

Scales of Change: Mastery Check

Learning target: I can show what I know about weathering, erosion, deposition and uplift, time and spatial scales, rates of change, sudden and gradual events, and uniformitarianism, and connect the ideas in a short explanation.

Retrieval and mastery check

About 40 min

Individual

MS-ESS2-2 · assesses

independent practice

writing

Standards connections

MS-ESS2-2 (assesses, the synthesis paragraph (q13); the retrieval items are practice): The synthesis paragraph asks for an explanation of how processes at different time and spatial scales change Earth's surface, using evidence from the chapter. The retrieval items check the vocabulary, scale reasoning and rate calculations that explanation depends on.

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

Answers with reasoning

Part A: Retrieval (12 items)

1. Which statement describes weathering, erosion and deposition correctly?

Answer: B. Weathering breaks rock where it sits; erosion carries the pieces away; deposition drops them in a new place.

Why: The three processes are a sequence for one piece of rock: break, carry, drop. A swaps the first two and confuses deposition with uplift.

Also acceptable: None.

2. Which example best shows that a change can be large in space and fast in time?

Answer: C. Dust from an asteroid impact that cooled the whole planet within days.

Why: Global in space, days in time. A is small and slow, B is large and slow, D is small and fast.

Also acceptable: None.

3. True or false: Uniformitarianism means that Earth's processes have always run at exactly the same speed, so sudden events did not happen in the past.

Answer: False.

Why: Uniformitarianism says the same kinds of processes and natural laws acted in the past as today; rates can vary, and sudden events are part of Earth's history.

Also acceptable: None.

4. A continent moves 3 cm per year. How far does it move in 2 million years? Give the answer in kilometers and show each unit step.

Answer: $3 \text{ cm per year} \times 2,000,000 \text{ years} = 6,000,000 \text{ cm}$. $6,000,000 \text{ cm} \div 100 = 60,000 \text{ m}$. $60,000 \text{ m} \div 1,000 = 60 \text{ km}$.

Why: Multiplication, then two unit conversions. The common error is dropping a factor of 1,000 (answering 6 km or 0.06 km).

Also acceptable: Accept 60 km with any correct conversion path (for example, $3 \text{ cm} = 0.03 \text{ m}$; $0.03 \times 2,000,000 = 60,000 \text{ m} = 60 \text{ km}$).

5. A hoodoo has a hard cap of rock on top of a softer pillar. Explain why the cap matters to the shape, and what finally happens to the hoodoo and why.

Answer: The cap rock weathers more slowly than the soft rock under it, so it acts like an umbrella: the softer rock around the hoodoo wears away, but the column right under the cap is sheltered and stays standing. That is why the shape is a pillar with a cap. Weathering and erosion keep thinning the pillar for a very long time until it can no longer hold the cap, and then the cap topples suddenly, so a slow process ends in a sudden collapse.

Why: Two ideas: the cap's resistance explains the shape, and the thinning pillar explains the eventual sudden fall.

Also acceptable: Accept 'the cap is harder' for resistance.

- Cap resists weathering and protects the rock under it
- Pillar thins until the cap falls (slow process, sudden end)

6. Fill in the process: _____ breaks rock apart in place; _____ carries loose rock away; _____ piles carried rock up in a new place; _____ raises a large area of crust from below.

Answer: Weathering; erosion; deposition; uplift.

Why: The four process terms in the order of their definitions.

Also acceptable: Spelling need not be perfect if the term is clear.

7. A stream deepens its channel by 2 mm per year. At that rate, how many years would it take to cut a channel 40 m deep? Show your work.

Answer: $40 \text{ m} = 40,000 \text{ mm}$. $40,000 \text{ mm} \div 2 \text{ mm per year} = 20,000 \text{ years}$.

Why: Convert the distance to the rate's unit, then divide distance by rate.

Also acceptable: Accept 20,000 years; accept 0.002 m per year as the converted rate ($40 \div 0.002 = 20,000$).

8. Which is the best example of a **sudden** event whose **conditions took a long time to develop**?

Answer: A. A volcanic eruption, because magma had been collecting underground for a long time before it erupted.

Why: The eruption is sudden and its setup is slow. B, C and D describe gradual processes, not sudden events.

Also acceptable: None.

9. Wind moves only a few sand grains at a time, yet some desert dunes are hundreds of meters tall. Explain how tiny changes can build something so large.

Answer: Each gust moves only a few grains, but the wind blows countless times over thousands of years, and the grains it drops on the sheltered side of a dune stay there (deposition), so the small additions accumulate. Many small changes repeated for a very long time add up to a dune hundreds of meters tall.

Why: The answer should contain repetition over a long time and accumulation (the moved sand stays).

Also acceptable: Accept an analogy (coins in a jar) if tied to sand and time.

- Repetition over a long time
- Accumulation: the small changes add up because the sand stays

10. A mineral formation in a cave is 20 cm long and took 4,000 years to grow. Which cell of a time-and-space chart does it belong in?

Answer: B. Small space, long time.

Why: 20 cm is small; 4,000 years is long compared with a human life.

Also acceptable: None.

11. A sea cliff retreats 0.4 m per year. A house stands 30 m from the edge. If the rate stays the same, in how many years will the edge reach the house? Then write one reason the real answer could be smaller.

Answer: $30 \text{ m} \div 0.4 \text{ m per year} = 75 \text{ years}$. The real answer could be smaller because a single storm or a landslide could remove several meters at once, and the average rate does not include such sudden events (or the rate could increase as sea level rises or the rock weakens).

Why: Distance divided by rate; the second part checks that students know an average rate can be punctuated by sudden losses.

Also acceptable: Accept 75 years with any sudden-event or rate-change reason.

12. Draw a time-and-space chart with two columns (small space, large space) and two rows (short time, long time). Place one labeled example in each of the four cells. Label both rulers.

Answer: A 2×2 chart with columns labeled small space and large space and rows labeled short time and long time (both rulers named). Example placements: small-short: a raindrop splashing sand grains or a frost crack; small-long: a cave formation growing over thousands of years; large-short: an asteroid impact cooling the planet in days, a flash flood or a lava flow burying a valley in weeks; large-long: a continent drifting or a mountain range rising over millions of years.

Why: Check that each example fits both rulers; the large-short cell is the one most often filled wrongly (students put a slow large event there).

Also acceptable: Any accurate examples; a landslide is acceptable as large-short if the student notes it is large compared with a sand grain.

- Two labeled columns and two labeled rows
- Four examples, one per cell
- Each example fits both its size and its time

Part B: Synthesis

13. Write a paragraph (5-7 sentences) that answers: **How can Earth's surface look stable from one year to the next and yet be constantly changing?** Your paragraph must use both scales (time and space), explain how small changes add up, include one sudden event and what set it up, and say what uniformitarianism lets scientists do.

Answer: Model paragraph: A landscape looks stable from one year to the next because most of its changes are too small or too slow to notice in that time. A river may deepen its channel only a few millimeters a year, and a continent moves only a few centimeters, which no one can see by looking. But those small changes never stop, so over thousands or millions of years they add up: millimeters a year become a canyon, and centimeters a year carry a continent thousands of kilometers. Some changes are sudden instead, like a landslide that drops a hillside in a minute, yet even that was set up by years of rain soaking the slope and centuries of a stream steepening its base. To describe any change, scientists need two rulers, how much space it covers and how long it takes, because a change can be huge and fast, like impact dust cooling the whole planet in days, or tiny and slow, like a cave formation growing for thousands of years. Uniformitarianism lets scientists use rates they measure today to estimate how long past changes took and to predict future ones, as long as they remember that rates can vary and sudden events happen. So the ground under us is always changing; it only looks still because our lifetimes are short compared with Earth's clocks.

Why: Score for the required elements: both scales, small changes adding up with a rate or example, one sudden event with its setup, and what uniformitarianism allows. The paragraph should be coherent and 5-7 sentences.

Also acceptable: A paragraph built around hoodoos (slow thinning, sudden cap fall) or a glacier (slow flow, sudden calving) covers the required elements and is acceptable.

- Explains why landscapes look stable (changes too small or slow to notice)
- Uses both time scale and spatial scale
- Explains how small changes add up, with an example or rate
- Includes one sudden event and what set it up
- States what uniformitarianism lets scientists do (and, ideally, its limit)
- 5-7 sentences, coherent

Teacher notes

Suggested scoring: q1-q3, q6, q8, q10 one point each; q4, q7, q11 two points each (one for the setup, one for the answer with units); q5 and q9 two points each; q12 three points; q13 five points; total 25. The most common errors: dropping a factor of 1,000 in q4 (answering 6 km) and placing a slow large event in the large-short cell of q12. In q3 and q13, accept only the modern meaning of uniformitarianism (same processes and laws; rates vary; sudden events included), which corrects the textbook's 'in the same way' phrasing. q11's follow-up and q8 both check the chapter's claim that sudden events punctuate gradual change and are set up by slow conditions.

Scaffold offered to students: Paragraph frame for Part B

Sentence 1: why a landscape looks stable (changes too small or slow to notice in a year). Sentence 2: an example of a slow change with a rate (millimeters or centimeters per year). Sentence 3: how that small change adds up over thousands or millions of years to a large one. Sentence 4: a sudden event and the slow conditions that set it up. Sentence 5: what the two rulers (time and space) tell you that one alone cannot. Sentence 6: what uniformitarianism lets scientists do with rates they measure today. Sentence 7: a closing sentence that answers the question.

Extension: Two-way check

After the quiz, trade with a partner and grade each other's chart (q12) using three checks: is each example really in the right cell for both rulers, are both rulers labeled, and could the partner explain why the large-space, short-time example is the hardest cell to fill? Then together write one more example for that cell that neither of you used.