on the Principle of Population*. The central theme of this work was that human population growth would always exceed food supply growth, thus creating ongoing states of hunger, disease, and struggle. Malthus observed that unless kept in check, human populations would double every 25 years. He wrote:

*I think I may fairly make two postulata. First, That food is necessary to the existence of man. Secondly, That the passion between the sexes is necessary and will remain nearly in its present state. These two laws, ever since we have had any knowledge of mankind, appear to have been fixed laws of our nature, and, as we have not hitherto seen any alteration in them, we have no right to conclude that they will ever cease to be what they now are. ... Assuming then my postulata as granted, I say, that the power of population is indefinitely greater than the power in the earth to produce subsistence for man.*

(Excerpt from *An Essay on the Principle of Population*, Chapter 1)

Both Darwin and Wallace read Malthus and realized that plant and animal populations have the same potential as human populations to increase rapidly unless kept in check by predators, diseases, and limited resources. On this topic, Darwin wrote:

*Can it, then, be thought improbable, seeing that variations useful to man have undoubtedly occurred, that other variations useful in some way to each being in the great and complex battle of life, should sometimes occur in the course of thousands of generations? ... This preservation of favourable individual differences and variations, and the destruction of those which are injurious, I have called Natural Selection, or the Survival of the Fittest.*

(Excerpt from *On the Origin of Species*, Chapter 4: Natural Selection)

8. Darwin and Wallace used DNA evidence to support their ideas about evolution and how species are related.

**False.** The film shows that Darwin and Wallace based their theory of evolution on observations of the natural world — mainly ones of the variation in physical traits among individuals within species, similarities between animals in the fossil record and existing species, and the geographical distributions of related species. In Darwin and Wallace's time, DNA and genes had not yet been discovered or defined.

At around the same time as Darwin's and Wallace's voyages, Gregor Mendel's experiments with pea plants showed the basic mechanisms of heredity. Mendel provided the famous ratios of variations passed on from one generation to the next, which were the basis for what we now know as Mendel's principles. However, Darwin and Wallace were not familiar with Mendel's work. It was not until the next century, around 1900, when new researchers, including Thomas Hunt Morgan, worked with Mendel's discoveries and found that natural selection and heredity could be brought harmoniously together.

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