

Deep Time Check: Retrieval Practice and Synthesis

Learning target: I can show that I understand how Earth's age is known, how the geologic time scale is built from rock strata and organized by events, how to read its units and numbers, and how major changes in life, land and climate are recorded.

Retrieval and mastery check

About 35 min

Individual

MS-ESS1-4 · assesses

MS-ESS2-2 · supports

MS-LS4-1 · supports

independent practice

writing

Standards connections

MS-ESS1-4 (assesses, the explanation items (q4, q7, q11, q12); the other items are retrieval practice): MS-ESS1-4 is a California Grade 8 performance expectation; this quiz gathers evidence toward it from Grade 7 students. Items ask how the time scale is organized, how ages are attached and how strata are joined; no item requires recalling the name of a period or epoch or the events within it, in keeping with the assessment boundary.

MS-ESS2-2 (supports): Two items (q9 and q10) use surface processes acting over long time scales (recycling of old crust, ice sheets shaping land), the Grade 7 idea this chapter leans on.

MS-LS4-1 (supports): MS-LS4-1 is a California Grade 8 performance expectation. Item q6 uses the order of appearance in the fossil record without species or era names.

Purpose: assess · **Time:** about 35 minutes · **Format:** individual

Answers with reasoning

Part A: Retrieval practice

1. Which evidence gives scientists the age of Earth, and why?

Answer: B: Meteorites and moon rocks, because they formed with Earth but were never recycled.

Why: Earth's surface has been melted, recycled and eroded, so its oldest rock (about 4.0 billion years) is younger than the planet; meteorites (about 4.56 billion years) and the oldest moon rocks (4.4 to 4.5 billion) preserve the formation age. A is the most common error.

Also acceptable: None.

2. Convert: 2.5 Ga = _____ Ma. 66 Ma = _____ ka. Show the factor you used.

Answer: $2.5 \text{ Ga} \times 1,000 = 2,500 \text{ Ma}$. $66 \text{ Ma} \times 1,000 = 66,000 \text{ ka}$. Each step between Ga, Ma and ka is a factor of 1,000.

Why: Students must show the factor; the common error is using 100 or 1,000,000.

Also acceptable: None.

3. True or false, with a one-sentence reason: 'Rock strata by themselves tell geologists the ages of layers in years.'

Answer: False. Strata give relative order (lower is older, higher is younger); ages in years come from absolute dating of certain layers, such as volcanic ash or lava, which then bracket the layers between them.

Why: The relative-versus-absolute distinction is a core idea of the chapter.

Also acceptable: Accept 'strata give order, not years.'

- False
- Reason mentions order only, or that years come from dated volcanic layers

4. Where do scientists place the boundaries between units of the geologic time scale?

Answer: C: Where the rock and fossil record shows a major change, such as a mass extinction.

Why: Boundaries follow events recorded in strata; that is why units have unequal lengths. A and B are the equal-interval errors; D confuses bookmarks with boundaries.

Also acceptable: None.

5. List the four units of the geologic time scale from longest to shortest, and name the one we live in at the longest level.

Answer: Eon, era, period, epoch. We live in the Phanerozoic Eon.

Why: The nesting order and the current eon are vocabulary from W2. The eon name is the only name asked for, and it is the lesson's anchor term, not a period or epoch.

Also acceptable: Accept a student who adds 'Cenozoic Era, Quaternary Period, Holocene Epoch'; do not penalize a missing eon name heavily if the order is right.

- Correct order
- Phanerozoic

6. Which order of first appearances matches the fossil and rock record?

Answer: B: Microbes, then oxygen building up in the air, then animals with shells.

Why: Microbial mounds at about 3.5 billion years; oxygen building up in the air from about 2.4 billion years; animals with hard parts diversifying from about 539 million years. The order is the pattern the fossil and rock record shows.

Also acceptable: None.

7. A shale layer lies between a lava flow dated 420 million years and an ash band dated 300 million years. State everything you can and cannot say about the shale's age, and name the kind of dating used on the lava and ash.

Answer: Can say: the shale is younger than 420 million years (it lies above the lava) and older than 300 million years (it lies below the ash), so it formed sometime in that 120-million-year window. Cannot say: its exact age, because shale cannot be dated directly, and nothing about how much of the window it represents. The lava and ash were dated by absolute dating (a mineral clock based on the steady change of certain atoms).

Why: Bracketing by dated layers is the method taught in W3, W4 and W6.

Also acceptable: Accept 'radiometric dating' or 'mineral-clock dating' for the method name.

- Window of 420 to 300 million years from the positions
- States the exact age is unknown
- Names absolute dating

8. The most recent eon began about 539 million years ago and Earth is about 4,540 million years old. Calculate the percentage of Earth's history in that eon, to the nearest whole percent, and explain in one sentence why it takes up most of a classroom chart anyway.

Answer: $539 \div 4,540 \times 100 = 11.9$ percent, which rounds to 12 percent. It takes up most of a chart because its rocks are widespread, well preserved and full of fossils, so it has been divided into many named units that all need space for labels.

Why: The calculation corrects the textbook's 'about 10 percent'; the explanation tests the chart-space idea.

Also acceptable: Accept 'about one-eighth.'

- 12 percent with the division shown
- Reason based on fossil richness, preservation or many labeled divisions

9. Draw two cliffs 50 km apart that share one volcanic ash band. In cliff 1 draw two layers above the ash; in cliff 2 draw the ash on top and two layers below it. Label the oldest layer, the youngest layer, and write beside the ash band the rule that lets you match it between the cliffs.

Answer: Two cliff columns. Cliff 1: two layers on top, the ash band at the bottom. Cliff 2: the ash band on top, two layers below. The youngest layer is the top layer of cliff 1; the oldest is the bottom layer of cliff 2. Beside the ash: 'lateral continuity: a layer spreads sideways as a sheet, so the same ash band in both cliffs was one layer' (accept 'same layer in both cliffs' with the rule named).

Why: Checks superposition (oldest and youngest placed correctly across two cliffs) and lateral continuity as the matching rule.

Also acceptable: Accept 'the ash fell everywhere at once' as a description of why the band matches, if the rule's name is missing but the idea is clear.

- Ash band at the bottom of cliff 1 and the top of cliff 2
- Oldest labeled at the bottom of cliff 2, youngest at the top of cliff 1
- Lateral continuity named or described

10. Explain why today's atmosphere contains about 21 percent oxygen when the first atmosphere contained almost none. Include where the oxygen came from and one reason it took so long to build up.

Answer: The first atmosphere came from volcanic gases, which contain water vapor and carbon dioxide but no free oxygen. The oxygen came from microbes (cyanobacteria) that photosynthesize and release oxygen. It took so long to build up because for a very long time the oxygen reacted with iron dissolved in the oceans and settled out as iron-rich layers on the seafloor; only after that could oxygen accumulate in the air, beginning about 2.4 billion years ago, and reaching today's level long afterward.

Why: Source and delay are both required; the iron sink is the accurate explanation for the delay.

Also acceptable: Accept 'it was absorbed by the oceans and seafloor' as the delay reason.

- Oxygen from photosynthesizing microbes
- A reason for the delay (reaction with iron in seawater, or slow accumulation)

11. True or false, with a one-sentence reason: 'The ice age ended about 11,700 years ago.'

Answer: False. About 11,700 years ago the last glacial period ended and the current interglacial period began, but Earth is still in an ice age because permanent ice remains at both poles.

Why: The ice-age/interglacial distinction from W2 and W7.

Also acceptable: Accept 'the glacial period ended, not the ice age.'

- False
- Reason: interglacial began, ice age continues (poles still have ice)

12. Which observation most directly supports the idea that the moon formed from material knocked out of the young Earth?

Answer: A: Moon rocks that closely match the chemistry of Earth's mantle.

Why: A chemical match to Earth's mantle is the direct evidence for the giant impact hypothesis. Craters (B) show impacts in general; size (C) is not evidence of origin; meteorite ages (D) date the solar system, not the moon's origin.

Also acceptable: None.

Part B: Synthesis

- 13.** No rock on Earth is as old as Earth, and no single cliff shows more than a small part of Earth's history. Explain, in 6 to 8 sentences, how scientists still built a timeline of 4.54 billion years. Your answer must include: how the age of Earth was found; how rock records from different places are joined; how boundaries on the time scale are chosen; how ages in years are attached; and one reason the early part of the record is thin.

Answer: Model response: Scientists found Earth's age from meteorites and the oldest moon rocks, which formed with Earth about 4.5 to 4.6 billion years ago but were never melted or recycled, giving Earth an age of about 4.54 billion years. On Earth, each cliff records only a short stretch, so geologists read layers from bottom (oldest) to top (youngest) and join cliffs by matching layers that continue sideways from one place to another, such as a distinctive ash band or a fixed sequence of fossils, stacking short records into one long column. They place the boundaries of the time scale where the strata show a major change in life, above all mass extinctions where many kinds of fossils stop at one level, which is why eons, eras and periods have unequal lengths. Ages in years are attached by absolute dating of volcanic layers such as ash and lava, which act like bookmarks that bracket the undated layers between them; the boundaries were set from fossils first and the numbers were added later. The early part of the record is thin because Earth's surface has been recycled by plate motion, melted and worn away, so almost no rock survives from the first 500 million years and early life was microscopic and rarely preserved. Put together, the result is a timeline of 4.54 billion years built from many places, organized by events and pinned by a limited number of dates.

Why: Full credit needs all five required elements, in a coherent order, with accurate numbers where numbers are used. This is the chapter's summative explanation for MS-ESS1-4.

Also acceptable: Accept the elements in any order. A response that uses the textbook's 4.6 billion years for Earth is acceptable; 4.54 is the reference value.

- Age of Earth from meteorites and/or moon rocks, with the reason they preserve the age
- Joining records by matching layers across places (lateral continuity or matching fossil sequences)
- Boundaries at major changes in the fossil or rock record (mass extinctions)
- Ages in years from absolute dating of volcanic layers that bracket other layers
- A reason the early record is thin (recycling, melting, erosion, or microscopic life)
- 6 to 8 sentences, coherent

Teacher notes

Scoring suggestion: Part A items 1 point each except q7, q9 and q10 (2 points each) for 15 points, plus Part B (q13) at 6 points using the criteria, for 21 total. Items were written to respect the MS-ESS1-4 assessment boundary: no item asks for the name of a period or epoch, and q5 asks only for the unit order and the current eon. Reference values: Earth 4.54 billion years; meteorites about 4.56 billion; oldest Earth rock about 4.0 billion; oxygen building up from about 2.4 billion years ago; Phanerozoic from about 539 million years (12 percent of Earth's history, correcting the textbook's 'about 10 percent'); Holocene from 11,700 years ago. The Anthropocene extension reflects the March 2024 decision of the International Union of Geological Sciences not to ratify the proposed epoch; it is a live example of the boundary rules being applied and debated, and it should be presented as an open scientific discussion rather than a settled matter.

Scaffold offered to students: Plan the synthesis with five words

Before writing Part B, jot down these five words in order and write one fact next to each: meteorites, matching, boundaries, bookmarks, recycling. Each word is one of the five things your answer must include. Then turn each note into one or two sentences. If a multiple-choice item stumps you, cross out the answers you know are wrong first; there is usually one that contradicts something you drew or calculated earlier in the chapter.

Extension: One more boundary

Some scientists have proposed a new epoch, the Anthropocene, to mark the time when human activity began leaving a worldwide signature in sediments, such as plastic particles, radioactive fallout from 1950s weapons tests, and chemical changes in lake muds. In 2024 the official body that manages the time scale voted not to add it, partly over the question of whether the change is recorded sharply enough and whether a boundary set in the 1950s is useful. Using what you know about how boundaries are chosen, write a paragraph arguing for or against the proposal, with at least two reasons that use the rules from this chapter.