

Fix Dario's Exhibit: Finding the Errors in a Timeline of Earth

Learning target: I can find the errors in another student's explanation of Earth's history, explain what went wrong in each one, and rewrite the statements so they are accurate.

Error analysis

About 40 min

Individual

MS-ESS1-4 · practice

MS-LS4-1 · supports

writing

independent practice

Standards connections

MS-ESS1-4 (practice): MS-ESS1-4 is a California Grade 8 performance expectation. Repairing claims about how the time scale is organized, how Earth's age is known and what the chart's proportions mean builds the accurate explanation the PE asks for; no period names are required to fix any error.

MS-LS4-1 (supports): MS-LS4-1 is a California Grade 8 performance expectation. Two of Dario's errors concern the order of appearance of life forms in the fossil record (oxygen-producing microbes before animals; dinosaurs long before humans), which students correct using order, not species names.

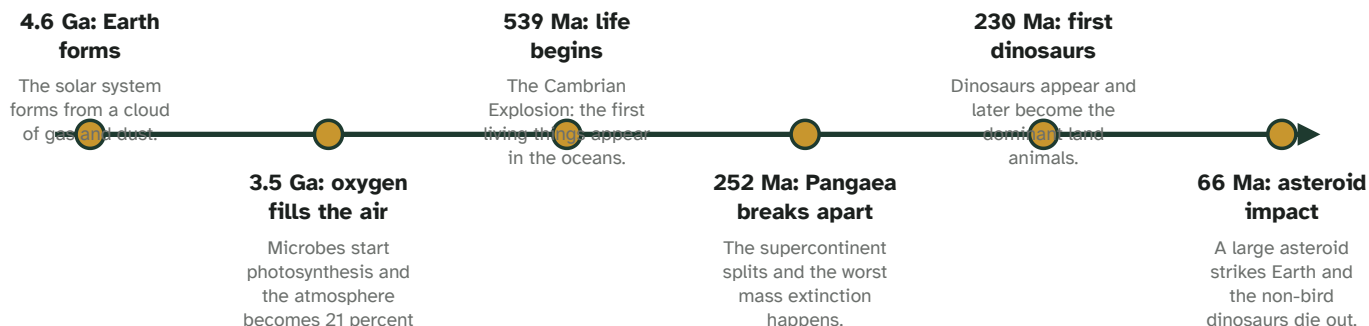
Purpose: practice · **Time:** about 40 minutes · **Format:** individual

Answers with reasoning

Dario's exhibit text (sentences are numbered for you)

S1. Earth is about 4.6 billion years old; scientists measured this from the oldest rock ever found on Earth. **S2.** The Phanerozoic Eon takes up most of the chart on our classroom wall, so it covers most of Earth's history. **S3.** Volcanoes gave Earth its first atmosphere, which was full of oxygen because volcanoes release oxygen. **S4.** Scientists decided where to put the boundaries between eras by splitting Earth's history into equal lengths of time. **S5.** The dinosaurs died out 66 million years ago, and the first humans appeared soon after, so our early ancestors saw the last dinosaurs. **S6.** The ice age ended 11,700 years ago, which is why there is no ice at the poles today. **S7.** The same rock layer can be found in canyons far apart because a layer of sediment spreads sideways as a sheet. **S8.** Every rock layer takes about the same amount of time to form, so a layer that is twice as thick represents twice as much time.

Earth: The Whole Story (Dario's draft)



Dario's timeline for the exhibit. Three of the six entries contain an error in the event, the date, or both.

Part A: Diagnose

1. Mark each sentence as correct or error. For each error, write in a few words what is wrong. Exactly one sentence is fully correct.

Answer: S1 error (age comes from meteorites and moon rocks, not from the oldest Earth rock, which is only about 4.0 billion years old). S2 error (chart space is not time; the Phanerozoic is about 12 percent of Earth's history). S3 error (volcanoes release water vapor and carbon dioxide, not oxygen; the early air had almost no free oxygen). S4 error (boundaries are placed at major changes in the fossil and rock record, not at equal lengths). S5 error (humans appeared about 66 million years after the non-bird dinosaurs died out, not soon after). S6 error (11,700 years ago the current interglacial began; the ice age continues and both poles have ice). S7 correct (lateral continuity). S8 error (layers form at very different rates; thickness is not time).

Why: Seven errors and one correct sentence. The table is the diagnosis step; grade it for correct sorting and for a specific reason on each error.

Also acceptable: Accept 'Earth is 4.54 billion years, not 4.6' as an additional note on S1, but the main error is the source of the age.

- S7 marked correct and all others marked error
- A specific reason for each error, not just 'wrong'

2. Which sentence is correct? Name the rule it describes and give one reason a student might wrongly mark it as an error.

Answer: S7 is correct: it describes the principle of lateral continuity, which is why the same layer can be matched between distant canyons. A student might mark it wrong because 'spreads sideways' sounds like the rock is moving, or because they assume layers stop at the edge of the canyon where they can no longer see them.

Why: Including a correct sentence prevents students from assuming everything is wrong and checks that they can recognize an accurate principle.

Also acceptable: Any reasonable false-alarm reason earns credit.

- Names S7
- Names lateral continuity
- Gives a plausible reason for a false alarm

Part B: Explain and rewrite

3. **S1.** Explain what Dario misunderstood about where Earth's age comes from, then rewrite the sentence correctly. Include the age of the oldest known Earth rock.

Answer: Misunderstanding: Dario assumes Earth's age must be measured on Earth. But Earth's surface has been melted, recycled by plate motion and worn away, so its oldest surviving rock (the Acasta Gneiss, about 4.0 billion years) is more than 500 million years younger than the planet. Earth's age comes from meteorites (pieces of asteroids that formed with Earth and were never recycled, about 4.56 billion years) and the oldest moon rocks (about 4.4 to 4.5 billion years). Rewrite: 'Earth is about 4.54 billion years old. Scientists know this from meteorites and moon rocks, which formed at the same time as Earth; the oldest rock found on Earth itself is only about 4.0 billion years old, because Earth's surface keeps being recycled.'

Why: The key move is explaining why Earth's rocks cannot give the answer and what does.

Also acceptable: Accept 4.6 or 4.5 billion in the rewrite if the source of the age is correct.

- Identifies the assumption that Earth's age comes from Earth rock
- Names meteorites (and/or moon rocks) as the source
- Gives about 4.0 billion years for the oldest Earth rock
- A correct rewritten sentence

4. **S2.** Explain the misunderstanding, support your explanation with a calculation (the Phanerozoic began about 539 million years ago; Earth is about 4,540 million years old), and rewrite the sentence.

Answer: Misunderstanding: Dario reads the size of a section on the chart as the length of time it covers. Charts give the Phanerozoic most of the space because its rocks are well preserved and full of fossils, so it has been split into many labeled units; the earlier eons have few divisions and get a stub. Calculation: $539 \div 4,540 \times 100 = 11.9$ percent, about one-eighth. Rewrite: 'The Phanerozoic Eon fills most of the chart because it is divided into many named units, but it covers only about 12 percent of Earth's history; the first three eons cover the other 88 percent.'

Why: Students must do the division and explain the chart's layout.

Also acceptable: Accept 'about one-eighth' or 'about one-tenth' with the calculation shown and the reasoning intact.

- Identifies chart space being mistaken for time
- Correct calculation (about 12 percent)
- Explains why the chart is drawn that way
- A correct rewritten sentence

5. **S3.** Explain what is wrong, including where the oxygen in today's air actually came from and why it took so long to build up. Rewrite the sentence.

Answer: Misunderstanding: Dario assumes volcanoes release oxygen gas and that the first atmosphere was like today's. Volcanic gas is mostly water vapor and carbon dioxide (with sulfur gases), so Earth's first atmosphere had almost no free oxygen. The oxygen in today's air came from cyanobacteria, microbes that photosynthesize and release oxygen. For a very long time that oxygen reacted with iron dissolved in seawater and settled out as iron-rich layers on the seafloor; only after that did oxygen begin to build up in the air, about 2.4 billion years ago, and it took far longer to reach today's 21 percent. Rewrite: 'Volcanoes gave Earth its first atmosphere, made mostly of water vapor and carbon dioxide with almost no oxygen; the oxygen in today's air was released by photosynthesizing microbes and built up slowly over billions of years.'

Why: This repairs the textbook's framing and the common 'volcanoes make oxygen' error. The iron-sink delay is the subtle part and earns the top mark.

Also acceptable: Accept 'the oxygen was used up by rusting the oceans' as the delay explanation.

- Says volcanic gases contain no free oxygen (names water vapor and/or carbon dioxide)
- Names photosynthesizing microbes (cyanobacteria) as the oxygen source
- Explains the delay (oxygen reacted with iron in seawater first) or at least that buildup was slow
- A correct rewritten sentence

6. **S4.** Explain what rule scientists actually use to place boundaries on the time scale, and why that rule makes the units unequal in length. Rewrite the sentence.

Answer: Misunderstanding: Dario thinks the time scale is like a ruler with equal ticks. Scientists place boundaries where rock strata record major changes, above all mass extinctions, when many kinds of fossils stop at one level and new kinds appear above it; the names and boundaries were set from fossils before anyone could measure the ages in years. Because those events happened at irregular times, the eras and periods have very different lengths (for example the three eras of the current eon are about 287, 186 and 66 million years long). Rewrite: 'Scientists placed the boundaries between eras where the fossil record shows a major change, such as a mass extinction, so the eras are not equal in length.'

Why: This is the lesson's central idea and the core of MS-ESS1-4.

Also acceptable: Accept 'the appearance of many new kinds of fossils' as a boundary event.

- Identifies the equal-ticks assumption
- States the boundaries-at-major-changes rule with mass extinctions as the example
- Explains why unequal lengths follow
- A correct rewritten sentence

7. **S5.** Calculate how many years separate the extinction of the non-bird dinosaurs (66 million years ago) from the appearance of modern humans (about 300,000 years ago). Explain Dario's misunderstanding and rewrite the sentence.

Answer: Calculation: $66,000,000 - 300,000 = 65,700,000$ years, about 65.7 million years.

Misunderstanding: Dario compresses the gap, probably because both events are 'near the end' of the chart, where tiny spaces hold enormous amounts of time. Modern humans appeared about 300,000 years ago, roughly 66 million years after the non-bird dinosaurs died out; no human ancestor that could be called human ever saw a non-bird dinosaur (though birds, which are living dinosaurs, were around for all of it). Rewrite: 'The non-bird dinosaurs died out 66 million years ago. Modern humans appeared only about 300,000 years ago, nearly 66 million years later, so no humans ever lived with them.'

Why: The subtraction forces students to handle the units; the 'near the end of the chart' explanation connects to S2.

Also acceptable: Accept 'about 66 million years' as the answer to the subtraction. A student who notes that birds are living dinosaurs is adding an accurate point.

- Correct subtraction (about 65.7 million years)
- Explains the compression error
- A correct rewritten sentence

8. **S6.** Explain the difference between an ice age and an interglacial period, say what actually happened 11,700 years ago, and rewrite the sentence.

Answer: Misunderstanding: Dario treats 'ice age' and 'glacial period' as the same thing. An ice age is a long stretch of cooler climate with permanent ice at the poles; it contains colder glacial periods, when ice sheets grow outward, and warmer interglacial periods, when they shrink back. About 11,700 years ago the most recent glacial period ended and the current interglacial began. The ice age itself has not ended: both poles still carry permanent ice, which is the definition of being in an ice age. Rewrite: 'About 11,700 years ago the last glacial period ended and the current warm interglacial period began, but Earth is still in an ice age, because permanent ice covers both poles.'

Why: The poles-have-ice evidence directly contradicts Dario's claim and is checkable by any student.

Also acceptable: Accept 11,500 years (the textbook's figure) with the rest correct.

- Distinguishes ice age from glacial and interglacial periods
- States what happened 11,700 years ago (interglacial began)
- Notes that the poles still have ice, so the ice age continues
- A correct rewritten sentence

9. **S8.** Explain why thickness is not a clock, using an example of two layers that could form at very different rates. Rewrite the sentence so it says what thickness can and cannot tell you.

Answer: Misunderstanding: Dario assumes sediment piles up at one steady rate everywhere. Rates differ enormously: a volcanic ash band 20 cm thick can settle in days, while a thin layer of deep-sea mud can take thousands of years per centimeter; a river delta may build meters of sand in a flood season, while a limestone forms slowly from shells over a very long time; and a layer can be partly worn away before the next one forms, removing time entirely. So a thick layer may represent less time than a thin one. Rewrite: 'Rock layers form at very different rates, so a layer's thickness tells you how much sediment settled, not how much time passed; to find the time you need dated layers above and below it.'

Why: Any two layer types with clearly different rates earn credit; the rewrite must separate thickness from time.

Also acceptable: Accept an example drawn from Worksheet 6 (57 m in 10 million years versus 53 m in 90 million years).

- Identifies the steady-rate assumption
- Gives an example of two layers forming at very different rates
- A rewritten sentence that says thickness is not time and names what does give time

Part C: Fix the timeline

10. Three timeline entries are wrong. For each, say what is wrong and write a corrected entry. You may split an entry into two if two different events were mixed together.

Answer: Entry 3.5 Ga: mixes two events and the wrong outcome. Correct: 'About 3.5 Ga: the oldest widely accepted fossils (stromatolites built by microbes)' and 'About 2.4 Ga: oxygen begins to build up in the air (it reached today's level much later).' Entry 539 Ma: life did not begin then; it began more than 3.5 billion years ago. Correct: 'About 539 Ma: the Cambrian Explosion, when early relatives of most major animal groups appear in the fossil record.' Entry 252 Ma: Pangaea did not break apart then; it was complete or nearly complete, and the worst mass extinction happened. Correct: 'About 252 Ma: the end-Permian mass extinction, the most severe in Earth's history, while Pangaea was assembled' and 'About 200 to 180 Ma: Pangaea begins to break apart.'

Why: Each entry contains a mixed-up pair; splitting them is the cleanest fix. Dates: stromatolites about 3.5 Ga; the Great Oxidation Event about 2.4 Ga; the Cambrian began 538.8 Ma; the end-Permian extinction 251.9 Ma; Pangaea's breakup began roughly 200 to 180 Ma.

Also acceptable: Accept '2.4 to 2.0 Ga' for the oxygen buildup and 'about 200 Ma' for the breakup.

- Oxygen buildup moved to about 2.4 Ga and separated from the first fossils at 3.5 Ga
- 'Life begins' corrected to the Cambrian diversification of animals, with life itself much older
- 252 Ma corrected to the mass extinction, with the breakup of Pangaea moved to about 200 to 180 Ma

11. Look back over all of Dario's errors. Describe one habit of thinking that caused more than one of them (for example, trusting how something looks on a chart, or assuming that steady rates apply everywhere). Give two sentences from the exhibit as examples.

Answer: Examples of habits: (1) Trusting appearances on the chart: S2 (big space means long time) and S5 (two events close together on the chart must be close in time). (2) Assuming steady, even rates or equal divisions: S4 (equal-length eras) and S8 (equal time per layer). (3) Assuming Earth works like the familiar present: S3 (air has always had oxygen) and S1 (Earth's age must be measured on Earth). Any one habit with two matching sentences earns full credit.

Why: Metacognition item: recognizing the habit behind errors helps students catch their own.

Also acceptable: Accept other reasonable groupings if the link is explained.

- Names a habit of thinking
- Links it to two sentences from the exhibit

Teacher notes

Dario's errors were chosen to match the chapter's documented misconceptions and the prior review's flags: Earth's age from Earth rock (W1), chart space as time (RF3), volcanic oxygen (RF17), equal units, dinosaurs-with-humans, 'the ice age ended' (RF8), thickness as time, plus three timeline mix-ups (oxygen at 3.5 Ga, 'life begins' in the Cambrian per RF6, and Pangaea breaking up at 252 Ma per RF13). All corrected values are current: Acasta Gneiss about 4.0 billion years, meteorites about 4.56 billion, Phanerozoic from 538.8 Ma (12 percent of 4,540), Great Oxidation Event about 2.4 Ga, Homo sapiens about 300,000 years, Holocene from 11,700 years ago, Pangaea breakup from about 200 Ma. S7 is intentionally correct; students who mark it wrong usually picture the layer physically sliding, which is worth a quick class discussion. If time is short, assign q3 to q9 across pairs and have each pair present one rewrite.

Scaffold offered to students: A rewrite in three moves

For every rewrite, use three sentences. Move 1, the misunderstanding: 'Dario thinks ____.' Move 2, the evidence: 'But ____ shows ____' (use a number or a fact from the chapter). Move 3, the correction: 'A correct sentence would say: ____.' If you are stuck on where to find the facts, S1 and S2 are in Worksheets 1 and 5, S3 and the timeline are in the presentation, S4 and S8 are in Worksheet 6, and S5 and S6 are in Worksheet 2.

Extension: Write the exhibit Dario should have written

Using your corrected sentences and your corrected timeline, write a 120- to 150-word exhibit panel titled 'Earth: The Whole Story' for a hallway audience of sixth graders. It must include one number that shows how little of Earth's history humans have been part of, one sentence about where the age of Earth comes from, and one sentence about how the boundaries of the time scale are chosen. Then add one 'honest uncertainty' sentence: something about Earth's history that scientists are still working out (for example, exactly when oxygen-producing microbes first appeared).