

The Idea That Waited Fifty Years: From Wegener to Plate Tectonics

Learning target: I can explain, with evidence from a passage, why continental drift was set aside in the 1920s and what seafloor evidence turned it into the theory of plate tectonics.

Reading with evidence

About 40 min

Individual

MS-ESS2-3 · supports

reading

writing

Standards connections

MS-ESS2-3 (supports): The passage gives the history behind the fossil, rock, shape and seafloor evidence that the PE asks students to analyze. It is background for the data tasks in Worksheets 5, 6 and 8 rather than a data analysis itself.

Purpose: build · **Time:** about 40 minutes · **Format:** individual

Answers with reasoning

The Idea That Waited Fifty Years

[1] In 1596 a Flemish mapmaker, Abraham Ortelius, noticed while making an atlas that the coasts on the two sides of the Atlantic looked like the edges of a torn page. He guessed the Americas had been ripped away from Europe and Africa. For three centuries the fit stayed a curiosity. Then, on January 6, 1912, a German scientist named Alfred Wegener told a geology meeting in Frankfurt that the fit was real. The continents, he argued, had once been one landmass, which he named Pangaea, and had slowly drifted apart. His book, *The Origin of Continents and Oceans*, appeared in 1915.

[2] Wegener was trained in astronomy and worked on weather, not geology, but he gathered clues that other people had kept separate. Fossils of *Mesosaurus*, a small reptile of shallow water, lay in rocks of the same age in Brazil and southern Africa. The seed plant *Glossopteris* had left its leaves across South America, Africa, India, Australia and Antarctica. Old mountain belts in eastern North America had the same rock types, in the same order and of the same age, as belts in northwest Africa and in Scotland and Norway. And rocks in India, Africa, Australia and South America carried the scratches and rubble of ancient glaciers, even though those places are warm today. Put the southern lands back together near the South Pole, and all the clues fell into place.

[3] Most geologists were not convinced, and their objection was fair. Wegener could not say what force moved a continent. He suggested the pull of the tides and a slow slide away from the poles, but in 1924 the British physicist Harold Jeffreys showed those forces were far too weak. At a meeting in New York in 1926, many speakers rejected drift. Wegener died in November 1930 on an expedition across the Greenland ice sheet. His idea was not disproved. It was shelved, because an explanation without a mechanism could not be tested.

[4] In 1931 the British geologist Arthur Holmes proposed that heat inside Earth might drive very slow currents in the solid mantle, carrying the continents along. Few took the idea up, because nobody could see the mantle. The test came instead from the ocean floor. Echo sounders improved during the Second

World War, and in the 1950s Marie Tharp, working with Bruce Heezen at Columbia University, plotted thousands of depth readings. In 1952 she found a deep valley running down the crest of the Mid-Atlantic Ridge, and their 1957 map showed the ridge winding midway between the continents, following the coasts.

[5] Earthquakes clustered along that valley, as if the crust were being pulled apart. In 1962 the American geologist Harry Hess published an explanation: new seafloor forms at the ridge, moves outward, and sinks back into the mantle at the deep trenches; Robert Dietz had named the process seafloor spreading in 1961. The idea made a sharp prediction. Seafloor rock should get older with distance from the ridge, by the same amount on both sides. In 1963 Fred Vine and Drummond Matthews proposed that magnetic stripes frozen into seafloor rock recorded spreading; by 1966, surveys showed the stripes formed mirror images on either side of ridges, as predicted.

[6] The direct test needed a ship that could drill through kilometers of water into the seafloor. The Glomar Challenger was built for the job in 1967-68. Between December 1968 and January 1969 it drilled 17 holes at 10 sites across the South Atlantic ridge. The oldest sediment resting on the volcanic rock at each site grew steadily older with distance from the ridge, on both sides, at a rate of about 2 centimeters a year. By the end of the 1960s geologists had joined ridges, trenches and earthquake belts into one picture of moving plates: the theory of plate tectonics.

[7] Today satellites measure plate motion directly, and the rates agree with those read from seafloor ages. Wegener's idea waited half a century, not because his evidence was weak, but because science asks two more things of an idea: a mechanism that could work, and a prediction that could fail. Once the seafloor supplied both, continental drift stopped being a hypothesis and became part of a theory.

Questions: cite the passage

1. According to paragraph 1, who first noticed the fit of the Atlantic coasts, and in what year? What did Wegener add to that observation in 1912?

Answer: Abraham Ortelius, a Flemish mapmaker, noticed the fit in 1596. In 1912 Wegener argued that the fit was real and proposed a specific explanation: the continents were once joined in one landmass (later named Pangaea) and had slowly drifted apart.

Why: Paragraph 1 separates the observation (Ortelius) from the explanation (Wegener). Students should name both the person and the year.

Also acceptable: Accept 'he proposed Pangaea and continental drift' for Wegener's contribution.

- Ortelius and 1596
- Wegener's claim that the continents were once joined and drifted apart

2. Paragraph 2 describes four kinds of clues. List all four in your own words. Then say which clue depends on **climate** rather than on matching, and explain how it supports drift.

Answer: The four clues: (1) the same fossils (Mesosaurus, Glossopteris) on continents now separated by ocean; (2) mountain belts on facing coasts with the same rock types, order and age; (3) the fit of the coastlines (paragraph 1 and the end of paragraph 2); (4) scratches and rubble left by ancient glaciers in lands that are warm today. The climate clue is the glacial one: glaciers in India, Africa, Australia and South America make sense only if those lands once sat together near the South Pole and have since moved to warmer latitudes.

Why: Students may list the fossil clue as two items (Mesosaurus and Glossopteris); accept that if the glacier clue is identified correctly. The glacier evidence is the one that argues from past climate rather than from matching shapes or rocks.

Also acceptable: If a student counts fossils as two clues and omits the coastline fit, accept the list if the glacier explanation is correct.

- Four clues named in the student's words
- Glacial evidence identified as the climate clue
- Explains that the lands must have been near the pole and moved

3. Paragraph 3 says the geologists' objection 'was fair.' What was the objection? Then explain the difference the passage draws between an idea that is **disproved** and one that is **shelved**.

Answer: The objection was that Wegener could not name a force strong enough to move a continent; the forces he suggested (tides, a slide away from the poles) were shown in 1924 to be far too weak. A disproved idea has been shown wrong by evidence. A shelved idea has not been shown wrong; it has been set aside because, without a mechanism, there was no way to test it.

Why: This is the chapter's key correction to the 'Wegener had no evidence' misconception: the evidence was good, the mechanism was missing.

Also acceptable: Accept 'nobody had found evidence against it, they just could not explain it' for the shelved idea.

- Names the missing mechanism as the objection
- Distinguishes disproved (shown wrong) from shelved (set aside, untestable)

4. How many years passed between Wegener's talk in Frankfurt (paragraph 1) and the Glomar Challenger's drilling across the South Atlantic (paragraph 6)? Show the subtraction. Does paragraph 7's phrase 'half a century' fit your number? Explain briefly.

Answer: $1968 - 1912 = 56$ years. 'Half a century' is 50 years, so the phrase is a round figure; it fits reasonably because the explanation (Hess, 1962) came exactly 50 years after the talk and the confirming data came 56 years after.

Why: The subtraction must be shown. The follow-up asks students to judge an approximate phrase against an exact number.

Also acceptable: Accept 57 years if the student uses January 1969 as the end of the drilling. Accept either 'fits' or 'is a little short' with a reason.

5. Paragraph 4 says Holmes's idea was not taken up. Quote the words that give the reason. Then name the technology that finally let scientists test ideas about the seafloor.

Answer: Quote: 'because nobody could see the mantle.' The technology was the echo sounder (sonar), which improved during the Second World War and let Tharp and Heezen map the seafloor.

Why: An idea that cannot be observed or tested does not spread, which is the same problem Wegener faced. The echo sounder is the turning point in paragraph 4.

Also acceptable: Accept 'sonar' or 'depth soundings'.

- Quotes or closely paraphrases the reason
- Names echo sounding or sonar

6. In your own words, state the prediction that seafloor spreading made about the **ages** of seafloor rocks (paragraph 5). What two things would a scientist have to measure at each site to test it?

Answer: If new seafloor forms at the ridge and moves outward, then the rock should be youngest at the ridge and get older the farther away you go, with the same ages at the same distances on both sides. To test it, a scientist would need to measure each site's distance from the ridge and the age of the rock (or of the oldest sediment resting on it) at that site.

Why: The prediction is the one the Glomar Challenger tested in paragraph 6. Students should give both measured quantities; the magnetic stripes in paragraph 5 are history, not the prediction asked for here.

Also acceptable: Accept 'how far from the ridge' and 'how old' in everyday words.

- Older with distance, youngest at the ridge
- Same pattern on both sides
- Names distance and age as the measurements

7. Paragraph 6 gives a spreading rate of about 2 centimeters a year on each side of the ridge. At that rate, how far from the ridge would you expect to find seafloor rock that is 50 million years old? Give your answer in kilometers and show every step of the unit conversion (1 km = 100,000 cm).

Answer: $2 \text{ cm/yr} \times 50,000,000 \text{ yr} = 100,000,000 \text{ cm}$. $100,000,000 \text{ cm} \div 100,000 \text{ cm/km} = 1,000 \text{ km}$. Rock that is 50 million years old should lie about 1,000 km from the ridge.

Why: Rate times time gives distance; the conversion from centimeters to kilometers is the step most often skipped. A student who converts first ($2 \text{ cm} = 0.00002 \text{ km}$, then $\times 50,000,000 = 1,000 \text{ km}$) is also correct.

Also acceptable: Accept 1,000 km or $1 \times 10^3 \text{ km}$ with both the multiplication and the conversion shown.

8. Paragraph 7 says science asks for 'a mechanism that could work, and a prediction that could fail.' Using evidence from at least **two** different paragraphs, explain how plate tectonics met both demands when continental drift did not.

Answer: Model response: Continental drift failed the first demand, because Wegener's proposed forces were far too weak (paragraph 3), so the idea could not be tested and was shelved. Plate tectonics met the mechanism demand when Holmes proposed slow currents in the solid mantle (paragraph 4) and Hess explained that seafloor is made at ridges and destroyed at trenches (paragraph 5). It met the prediction demand because seafloor spreading predicted that rock ages should increase away from the ridge on both sides, a claim that could have failed (paragraph 5); when the Glomar Challenger drilled 17 holes across the South Atlantic in 1968-69, the ages increased with distance exactly as predicted (paragraph 6). An idea with a working mechanism and a prediction that survived a real test earned the name theory.

Why: Full credit requires both demands addressed, each tied to a specific paragraph, and a clear contrast with drift. The strongest answers note that the prediction 'could fail' means the drilling could have come back with random ages.

Also acceptable: A student who uses the satellite measurements in paragraph 7 as a second successful prediction is giving a strong answer. A student who treats the magnetic stripes as the confirming test has read paragraph 5 correctly; still look for the drill-core evidence as well.

- Explains why drift lacked a mechanism, citing paragraph 3
- Names the mechanism (mantle currents, seafloor made and destroyed), citing paragraph 4 or 5
- States the age prediction and its confirmation, citing paragraph 5 or 6
- Evidence from at least two paragraphs

Teacher notes

The passage is about 700 words. Every date is historically established: Ortelius's atlas note (1596); Wegener's Frankfurt lecture (6 January 1912) and book (1915, with later editions in 1920, 1922 and 1929); Jeffreys's critique (1924); the New York symposium (November 1926); Wegener's death in Greenland (November 1930); Holmes's convection paper (1931); Tharp's identification of the rift valley (1952) and the Heezen-Tharp North Atlantic map (1957); Dietz's term (1961) and Hess's paper (1962); Vine and Matthews's proposal (1963) and the surveys that showed mirror-image stripes (1965-66); the Glomar Challenger's construction (keel laid October 1967, launched March 1968) and Leg 3 (December 1968 to January 1969, 17 holes at 10 sites, about 2 cm per year on each side). The passage deliberately corrects the textbook on two points: the ship was newly built, not converted, and the South Atlantic transect was one of its first voyages rather than its very first. The magnetic stripes in paragraph 5 are told as history only; the MS-ESS2-3 assessment boundary excludes paleomagnetic anomalies, so no question asks students to use them as evidence. *Glossopteris* is described as a seed plant, as it was, not a fern.

Scaffold offered to students: Build the timeline first

Before you answer, draw a line across scrap paper and mark these dates from the passage: 1596, 1912, 1915, 1924, 1926, 1930, 1931, 1952, 1957, 1961, 1962, 1963, 1966, 1968. Above each date write the person or event in three words or fewer. Most questions can be answered by finding the right date on your line and rereading the paragraph that holds it.

Extension: What would have changed Wegener's luck?

Imagine that echo sounders and drill ships had existed in 1915. Write a paragraph describing the single measurement Wegener could have ordered that would have done the most to convince the 1926 meeting, and explain what result he would have needed. Then write a second paragraph on whether the discovery of a mechanism (paragraph 4) or the success of a prediction (paragraph 6) mattered more, and defend your choice with the passage.