



Deep Time Museum: Four Teams, Twelve Lessons

DRIVING QUESTION

What does the rock record tell us about deep time, and are we using Earth's resources faster than deep time can replace them?

YOUR CHALLENGE

Build it. Make it work. Teach it. Your team is the class expert on three lessons, and your build is how you teach them.

THE PROJECT

The phenomenon

One roadside cliff can hold millions of years in a few metres of rock. Coal, oil, and groundwater took thousands to millions of years to collect, and people can use them up in a few decades. Module 5 is about two clocks: the slow clock of the rock record and the fast clock of human use. No one team can learn all twelve lessons in time, so each team becomes the expert on three and teaches them.

THE PROJECT

How it works

- Your group forms on your Scholar Dashboard and picks one focus.
- Each focus covers three Module 5 lessons.
- Each teammate leads one of your three lessons.
- In a group of four, the fourth teammate is the Verifier.
- Your team builds something that works.
- It is not a poster.
- It has to do something you can test.
- Your team keeps one shared group note in Note Studio.
- Everyone types in it at the same time.
- You photograph your build.
- When Dr. Ijezie approves the photos, they appear on the Module 5 page.
- On teach-back day your team teaches its three lessons with the build.
- Everyone learns all twelve lessons.
- Each of you turns in the group note to the Assessment Center, like notes homework.

TEAMS

Four teams, four focuses

Three teams of three and one team of four. Every focus answers the same driving question: what does the rock record tell us about deep time, and are we using resources faster than deep time can replace them?

TEAM	FOCUS QUESTION
Team 1 • Layer Detectives Fossils and the rock record	How do we read the order of rock layers, and what do fossils tell us about the time and place each layer formed?
Team 2 • Time Keepers Radiometric dating and the geologic time scale	How can atoms give a rock an age in years, and how long is Earth's 4.6-billion-year history really?
Team 3 • Aquifer Lab Natural resources, people, and water	What makes a resource renewable, and what happens to our water when more people pump more of it?
Team 4 • Footprint Lab Land, air, energy, and human impact	How do we use land, air, and energy, and what marks does that use leave on Earth?

TEAMS

Form your group

Groups form on your Scholar Dashboard. First come, first served: once a group takes a focus, no other group can take it.

1. Talk with your partners first and agree on the focus you want, plus a backup.
2. When Dr. Ijezie opens group forming, a pop-up appears on your Scholar Dashboard.
3. Your dashboard shows the opening time before then.
4. One person signs in to the Scholar Dashboard with their alias and PIN.
5. That person adds each partner by typing at least 3 letters of their alias.
6. Then they pick the group's focus and press Create group.
7. Taken focuses are crossed out.
8. Groups are 3 people.
9. One group in the class can have 4.
10. Everyone in the group now sees the group and focus on their own dashboard.
11. To change a group, talk to Dr. Ijezie.

WHO DOES WHAT

Team roles

EVERY TEAM

Lead Investigator

- Runs the lab investigation and the build tests, and records every setting and reading.
- Keeps the team on schedule and checks each day's checkpoint in the group note.
- Leads one of your three lessons.

Hands the raw readings to the Data Analyst by the end of Day 2.

EVERY TEAM

Data Analyst

- Does the team's calculation and checks it with the self-check.
- Builds the data table in the group note, with units on every number.
- Leads one of your three lessons.

Hands a checked table and one finished calculation to the Communicator by the end of Day 3.

EVERY TEAM

Science Communicator

- Leads the build and takes the build photos for approval.
- Plans the teach-back so every lesson gets equal time.
- Leads one of your three lessons.

Uploads at least two approved-quality photos by the test day.

ONLY THE TEAM OF FOUR

Verifier

- Repeats every test and calculation on their own and settles differences.
- Checks every number in the group note against its source.
- Helps each lesson lead and builds the strongest argument against the team's claim before teach-back.

Turns in a one-page verification log with the team's products. In a team of three, the Analyst writes the uncertainty statement and the Lead writes the counter-argument.

WHAT YOU MAKE

What every team makes

- **Working build** (Presented in class · Day 4).
 1. The thing your team builds.

2. It must pass its 'It works when' tests at least twice.
- **Build photos** (Group note · Day 4).
 1. At least two clear photos of the build only (no faces or people), uploaded in your group note.
 2. Approved photos appear on the Module 5 page.
 - **Group note** (Note Studio → Assessment Center · Day 7).
 1. Your shared Note Studio group note: your three lessons, build plan, test data, results, teach-back plan, and each teammate's own contribution and reflection.
 2. Each of you turns in your copy like notes homework.
 - **Teach-back lesson** (Presented in class · Day 7).
 1. A ten-minute lesson: show the build working, then each lesson lead teaches their lesson with it and asks one check question.

Your Note Studio group note

Open Note Studio and choose **ESS Group Project**. Your team types in one shared note at the same time, and nobody can erase a teammate's section.

Build plan and materials

- Sketch description.
- Materials list.
- Who brings what.

What this lesson teaches (one per lesson)

- Two to four key ideas.
- Vocabulary.
- One example.
- The lesson lead writes this; teammates add.

Build log and test data

- Every try:
- Date.
- What you changed.
- Results with units.

What our build shows and what it leaves out

- Claim.
- Evidence from your tests.
- One limit of the build.

Teach-back plan and check questions

- Who teaches what.
- In what order.
- One check question per lesson with the answer.

What I did (each scholar, only you type here)

- Your own work on each day.
- Only you type here.

My reflection (each scholar, only you type here)

- What you learned from another team.
- One thing you would change.

Turn in your copy

Photos: at least two of the build only, no faces or people. Dr. Ijezie approves them before they appear on the Module 5 page. On teach-back day:

1. Each of you presses Update my turn-in copy.
2. Turn it in on the Assessment Center.

THE PLAN

Seven days, seven checkpoints

DAY	WHAT HAPPENS	CHECKPOINT
Day 1 Tue, Mar 30	Form up and plan. Know your three lessons and plan the build. • Form your group on the Scholar Dashboard. • Pick your focus. • Open your group note in Note Studio. • Choose who leads each lesson. • Read your three lessons in the textbook and the Module 5 slides named in your brief. • In the note, write two key ideas from each. • Sketch the build. • List the materials.	Group note: lesson leads chosen, two key ideas per lesson, build sketch and materials list.
Day 2 Wed, Mar 31	Learn deeply. Become the expert on your lesson. • Each lesson lead fills in their lesson section: key ideas, vocabulary, one example. • Run your team's lab investigation in The Deep-Time Column. • Record every reading. • Gather materials.	Every lesson section filled in; lab readings recorded with units.
Day 3 Thu, Apr 1	Build. Build the thing and make it run once. • Build it. • Follow your build steps. • Anything that must settle or sit for a day starts today. • Try it once. • Write what happened and what you will fix. • Take progress photos (build only, no faces).	Build log in the group note; first try recorded.

DAY	WHAT HAPPENS	CHECKPOINT
Day 4 Fri, Apr 2	Test and photograph. Prove it works. - Run every 'It works when' test at least twice. - Record results with units. - Upload at least two photos of the finished build in the group note. - Do your team's calculation. - Check it.	Test data complete; two photos uploaded for approval.
Day 5 Mon, Apr 5	Improve and plan the lesson. Fix what failed and plan how to teach. - Fix one thing that did not work. - Test again. - Plan the ten-minute teach-back: two minutes of demo, then each lesson lead teaches with the build. - Write one check question per lesson, with an answer key.	Teach-back plan and three check questions in the group note.
Day 6 Tue, Apr 6	Rehearse. Practise until it runs smoothly. - Rehearse with another team. - They give one strength, one question, one fix. - Every teammate practises every part, not only their own lesson. - Each of you writes your own contribution and reflection in the group note.	Rehearsal feedback written; every teammate's contribution filled in.
Day 7 Wed, Apr 7	Teach-back day. Teach your lessons and learn all the others. - Each team teaches for ten minutes with its build. - Everyone takes learning notes. - Everyone answers every check question. - Press 'Update my turn-in copy' in the group note. - Turn it in to the Assessment Center. - Last-day partner review in the Assessment Center.	Teach-back given; learning notes; group note turned in; partner review done.

Layer Detectives

FOCUS QUESTION

How do we read the order of rock layers, and what do fossils tell us about the time and place each layer formed?

Every other team needs the rock record read in the right order. Your team teaches how layers stack, how fossils form and why most living things never become one, and how fossils let us match layers that are far apart.

Your lessons

1. Fossils and the Rock Record: Reading Layers in Order

Publisher lesson: your textbook pages. Dr. Ijezie shares the pages in class.

2. Fossils and the Rock Record: How Fossils Form and Why the Record Has Gaps

Publisher lesson: your textbook pages. Dr. Ijezie shares the pages in class.

3. Fossils and the Rock Record: Index Fossils, Correlation, and Past Environments

Publisher lesson: your textbook pages. Dr. Ijezie shares the pages in class.

Also read: Module 5 Slides — Geologic Time & Resources. Read the slide on reading the rock record from the bottom up (superposition, original horizontality, cross-cutting, and faunal succession with index fossils) and the trap slide 'Deepest Layer = Always Oldest Rock'.

Big ideas you will use

- Superposition: in a stack that has not been disturbed, the lowest layer formed first and the top layer formed last.
- Layers of sediment start out flat. Anything that cuts a layer, such as a dike or a fault, is younger than that layer.
- Most living things never become fossils. Fast burial and hard parts such as shells and bones make a fossil more likely, so the record has gaps.
- Fossils appear in the same order everywhere. An index fossil lived for a short time but spread widely, so it can match layers that are far apart. The kind of fossil also tells what the place was like, such as a shallow sea for a layer full of shells.

BUILD IT

Two sediment columns with buried fossils

Build two see-through sediment columns with 'fossils' buried in them. Classmates must put the layers in order and match the two columns using only the fossils.

Materials

- Two clear plastic bottles or jars with lids, the same size, and water
- Sand, fine gravel, and garden soil in cups (tint some sand with a drop of food colouring)
- Plastic beads in three or more shapes or colours that sink in water (drop one in water to test it first). These are the hard-shelled fossils.
- Tissue paper cut into small animal shapes (the soft-bodied animals)
- A cup, a spoon, and a kitchen strainer
- A ruler with millimetres, sticky notes, and a deposit log

Your model must show

1. Layers settle flat and in order: the first layer you pour ends up at the bottom.
2. Hard parts survive burial and rough water better than soft parts, so the fossil record has gaps.
3. The two columns have different layer thicknesses but still match by the same order of bead shapes.

Build steps

1. Fill each bottle one-third with water.
2. Spoon in one layer at a time and let each settle for 2 minutes.
3. Write every layer in the deposit log.
4. Before you bury each layer, drop in 5 beads of one shape.
5. Use a new shape for each time slice, in the same order in both bottles.
6. Make bottle B different: pour its layers thicker or thinner than bottle A, but keep the bead order the same.
7. Let both settle overnight, then measure every layer in mm.
8. Fossil test: mix 10 beads and 10 tissue-paper animals into a cup of wet sand.
9. Add water, stir hard for 30 seconds, and pour it through the strainer.
10. Count what comes out whole.
11. Cover your deposit logs with sticky notes before classmates test the columns.

It works when

- A classmate who did not watch you build puts every layer in the right order, oldest first, using only the bottle.
- In the fossil test, more of the 10 beads than of the 10 paper animals come out whole.
- A classmate draws every tie line between the two bottles using only the bead shapes, even where matching layers differ in thickness by 5 mm or more.

Test it: Run the classmate order-and-match test twice, with two different classmates. Record how many layers and tie lines each got right. Run the fossil test twice and record whole beads and whole paper

animals out of 10 each time. Record every layer thickness in mm.

Safety: Keep the bottles in a tray and wipe spills right away. Wash hands after handling soil. Keep beads off the floor.

The Deep-Time Column: Investigation 5, Correlation with limits

1. Open the Fossils scene in Succession mode.
2. Record the age window and the thickness of each layer in Measured Section A.
3. Open Correlation mode.
4. In Inspect fossil, select Graptoloid group.
5. Record its approximate group range.
6. Find a tie line.
7. Record which fossils the two layers share and each layer's age window.
8. Explain why the two tied layers can have different physical thickness.
9. Select Trilobite group.
10. Explain why a broad group makes a weaker index fossil than a short-lived species.

Calculate: Bracketing an age and overlapping age windows

1. A cliff has, from the bottom up: sandstone, a volcanic ash dated 62 million years old (62 Ma), shale, an erosion surface, and a second ash dated 48 Ma.
2. A dike cuts the sandstone, the lower ash, and the shale, but it stops at the erosion surface.
3. Give the tightest age range for the dike, and the most time the erosion gap could hold.
4. Then: a shale in Section A is 468 to 448 Ma old, and a sandstone in Section B is 472 to 452 Ma old.
5. Find the age window both layers could share, and how many million years wide it is.

Self-check: The dike is younger than 62 Ma (it cuts that ash) and older than 48 Ma (that ash buries it). The gap is less than $62 - 48 = 14$ million years. Shared window: 468 to 452 Ma, which is $468 - 452 = 16$ million years wide, and it sits inside both layers' windows.

Real data

- **The Grand Canyon's rock stack** · National Park Service, Grand Canyon Geology. The Park Service says the story begins almost two billion years ago with the igneous and metamorphic rocks of the inner gorge. The youngest rock layer, the Kaibab Formation at the rim, is 270 million years old. The Colorado River began carving the canyon only 5 to 6 million years ago. Use this to order your era and to show that the canyon, a cut, is younger than every rock it cuts.
<https://www.nps.gov/grca/learn/nature/grca-geology.htm> · Read on 2026-09-23.
- **A fossil of our own time** · Royal Society Open Science (2018), The broiler chicken as a signal of a human reconfigured biosphere. The authors report that broiler chickens now weigh more, all together, than all other birds on Earth combined. Their body mass has grown up to five times since the mid-twentieth century. The authors call this new kind of chicken a sign that humans are reshaping Earth's living world.
<https://zenodo.org/records/14816040> · Read in the paper's abstract on 2026-09-23.

- **How much trash we add each year** · U.S. EPA, National Overview: Facts and Figures on Materials, Wastes and Recycling. EPA reports 292.4 million tons of municipal solid waste in 2018. More than 146 million tons (50 percent) went to landfills. Almost 94 million tons were recycled or composted, a rate of 32.1 percent. Use this when you teach the landfill layer at the teach-back.

<https://www.epa.gov/facts-and-figures-about-materials-waste-and-recycling/national-overview-facts-and-figures-materials> · Figures read from the EPA page on 2026-09-23. They describe 2018.

- **Rules for building a landfill** · U.S. EPA, Municipal Solid Waste Landfills (40 CFR part 258). EPA says landfills must be built away from faults, wetlands, and flood plains. They need a composite liner: a plastic sheet laid over two feet of packed clay. Use it as evidence for your two existing responses.

<https://www.epa.gov/landfills/municipal-solid-waste-landfills> · Read on 2026-09-23.

A choice people make

1. Landfills stack a new layer of trash on the land every year.
2. A future geologist would read that layer with superposition, and the things in it would be the fossils of our time.

Two options to compare

- Lined landfills built under federal rules (40 CFR part 258)
- Recycling and composting, which keep material out of the landfill layer

Your map hotspot

1. Mark the tie line between your two bottles that you are most sure of, and name the bead shape that proves it.

Trap to avoid

The deepest layer is not always the oldest. Folding or a fault can push older rock on top of younger rock.

TEACH IT

Show your build working, then teach:

1. Lower layers formed first, unless something tilted, folded, or faulted them; anything that cuts a layer is younger than it.
2. Most living things never become fossils; hard parts and fast burial help, so the record has gaps.
3. Fossils appear in the same order everywhere, so index fossils match layers far apart even when the layers differ in thickness; the kinds of fossils also show what the place was like then.

Check question: Two layers far apart both contain trilobites. Why is that not enough to say they are the same age?

Texas standards

- **ESS.7B** Apply relative dating methods, principles of stratigraphy, and index fossils to determine the chronological order of rock layers. §112.49(c)(7)(B) *You use superposition, cross-cutting, and index fossils to put rock layers in order.*
- **ESS.7D** Explain how sedimentation, fossilization, and speciation affect the degree of completeness of the fossil record. §112.49(c)(7)(D) *You test why hard parts and fast burial make the fossil record more complete, and why it has gaps.*
- **ESS.7E** Describe how evidence of biozones and faunal succession in rock layers reveal information about the environment at the time those rocks were deposited and the dynamic nature of the Earth. §112.49(c)(7)(E) *You use faunal succession and fossil zones to match layers and read when they formed.*
- **ESS.1G** Develop and use models to represent phenomena, systems, processes, or solutions to engineering problems. §112.49(c)(1)(G) *You build a model of the rock record and use it to test an order of events.*
- **7.10A** Describe the evidence that supports that Earth has changed over time, including fossil evidence, plate tectonics, and superposition. §112.27(b)(10)(A) *Grade 6–8 foundation.*

Word bank: superposition · original horizontality · cross-cutting · fossil · index fossil · faunal succession · correlation

Time Keepers

FOCUS QUESTION

How can atoms give a rock an age in years, and how long is Earth's 4.6-billion-year history really?

Layers give an order. Your team adds the numbers. You teach how the atomic clock in some minerals works, how the time scale is built and how long each part really is, and how mass extinctions mark the big breaks in the record.

Your lessons

1. Geologic Time Scale: Relative Dating, Radiometric Dating, and Half-Life

Publisher lesson: your textbook pages. Dr. Ijezie shares the pages in class.

2. Geologic Time Scale: Building a Scaled Model of Deep Time

Publisher lesson: your textbook pages. Dr. Ijezie shares the pages in class.

3. Geologic Time Scale: Mass Extinctions and Major Events in the Rock Record

Publisher lesson: your textbook pages. Dr. Ijezie shares the pages in class.

Also read: Module 5 Slides — Geologic Time & Resources. Read the slides on half-life as a clock that needs a closed mineral system, the geologic time scale as architecture, and deep time in proportion, plus the trap slide 'Half Decayed = Half a Half-Life Old'. The deck rounds the start of the Cambrian to 541 million years ago; the 2026 official chart says 538.8 million years ago.

Big ideas you will use

- A half-life is the time for half of the parent atoms that are left to decay. After one half-life $\frac{1}{2}$ is left, after two $\frac{1}{4}$, after three $\frac{1}{8}$.
- A radiometric date needs a closed system: no parent or daughter atoms got in or out. Dates come with a plus-or-minus.
- The Precambrian is about 88 percent of Earth's history. Humans are a tiny sliver at the very end.
- Time-scale boundaries sit where the rock and fossil record changes, often at a mass extinction.

BUILD IT

Decay clock and a walk-through timeline

Build a shake-box decay clock and a true-to-scale timeline of Earth's history. Classmates use your clock to date a sample, then walk your timeline to find the mass extinctions.

Materials

- 100 pennies or two-colour counters and a shoebox with a lid
- About 5 m of receipt tape or adding-machine tape
- A metre stick and a ruler with millimetres
- Markers, sticky notes, and masking tape
- Graph paper and a calculator

Your model must show

1. Each shake is one half-life: about half of the parent coins left decay each time, not half of what you started with.
2. The whole timeline at 1 mm per million years (4.567 m), with the Precambrian and the Phanerozoic marked and measured.
3. The five mass extinctions placed to scale by date, with the era boundaries at 251.9 and 66.0 million years ago.

Build steps

1. Clock: put 100 coins in the box, close the lid, and shake.
2. Take out every coin that lands heads up (decayed).
3. Count the coins left (parent).
4. Repeat until fewer than 3 are left, and graph coins left against shakes.
5. Timeline: tape the strip flat along a wall.
6. Mark 'Today' at one end.
7. Measure 4,567 mm for Earth's start and 538.8 mm for the start of the Phanerozoic.
8. Mark the era boundaries at 251.9 mm and 66.0 mm, and the five mass extinctions at the Natural History Museum's dates.
9. Write a mystery-sample card: $\frac{1}{8}$ of the parent is left and the half-life is 1.3 million years.
10. Classmates date it with your graph and mark it on the tape.

It works when

- After 3 shakes, between 5 and 20 of the 100 coins are left (about $\frac{1}{8}$).
- Two scholars measure the Precambrian on the tape on their own, and each gets 4,028 mm, within 5 mm.
- A classmate dates the mystery sample from your graph (three half-lives) and finds all five mass extinctions on the tape using only your labels.

Test it: Run the shake test twice and graph both runs on the same axes. Record the coin count after every shake. Have two scholars measure the tape on their own; record both lengths in mm and fix any mark more than 5 mm off.

Safety: Keep coins out of your mouth and the lid on while shaking. Tape the timeline flat so no one trips, and keep walkways clear.

The Deep-Time Column: Investigation 3, Equal half-life steps

1. On the Column scene, choose Volcanic ash in Sediment and press Deposit layer.
2. Set Idealized half-life T (Ma) to 1.3.
3. Predict the age for 1/8 parent left.
4. Then move Parent remaining to 1/8 and read the Idealized radiometric clock box.
5. Move Parent remaining to 1/16.
6. Record how much the age went up.
7. Did it go up by one T, or did it double?
8. Move Parent remaining to 1/2, 1/4, and 1/32.
9. Record each age and each D*:P ratio in a table.
10. Read the Datability box.
11. Write down the three things a real date needs.

Calculate: Age from half-lives and scaling time to length

1. A mineral's clock has a half-life of 1.3 million years, and 1/8 of its parent atoms are left.
2. Find its age and its daughter-to-parent ratio.
3. Then let 1 mm stand for 1 million years.
4. The ICS chart puts Earth's start at 4,567 million years ago and the start of the Phanerozoic at 538.8 million years ago.
5. Find the length of the whole timeline, the length of the Precambrian part, and the Precambrian's percent of the total.

Self-check: 1/8 left is three halvings: $3 \times 1.3 = 3.9$ million years. Daughter is 7/8, so D:P = 7:1. Whole timeline 4,567 mm = 4.567 m. Precambrian $4,567 - 538.8 = 4,028.2$ mm. $4,028.2 \div 4,567 = 0.882$, so 88.2%. Check: $4,028.2 + 538.8 = 4,567$.

Real data

- **Real atomic clocks** · USGS, Geologic Time: Radiometric Time Scale. USGS lists uranium-238 decaying to lead-206 with a half-life of 4.5 billion years, uranium-235 to lead-207 at 704 million years, and potassium-40 to argon-40 at 1.25 billion years. It says only certain rocks, chiefly igneous rocks, can be dated directly. Sedimentary rocks are dated by bracketing them between dated igneous rocks.
<https://pubs.usgs.gov/gip/geotime/radiometric.html> · Figures read from the USGS page on 2026-09-23.
- **The official time scale** · International Commission on Stratigraphy, International Chronostratigraphic Chart v2026/06. The June 2026 chart gives these ages. Earth's start (base of the Hadean): 4567 Ma. Start of the Phanerozoic (base of the Cambrian): 538.8 ± 0.6 Ma. Permian–Triassic boundary: 251.902 ± 0.024 Ma. Cretaceous–Paleogene boundary: 66.00 Ma. Base of the Quaternary: 2.58 Ma.
<https://stratigraphy.org/ICSchart/ChronostratChart2026-06.pdf> · Figures read from the ICS chart on 2026-09-23.
- **Dates get revised** · International Commission on Stratigraphy, chart update 2026/06. ICS says the June 2026 chart improved the ages of three stages: two in the Triassic and one in the Permian. For example, the Anisian stage moved from 246.7 Ma to 247.0 Ma. Use this on a panel to show that boundary dates change as dating improves.
<https://stratigraphy.org/news/156> · Read on 2026-09-23.

- **The five mass extinctions** · Natural History Museum (London), What is mass extinction and are we facing a sixth one?. The museum defines a mass extinction as about 75 percent of species lost in less than 2.8 million years. It lists five: Ordovician–Silurian (443 million years ago, about 85 percent), Devonian (374, about 75 percent), Permian (250, more than 95 percent), Triassic (200, about 80 percent), and Cretaceous (66, 78 percent).

<https://www.nhm.ac.uk/discover/what-is-mass-extinction-and-are-we-facing-a-sixth-one.html> · Figures read from the museum page on 2026-09-23. Note that this page says more than 95 percent for the Permian and USGS says about 96 percent.

- **Species at risk today** · IUCN Red List of Threatened Species. Record how many species have been assessed and how many are listed as threatened, with the date the page gives.

<https://www.iucnredlist.org/> · Look this up yourself. Record the date you read it.

- **Protecting species at risk** · U.S. Fish and Wildlife Service, Endangered Species Act. The Fish and Wildlife Service says the Act was signed into law on December 28, 1973. It protects fish, wildlife, and plants listed as threatened or endangered, and it plans for their recovery. Use it as evidence for your first existing response.

<https://www.fws.gov/law/endangered-species-act> · Read on 2026-09-23.

A choice people make

1. Species are being lost today, and a few farmed species are spreading fast.
2. Scientists ask whether this could become a sixth mass extinction in the rock record.

Your map hotspot

1. On your timeline, mark the boundary with the largest plus-or-minus you can find on the ICS chart, and show how thin the human part of the timeline is.

Two options to compare

- Legal protection for threatened and endangered species under the U.S. Endangered Species Act (1973)
- Protecting habitat in parks and reserves

Trap to avoid

Half the parent left does not mean half of a half-life has passed. It means one whole half-life has passed.

TEACH IT

Show your build working, then teach:

1. Relative dating gives an order; radiometric dating adds a number, counted in whole half-lives, with a plus-or-minus.
2. Earth's history is about 4.6 billion years long, and the Precambrian is almost nine-tenths of it.
3. Mass extinctions show up as sudden changes in the fossils, and two of them mark era boundaries.

Check question: A mineral has 1/4 of its parent atoms left. Its half-life is 1.3 million years. How old is its clock?

Texas standards

- **ESS.7A** Describe the development of multiple radiometric dating methods and analyze their precision, reliability, and limitations in calculating the ages of igneous rocks from Earth, the Moon, and meteorites. §112.49(c)(7)(A) *You analyze how precise and reliable radiometric dates are, and what limits them.*
- **ESS.7C** Construct a model of the geological time scale using relative and absolute dating methods to represent Earth's approximate 4.6-billion-year history. §112.49(c)(7)(C) *You build a scaled model of the geologic time scale that covers Earth's 4.6-billion-year history.*
- **ESS.7F** Analyze data from rock and fossil succession to evaluate the evidence for and significance of mass extinctions, major climatic changes, and tectonic events. §112.49(c)(7)(F) *You place mass extinctions on the time scale using fossil evidence.*
- **ESS.2C** Use mathematical calculations to assess quantitative relationships in data. §112.49(c)(2)(C) *You calculate ages from half-lives and turn ages into lengths and percents.*
- **7.10A** Describe the evidence that supports that Earth has changed over time, including fossil evidence, plate tectonics, and superposition. §112.27(b)(10)(A) *Grade 6–8 foundation.*

Word bank: isotope · half-life · parent atom · daughter atom · radiometric dating · eon · era · mass extinction

Aquifer Lab

FOCUS QUESTION

What makes a resource renewable, and what happens to our water when more people pump more of it?

Your team teaches what natural resources are, how a growing population uses them, and how people change the water we depend on. Groundwater is your example, because the slides say it sits between renewable and nonrenewable.

Your lessons

1. Natural Resources

Publisher lesson: your textbook pages. Dr. Ijezie shares the pages in class.

2. Populations and Use of Natural Resources

Publisher lesson: your textbook pages. Dr. Ijezie shares the pages in class.

3. Water — and Human Impacts on Water

Publisher lesson: your textbook pages. Dr. Ijezie shares the pages in class.

Also read: Module 5 Slides — Geologic Time & Resources. Read the slides on Earth's resources and the rate problem, reserve lifetime (the groundwater lesson), and sustainability as a testable inequality, plus the trap slide 'Renewable = Plenty Left, So We're Fine'.

Big ideas you will use

- A resource is renewable only if it is replaced at least as fast as it is used. It is about rates, not about how much is left.
- Total use = number of people × use per person. More people, or more use each, means a bigger draw.
- An aquifer is rock or sediment that holds groundwater. Rain soaks in and refills it; this is called recharge.
- Pumping faster than recharge lowers the water table. Pollution on the surface can soak down into the water we pump.

BUILD IT

Aquifer in a tub with a working well

Build a see-through aquifer with a well you can pump and rain you can add. Show when the water supply holds steady, when it runs down, and how pollution reaches the well.

Materials

- A clear plastic tub about the size of a shoebox (about 30 cm × 20 cm)
- Gravel and sand to fill the tub about two-thirds full
- Two clear plastic tubes about 2 cm wide for wells, each with a scrap of cloth taped over its bottom end
- A large syringe with no needle, or a turkey baster, to pump the well
- A paper cup with small holes in the bottom (the rain) and a measuring cup in mL
- Food colouring (the pollution) and a ruler taped to the side of the tub

Your model must show

1. Groundwater is renewable only when pumping is no faster than recharge.
2. A bigger town pumps more, and more pumping lowers the water table more.
3. Pollution on the surface soaks down and reaches the well.

Build steps

1. Layer gravel, then sand, in the tub.
2. Add water until the bottom half is soaked.
3. Mark the water table on the ruler.
4. Push one well tube down to the gravel near one end.
5. Pump out 100 mL while you rain 100 mL onto the sand.
6. Wait until the level on the ruler stops moving, then read the water table.
7. Rain until the water table is back at your first mark.
8. Pump 300 mL while you rain only 100 mL, wait, and read the water table again.
9. Rain back up to the first mark.
10. Push in the second well for a bigger town.
11. Pump 300 mL from each well while you rain 100 mL, wait, and read the water table.
12. Put 3 drops of food colouring on the sand 5 cm from a well.
13. Rain 100 mL and pump.
14. Time how long until coloured water comes up the well.

It works when

- Pumping 300 mL with 100 mL of rain lowers the water table at least 3 mm on the ruler, and more than pumping 100 mL with 100 mL of rain.
- Two wells pumping 300 mL each for a bigger town lower the water table more than one well pumping 300 mL, with the same 100 mL of rain.

- Coloured water from the surface shows up in the pumped water, and you record how many seconds it took.

Test it: Run each pumping test twice. Record rain and pumping in mL, the water table in mm before and after, and the time in seconds for the colour to reach the well.

Safety: Keep the tub on a tray and wipe spills right away. Use a syringe with no needle. Never drink the water.

The Deep-Time Column: Investigation 6, Rate, stock, and pathway

1. Open the Resources scene.
2. Select Coal, Oil, Natural gas, and Metal ore in turn.
3. Record how each one forms.
4. Select Oil.
5. Trace the path from the mature source rock, through migration, into the oil reservoir under the seal.
6. Sketch it.
7. Set Reserve (classroom units) to 1200 and Annual use to 40, with Annual demand growth (%) at 0.
8. Record the lifetime.
9. Then set growth to 3 and record the new lifetime.
10. Select Aquifer.
11. Set Pumping units/year above Recharge units/year.
12. Record the net change and the word the lab uses for it.

Calculate: Net recharge, lifetime, and total use

1. An aquifer gets 80 units of recharge a year and is pumped at 110 units a year.
2. Find the net change each year.
3. If it holds 1,200 units, how many years until it runs dry at that rate?
4. Then a town of 5,000 people uses 400 L of water per person each day.
5. Find the town's use per day.
6. The town grows to 10,000 people and cuts use to 300 L per person.
7. Find the new use per day.

Self-check: $80 - 110 = -30$ units a year (a minus sign means overdraft). $1,200 \div 30 = 40$ years; check $40 \times 30 = 1,200$. $5,000 \times 400 = 2,000,000$ L a day. $10,000 \times 300 = 3,000,000$ L a day, so use still grows by 1,000,000 L a day.

Real data

- **The aquifer under campus** · Texas Water Development Board, Gulf Coast Aquifer. TWDB says the aquifer includes the Jasper, Evangeline, and Chicot aquifers, made of patchy beds of sand, silt, clay, and gravel. The thickness of the fresh-water-filled part averages about 1,000 feet.

<https://www.twdb.texas.gov/groundwater/aquifer/majors/gulf-coast.asp> · Read on 2026-09-23.

- **How deep is the water under campus?** · Texas Water Development Board, Groundwater Data Viewer. Find the well nearest campus. Record its depth, its most recent water-level measurement, and the date of that measurement. Compare that real water table with the one in your model.

<https://www3.twdb.texas.gov/apps/WaterDataInteractive/GroundwaterDataViewer> · Look this up yourself. Record the date you read it.

A choice people make

1. Pumping groundwater faster than rain refills it, and letting pollution soak down into it.

Two options to compare

- Pumping limits that keep total use at or below recharge
- Using less water per person: fixing leaks and using water-saving fixtures

Your map hotspot

1. Mark on your aquifer where the water table dropped the most, and where the pollution went in.

Trap to avoid

A big aquifer is not renewable just because it is big. If pumping is faster than recharge, it runs down like a mine.

TEACH IT

Show your build working, then teach:

1. Renewable is a rate: a resource stays renewable only while we use it no faster than it is replaced.
2. Total use = people × use per person, so a growing population needs either more water or less use per person.
3. Pumping faster than recharge lowers the water table, and surface pollution can reach the water we pump.

Check question: An aquifer is huge, but it is pumped faster than rain refills it. Is it acting like a renewable resource? Explain.

Texas standards

- **ESS.9D** Evaluate how weather and human activity affect the location, quality, and supply of available freshwater resources. §112.49(c)(9)(D) *You test how human activity changes the supply and quality of freshwater.*
- **ESS.9B** Investigate and model how surface water and ground water change the lithosphere through chemical and physical weathering and how they serve as valuable natural resources. §112.49(c)(9)(B) *You model groundwater as a valuable resource.*
- **ESS.13A** Analyze the policies related to resources from discovery to disposal, including economics, health, technological advances, resource type, concentration and location, waste disposal and recycling, mitigation efforts, and environmental impacts. §112.49(c)(13)(A) *You compare pumping limits and conservation as policies for a shared resource.*
- **ESS.16** Develop and use models to represent phenomena, systems, processes, or solutions to engineering problems. §112.49(c)(1)(G) *You build a working aquifer model and test it.*
- **7.11A** Analyze the beneficial and harmful influences of human activity on groundwater and surface water in a watershed. §112.27(b)(11)(A) *Grade 6–8 foundation.*
- **6.11B** Explain how conservation, increased efficiency, and technology can help manage air, water, soil, and energy resources. §112.26(b)(11)(B) *Grade 6–8 foundation.*

Word bank: natural resource · renewable resource · nonrenewable resource · aquifer · groundwater · recharge · water table · overdraft

Footprint Lab

FOCUS QUESTION

How do we use land, air, and energy, and what marks does that use leave on Earth?

Your team teaches three resources and the human impact on each: soil and land, the air we breathe, and the energy we use. The slides call it spending deep time on a short budget: what took centuries or millions of years to make can be used up in decades.

Your lessons

1. Land — and Human Impacts on Land

Publisher lesson: your textbook pages. Dr. Ijezie shares the pages in class.

2. Air — and Human Impacts on Air

Publisher lesson: your textbook pages. Dr. Ijezie shares the pages in class.

3. Energy — and Human Impacts on Energy Resources

Publisher lesson: your textbook pages. Dr. Ijezie shares the pages in class.

Also read: Module 5 Slides — Geologic Time & Resources. Read the slide 'Human Impact: Spending Deep Time on a Short Budget' (fossil fuel burning, topsoil erosion, and ore dispersal) and the reserve-lifetime slide on how fossil fuels form.

Big ideas you will use

- Topsoil forms very slowly, at a fraction of a millimetre a year. One heavy storm on bare ground can wash away soil that took decades or centuries to build.
- Clean air is a resource. Burning fuel and stirring up dust add particles and gases to it.
- Oil and gas form from buried remains, move up through rock, and collect in a porous reservoir under a seal.
- Burning fossil fuels moves carbon that was buried for millions of years into the air in decades. Wind and sunlight are renewable flows.

BUILD IT

Land, air, and energy test bench

Build three working stations, one per lesson: a rain test on soil, particle catchers for the air, and an oil trap. Each station must show its process happening in front of the class.

Materials

- Land: two foil baking pans of soil, each with a small notch cut in one short end for runoff (an adult cuts it). Cover one with grass clippings, leaves, or mulch. Two clear cups that hold 500 mL catch the runoff.
- A paper cup with small holes in the bottom (the rain) and a measuring cup in mL
- Air: five index cards smeared with petroleum jelly, tape, and a hand lens
- Energy: a clear plastic cup, gravel, a hollow dome of modeling clay (the seal), water, and vegetable oil
- A syringe with no needle and a thin tube
- A ruler with millimetres and a timer

Your model must show

1. Bare soil loses more soil to rain than covered soil.
2. Particle catchers show how many particles settle from the air in different places.
3. Oil rises through wet rock and collects under a seal; without the seal it rises to the top and escapes.

Build steps

1. Land: tilt both pans the same way (one book under the end without the notch), with the notch over a clear cup.
2. Rain 500 mL on each from the same height.
3. Let the runoff settle for 10 minutes, then measure the mud layer in mm.
4. Air: tape particle cards in 3 to 5 places, such as near the car drop-off, a hallway, a classroom, and a window.
5. Collect them after 24 hours.
6. Count particles in a 1 cm square with the hand lens.
7. Energy: fill the cup halfway with gravel and bury the end of the tube in the middle of the gravel.
8. Fill the cup with water.
9. Tip the clay dome as you lower it so no air is trapped, and press its rim into the gravel over the tube end.
10. Inject 10 mL of oil and wait 2 minutes.
11. Then lift the dome and watch.
12. Repeat with no dome.
13. Label each station with its lesson and the resource it models.

It works when

- The bare tray's runoff settles a thicker mud layer, in mm, than the covered tray's.

- Every particle card has a count per square centimetre, and you can say which place had the most.
- With the dome on, no oil reaches the water surface in 2 minutes, and when you lift the dome a layer of oil rises to the top. With no dome, the oil reaches the top on its own.

Test it: Run the rain test and the oil test twice each. Record runoff in mL, mud layers in mm, particle counts per cm², and the thickness in mm of the oil layer on top of the water after you lift the dome and in the no-dome test.

Safety: Use a syringe with no needle. Wipe oil spills at once because oily floors are slippery. Wash hands after handling soil and petroleum jelly. Ask before taping cards outside the classroom.

The Deep-Time Column: Investigation 6, Rate, stock, and pathway

1. Open the Resources scene.
2. Select Coal, Oil, Natural gas, and Metal ore in turn.
3. Record how each one forms.
4. Select Oil.
5. Trace the path from the mature source rock, through migration, into the oil reservoir under the seal.
6. Sketch it.
7. Set Reserve (classroom units) to 1200 and Annual use to 40, with Annual demand growth (%) at 0.
8. Record the lifetime.
9. Then set growth to 3 and record the new lifetime.
10. Select Aquifer.
11. Set Pumping units/year above Recharge units/year.
12. Record the net change and the word the lab uses for it.

Calculate: Reserve lifetime and replacement time

1. A fuel reserve holds 1,200 units and we use 40 units a year.
2. Find its lifetime at constant use.
3. The lab shows a shorter lifetime when use grows 3 percent a year; record it and explain why growth makes it shorter.
4. Then suppose topsoil forms at 0.1 mm a year, and one storm on bare ground removes 5 mm.
5. How many years does it take to replace that soil?

Self-check: $1,200 \div 40 = 30$ years; check $30 \times 40 = 1,200$. With growth, each year uses more than the last, so the reserve empties sooner. Soil: $5 \div 0.1 = 50$ years; check $50 \times 0.1 = 5$ mm.

Real data

- **Carbon dioxide in the air** · NOAA Global Monitoring Laboratory, Trends in Atmospheric Carbon Dioxide (Mauna Loa). NOAA's monthly mean at Mauna Loa was 427.55 ppm in August 2026 and 425.48 ppm in August 2025. Read the newest monthly value yourself and find the change from a year earlier.
<https://gml.noaa.gov/ccgg/trends/> · Figures read from the NOAA page on 2026-09-23. The value changes every month, so record the month and the date you read it.

- **Texas energy** · U.S. Energy Information Administration, Texas State Profile. Record Texas's share of U.S. crude oil production and its share of U.S. wind generation, with the year each number describes.
<https://www.eia.gov/states/TX/analysis> · Look this up yourself. Record the date you read it.
- **Storing carbon back underground** · U.S. EPA, Class VI Wells used for Geologic Sequestration of Carbon Dioxide. EPA says Class VI wells inject carbon dioxide into deep rock formations. The rock is typically thousands of feet below the surface and cut off from underground sources of drinking water. This long-term storage is called geologic sequestration. Use it as evidence for your second existing response.
<https://www.epa.gov/uic/class-vi-wells-used-geologic-sequestration-carbon-dioxide> · Read on 2026-09-23. Background reading, no numbers to copy.

A choice people make

1. Burning fossil fuels moves carbon that was buried for millions of years into the air in decades, and clearing land lets topsoil wash away.

Two options to compare

- Making electricity from renewable flows such as wind and sunlight
- Capturing carbon dioxide and storing it deep underground in Class VI wells

Your map hotspot

1. Mark where the oil collects under your seal, and the place where your particle cards caught the most.

Trap to avoid

Fossil fuels are not renewable just because plants still grow. The fuel took millions of years to form, and we use it in decades.

TEACH IT

Show your build working, then teach:

1. Topsoil forms far more slowly than bare ground can lose it, so covering the land protects it.
2. Burning fuel and stirring up dust put particles and gases into the air we breathe.
3. Fossil fuels took millions of years to form and collect under a seal; we use them in decades and move their carbon into the air.

Check question: Why is coal called nonrenewable even though plants still grow today?

Texas standards

- **ESS.12E** Predict how human use of Texas's naturally occurring resources such as fossil fuels, minerals, soil, solar energy, and wind energy directly and indirectly changes the cycling of matter and energy through Earth's systems. §112.49(c)(12)(E) *You predict how using Texas fossil fuels, soil, and wind changes the cycling of matter and energy.*
- **ESS.12F** Explain the cycling of carbon through different forms among Earth's systems and how biological processes have caused major changes to the carbon cycle in those systems over Earth's history. §112.49(c)(12)(F) *You explain how carbon stored in rock over Earth's history moves back into the air.*
- **ESS.13A** Analyze the policies related to resources from discovery to disposal, including economics, health, technological advances, resource type, concentration and location, waste disposal and recycling, mitigation efforts, and environmental impacts. §112.49(c)(13)(A) *You analyze resource use from discovery to disposal, including rates and environmental impacts.*
- **ESS.16** Develop and use models to represent phenomena, systems, processes, or solutions to engineering problems. §112.49(c)(1)(G) *You build three working models of land, air, and energy processes.*
- **6.11B** Explain how conservation, increased efficiency, and technology can help manage air, water, soil, and energy resources. §112.26(b)(11)(B) *Grade 6–8 foundation.*
- **8.11C** Describe the carbon cycle. §112.28(b)(11)(C) *Grade 6–8 foundation.*

Word bank: topsoil · erosion · particulate matter · fossil fuel · reservoir rock · seal · reserve lifetime · carbon cycle

Day 7: teach, learn, decide

Teach-back day. Every team teaches its three lessons, so everyone leaves knowing all twelve.

ABOUT 40 MINUTES

Teach-back lessons

Each team teaches for ten minutes: two minutes showing the build working, then each lesson lead teaches their lesson with the build and asks one check question. Every visitor writes an answer.

ABOUT 7 MINUTES

Council

Mixed groups answer the driving question using evidence from all four teams.

ABOUT 8 MINUTES

On your own

Exit ticket, then turn in your group note and do the partner review.

Your learning notes, for every team's lesson

- Team and lessons
- What the build showed
- Key idea from each lesson
- My answers to their check questions
- A question I still have

SCORING

The rubric

One rubric for every ESS team project. Your team is scored together on the first four rows; the last row is scored for you alone. Read it before you start and check your work against it before teach-back day.

STRAND	4 • EXEMPLARY	3 • PROFICIENT	2 • DEVELOPING	1 • BEGINNING
Lesson science Content accuracy across all your lessons • 25% • team	Every lesson is correct and complete, uses the right vocabulary, and connects to the other lessons and the driving question.	Every lesson is correct, with key ideas and vocabulary.	One lesson has errors or gaps, or the ideas are listed without explanation.	Lessons are missing or mostly wrong.
The build works Function, testing, and photos • 25% • team	The build passes every 'It works when' test at least twice, the results have units, one fix improved it, and clear approved photos show it.	The build passes its tests, with recorded results and photos.	The build works only partly, or the tests are not recorded.	The build does not work or was not tested.
Teaching the class Teach-back and check questions • 20% • team	Each lesson lead teaches clearly with the build; most classmates answer the check questions correctly; timing is right.	Every lesson is taught with the build, and check questions are asked.	Some lessons are rushed or taught without the build.	The lesson is missing or unclear.
Group note Note Studio group note and evidence • 20% • team	Every section is complete, data has units and sources, the claim matches the evidence, and it names one limit of the build.	Every section is complete, with data and a claim.	Some sections are thin or missing.	The note is mostly empty.
My contribution Individual work, partner and teacher ratings • 10% • each scholar	You led your lesson well, did your role on time, and made a teammate's work better. Your contribution section, partner ratings, and teacher rating agree.	You led your lesson and did your role on time.	Your part was late or only partly done.	Little evidence of your part.

The first four rows are scored for the team. My contribution, your learning notes, and your exit ticket are scored for you alone.

ON YOUR OWN

Exit ticket

1. Pick a lesson another team taught. Explain its main idea in two or three sentences.
2. Name one test from another team's build and what it proved.
3. Write one number you learned today, with its unit and where it came from.
4. Name the part of your team's work you did yourself, and one thing you would rebuild.

Sentence starters

- *Our team claims that ___ because ___.*
- *We observed ___. From that we infer ___.*
- *The rock shows ___, so the order of events is ___.*
- *This date comes from ___ dating. It assumes ___.*
- *In the lab, when we changed ___, the ___ went up / went down by ___.*
- *It is renewable only if ___ is no faster than ___.*
- *The data came from ___, and we read it on ___.*
- *One limit of our model is ___.*
- *I agree with ___ because ___. I would add ___.*
- *Can you explain how ___ connects to ___?*

Supports you can use

- Every packet has a word bank. Look up any word in the Ascent Lexicon.
- You may draft in the language you think in best and then write the final version in English.
- Use the sentence starters above in your claim, your lesson, and the council.
- The teach-back lesson can be split between teammates, and it can use the slide's pictures and numbers as notes.
- Ask your teacher for a printed packet, a larger-print copy, or extra time on any checkpoint.

STANDARDS

Standards for the whole project

These are selected connections to the Texas standards for Earth Systems Science (19 TAC §112.49), not a claim that this project fully covers each one. No engineering-design (HS-ETS) standard is claimed.

- **ESS.3B** Communicate explanations and solutions individually and collaboratively in a variety of settings and formats. §112.49(c)(3)(B) *Every team teaches its lessons to the class and explains its build.*
- **ESS.3C** Engage respectfully in scientific argumentation using applied scientific explanations and empirical evidence. §112.49(c)(3)(C) *The council argues from evidence across all four teams.*

SOURCES

Where the numbers come from

1. National Park Service. Grand Canyon Geology. <https://www.nps.gov/grca/learn/nature/grca-geology.htm> (read 2026-09-23)
2. U.S. Environmental Protection Agency. National Overview: Facts and Figures on Materials, Wastes and Recycling. <https://www.epa.gov/facts-and-figures-about-materials-waste-and-recycling/national-overview-facts-and-figures-materials> (read 2026-09-23)
3. U.S. Environmental Protection Agency. Municipal Solid Waste Landfills. <https://www.epa.gov/landfills/municipal-solid-waste-landfills> (read 2026-09-23)
4. Bennett, C. E., and others (2018). The broiler chicken as a signal of a human reconfigured biosphere. Royal Society Open Science 5(12): 180325. <https://doi.org/10.1098/rsos.180325> <https://zenodo.org/records/14816040> (read 2026-09-23)
5. U.S. Geological Survey. Geologic Time: Radiometric Time Scale. <https://pubs.usgs.gov/gip/geotime/radiometric.html> (read 2026-09-23)
6. International Commission on Stratigraphy. International Chronostratigraphic Chart, v2026/06. <https://stratigraphy.org/ICSchart/ChronostratChart2026-06.pdf> (read 2026-09-23)
7. International Commission on Stratigraphy. ICS International Chronostratigraphic Chart receives update 2026/06. <https://stratigraphy.org/news/156> (read 2026-09-23)
8. Natural History Museum, London. What is mass extinction and are we facing a sixth one? <https://www.nhm.ac.uk/discover/what-is-mass-extinction-and-are-we-facing-a-sixth-one.html> (read 2026-09-23)
9. International Union for Conservation of Nature. The IUCN Red List of Threatened Species. <https://www.iucnredlist.org/> (live data)

10. U.S. Fish and Wildlife Service. Endangered Species Act. <https://www.fws.gov/law/endangered-species-act> (read 2026-09-23)
11. NOAA Global Monitoring Laboratory. Trends in Atmospheric Carbon Dioxide. <https://gml.noaa.gov/ccgg/trends/> (read 2026-09-23)
12. U.S. Energy Information Administration. Texas State Profile and Energy Estimates. <https://www.eia.gov/states/TX/analysis> (live data)
13. U.S. Environmental Protection Agency. Class VI Wells used for Geologic Sequestration of Carbon Dioxide. <https://www.epa.gov/uic/class-vi-wells-used-geologic-sequestration-carbon-dioxide> (read 2026-09-23)
14. Texas Water Development Board. Gulf Coast Aquifer. <https://www.twdb.texas.gov/groundwater/aquifer/majors/gulf-coast.asp> (read 2026-09-23)
15. Texas Water Development Board. Groundwater Data Viewer. <https://www3.twdb.texas.gov/apps/WaterDataInteractive/GroundwaterDataViewer> (live data)

Deep Time Museum: Four Teams, Twelve Lessons · drijezie.com/courses/earth-systems-science/projects/deep-time-museum/