ScienceNews

EDUCATOR GUIDE

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January 16, 2021

Shaking Up Earth

SOCIETY FOR SCIENCE

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About this Guide

In this Guide, based on the online *Science News* article "How the Earth-shaking theory of plate tectonics was born," students will learn about the development of the theory of plate tectonics and discuss how scientific theories are formed.

This Guide includes:

Article-based Comprehension Q&A — Students will answer questions about the online *Science News* article "How the Earth-shaking theory of plate tectonics was born," which explores how scientists formed the theory of plate tectonics. A version of the story, "Shaking up Earth," can be found in the January 16, 2021 issue of *Science News*. Related standards include NGSS-DCI: HS-ESS2; HS-ETS1.

> **Student Comprehension Worksheet** — These questions are formatted so it's easy to print them out as a worksheet.

Cross-curricular Discussion Q&A — Students will discuss the development of the theory of plate tectonics to determine how scientific theories are created. Related standards include NGSS-DCI: HS-ESS2; HS-ETS1.

> **Student Discussion Worksheet** — These questions are formatted so it's easy to print them out as a worksheet.

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Article-based Comprehension, Q&A

Directions for teachers: Ask your students to read the online *Science News* article "How the Earth-shaking theory of plate tectonics was born," which recounts how plate tectonics became a unifying theory in earth science, and answer the following questions. This story is the first installment of a series that celebrates *Science News*' upcoming 100th anniversary by highlighting some of the biggest advances in science over the last century. A version of the story, "Shaking up Earth," can be found in the January 16, 2021 issue of *Science News*. Please note that the questions do not cover the "Crucible of life" sidebar. For more on plate tectonics, and to see the rest of the series as it appears, visit *Science News*' Century of Science site at www.sciencenews.org/century.

1. What is the theory of plate tectonics? Explain it.

Plate tectonics describes how Earth's outermost layer, called the lithosphere, is broken into rock slabs (or plates) that float on an inner layer of hot churning fluid. Over eons, the plates collide, diverge and grind past one another to create features such as volcanoes, earthquakes, ocean basins and mountains.

2. Why does the article compare the theory of plate tectonics to Albert Einstein's general theory of relativity?

Just as Einstein's general theory of relativity upended our understanding of the universe, plate tectonics revolutionized our understanding of the Earth.

3. What early idea set the stage for plate tectonics? When was this idea proposed and what did it attempt to explain?

In 1912, a German meteorologist proposed that Earth's continents were on the move — an idea that is now known as continental drift. This idea holds that colliding continents are responsible for geologic formations such as mountains and that at one time, the continents were joined together as one supercontinent dubbed Pangaea. Continental drift would explain why fossils of the same organisms and rocks of the same type and age are found on either side of the Atlantic Ocean.

4. How did continental drift challenge accepted views of Earth? How was the idea initially viewed by other scientists?

Scientists at the time thought the Earth's crust was rigid and locked in place — a principle called uniformitarianism — and that mountains sprung up as the crust slowly cooled and contracted after its formation. While some scientists found continental drift intriguing, many geologists were skeptical of the idea.

5. What were critics' main arguments against continental drift?

Critics argued that continental drift contradicted uniformitarianism (which held that Earth's continents must be immovable), that the idea couldn't explain how the continents move and that it was a collection of unrelated observations not supported by data.

6. What explanation did English geologist Arthur Holmes come up with for how the continents might move? How did the geology community react to this explanation?

Holmes suggested that the continents might float like rafts atop a layer of thick, partially molten rocks deep inside Earth. Holmes admitted that he lacked data to back up his suggestion, and continental drift was largely shelved by the geology community for decades.

7. What scientific advances helped revive the idea of continental drift beginning in the 1950s? What historical event contributed to these advances?

Sonar mapping developed during World War II revealed the extent of a rift in the ocean floor. Magnetometers revealed alternating stripes of magnetic polarity in seafloor rocks, suggesting each of the stripes formed at different times. A global network of seismograph stations led scientists to discover and measure earthquakes along mid-ocean ridges and beneath trenches. And steel probes inserted into cores drilled into the seafloor revealed that the ridges were much hotter than the surrounding seafloor.

8. What is "seafloor spreading" and how does it connect to continental drift?

Circulating hot rock within the Earth pushes to the surface and forces apart areas of lithosphere. As the lava burbles up between, new seafloor is made. Mid-ocean ridges are where new seafloor is born and deep ocean trenches are where old lithosphere is reabsorbed into Earth's interior. This cycle is responsible for the growing and shrinking of the seafloor that brings continents together and splits them apart.

9. What sets the unified theory of plate tectonics apart from the idea of continental drift?

Plate tectonics says not only that continents drift, but also explains how and why they drift and connects the details of what is known to be happening within the Earth to the details of lithospheric movement and the features visible on Earth's surface.

10. How have people benefited from the understanding of plate tectonics?

Understanding how Earth recycles its crust has allowed people to better prepare for earthquakes, tsunamis and volcanoes. It has also shaped scientific research that has led to insights about Earth's climate and the evolution of life on the planet.

11. What questions do scientists still have about plate tectonics?

Why is Earth the only place in the solar system that seems to have plate tectonics, when and how did plate tectonics begin and when might it end?

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Student Comprehension Worksheet

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Cross-curricular Discussion, Q&A

Directions for teachers:

Use the online *Science News* article "How the Earth-shaking theory of plate tectonics was born," and the prompts below to have students explore scientific theories and determine the process behind creating theories. A version of the story, "Shaking up Earth," appears in the January 16, 2021 issue of *Science News*. As a final exercise, have students discuss the definition of a scientific theory and compare it with hypotheses and scientific laws.

This story is the first installment in a series that celebrates *Science News*' upcoming 100th anniversary by highlighting some of the biggest advancements in science over the last century. For more on the story of plate tectonics, and to see the rest of series as it appears, visit *Science News*' Century of Science site at www.sciencenews.org/century.

Want to make it a virtual lesson? Post the online *Science News* article "How the Earth-shaking theory of plate tectonics was born," to your learning management system. Pair up students and allow them to connect via virtual breakout rooms in a video conference, over the phone, in a shared document or using another chat system. Have each pair submit its answers to the second set of questions to you.

Thinking about theories

Discuss the following questions with a partner before reading the *Science News* article.

1. What does it mean to say that you have a theory about something? Think of a theory you've had about something outside of science.

Typically, when people say that they have theory, it means that they have an idea or philosophy. Student examples of theories will vary.

2. What is one scientific theory you have learned about this year in science? Explain what you remember about it.

Student answers will vary, but may include the general theory of relativity, evolution, etc.

3. How does the general use of the term theory differ from its use in a scientific context?

Theories in science are explanations rooted in data. Having a theory outside of the scientific context may be based on observations or data, or the term may be used to state a logical idea.

The theory of plate tectonics

Read the online *Science News* article "How plate tectonics upended our understanding of Earth," and answer the following questions individually before discussing them as a class.

1. What is the theory of plate tectonics? Over how many years was it developed?

The theory of plate tectonics states that the Earth's surface is broken up into various pieces (plates) and describes how and why they are constantly in motion and how that motion is linked to features seen on Earth. The theory was developed over about 50 years.

2. Who helped develop the theory and what did they contribute to it? What types of scientists were they and where were they from?

Meteorologist Alfred Wegner proposed the idea of continental drift in 1912, and geologist Arthur Holmes added to that proposal years later with an explanation for how the continents might drift. These ideas were the precursors to the development of the theory of plate tectonics. From there, seismologists, geophysicists, mathematicians and physicists established the ideas, such as seafloor spreading, and found the data necessary to develop the theory. Notable scientists include Lynn Sykes, Harry Hess, Robert S. Dietz, Robert Parker, W. Jason Morgan and Dan McKenzie. The researchers were from England and the United States.

3. Before the theory's development, what were the conflicting lines of thought?

Wegner's proposal sparked debates between mobilists, who supported the idea that the Earth's surface was in motion, and fixists, who thought the Earth's surface was static.

4. What did scientists need to resolve the conflict? Why did the conflict take so long to resolve?

In order to resolve the debate, scientists needed evidence. Wegner made his proposal in the early 1900s, but scientific evidence for why the continents move and how didn't become available until after World War II, when technological advancements allowed scientists to study Earth's surface and interior, and particularly the bottom of the oceans, in unprecedented detail.

5. How was evidence communicated to other members of the scientific community? Why was the communication important?

Evidence was communicated at conferences attended by scientists including geologists and geophysicists. By building on each other's ideas and using each other's data, the scientists were able to go beyond the idea of continental drift and come up with the unified theory of plate tectonics.

Defining a scientific theory

Discuss the following questions with a classmate.

1. Based on your answers to the questions above, how would you define a scientific theory?

A scientific theory is an explanation for how and why a natural phenomenon occurs based on evidence.

2. Think about a scientific hypothesis that you have written or look up an example of a hypothesis. How would you define a hypothesis? How is it different than a theory?

A hypothesis is a proposed explanation for a scientific question that hasn't been validated with evidence. A theory relies on evidence to explain phenomena, whereas a hypothesis is proposed before the gathering of evidence. A hypothesis can become a theory once it is proven or disproven with supporting evidence.

Possible Extension

What is a scientific law that you have learned about in school? Explain how a scientific law is different than a scientific theory. For more information, watch this Ted-Ed video called "What's the difference between a scientific law and a theory?" by educator Matt Anticole.

Student answers will vary, but could include Newton's three laws of motion, Bernoulli's principle, etc. A scientific law is different than a scientific theory in that it describes and predicts the relationships among variables, whereas a scientific theory describes how or why something happens.

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Student Discussion Worksheet

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1. What is the theory of plate tectonics? Over how many years was it developed?

2. Who helped develop the theory and what did they contribute to it? What types of scientists were they and where were they from?

3. Before the theory's development, what were the conflicting lines of thought?

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