Introduction to Fossils:

Evidence of Past Life

- A fossil is the preserved evidence of ancient life in a geologic context
- Body fossils: physical remains like bones, shells, and leaves
- Trace fossils: evidence of activity such as footprints and burrows
- The surrounding rock provides critical clues about environment and age
- Goal: confidently identify fossil types and interpret environmental clues

What is a Fossil?
A Scientific Definition

- A fossil is evidence of life preserved in a geological context
- Includes bones, shells, tracks, trails, and chemical signatures
- Fossils are not always stone; insects in amber, frozen mammoths are fossils too
- Fossilization is rare: rapid burial, hard parts, and stable environments are key
- Taphonomy: the study from an organism's death to its discovery

The Two Major Categories: Body and Trace

- **Body fossils:** preserved body parts (bones, shells, leaves)—the organism's anatomy
- **Trace fossils (ichnofossils):** evidence of activity (footprints, burrows, droppings)—the organism's behavior
- **Simple rule:** body fossils = what an organism *was*; trace fossils = what an organism *did*
- **Example:** dinosaur bone = body fossil; dinosaur footprint = trace fossil

Body Fossils: Direct Remains of Organisms

- Range from dinosaur skeletons to pollen, petrified wood, and amber insects
- Permineralization fills pore spaces; replacement swaps original minerals
- Carbonization leaves a thin carbon film of the organism
- Rare unaltered remains: original shells, mummies, frozen mammoths
- Molds (negative impression) and casts (mineral-filled positive)

PERMINERALIZED BONE (CROSS-SECTION)

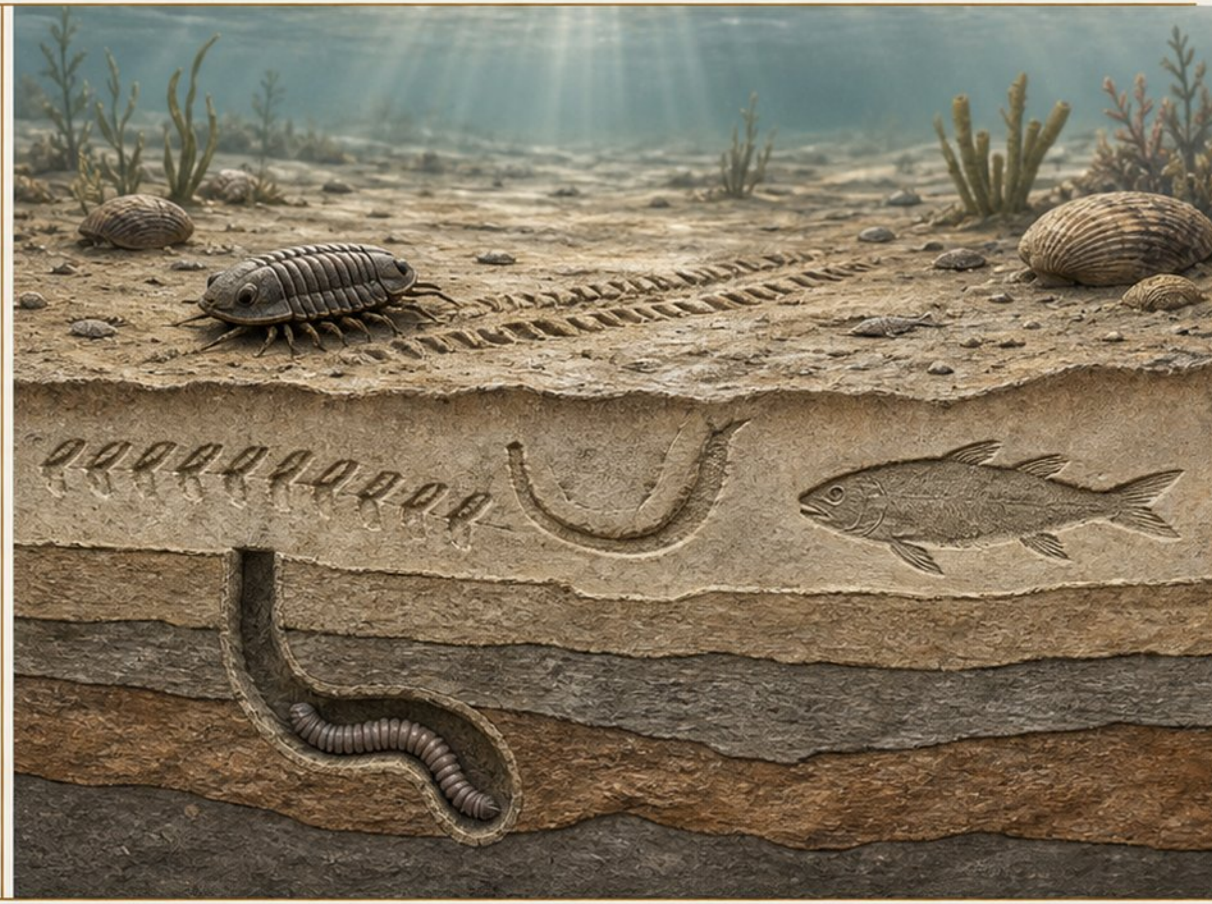
CARBONIZED FERN FROND

PYRITIZED AMMONITE

CAST AND MOLD PAIR OF BIVALVE

Trace Fossils: Evidence of Ancient Activity

- Trace fossils (ichnofossils) record behavior: moving, feeding, dwelling, resting, escaping.
- Major types: footprints (repichnia), burrows (domichnia), feeding traces (fodinichnia), resting traces (cubichnia), coprolites.
- They reveal what body fossils cannot: speed, social behavior, diet, and soft-tissue interactions.
- One maker can leave many trace types; different organisms can make identical traces.
- Classified by shape and behavior (ethology), not by the maker.



Distinguishing Body from Trace Fossils: A Practical Guide

Fossil egg with embryo
(body part)

Root cast
(root = body part)

Body part?

Yes → **Body Fossil**

No → **Result of activity?**

Yes → **Trace Fossil**

No

Coprolite
(animal feces)

Mold / cast (impression)
(of a shell)

Burrow structure
(animal burrow)

Checklist: Body part? → Body fossil. Result of activity? → Trace fossil.

Molds & casts are body fossils (impressions of the body).

Roots are body fossils; animal burrows are trace fossils.

Eggs with embryos are body fossils; the nest structure is a trace fossil.

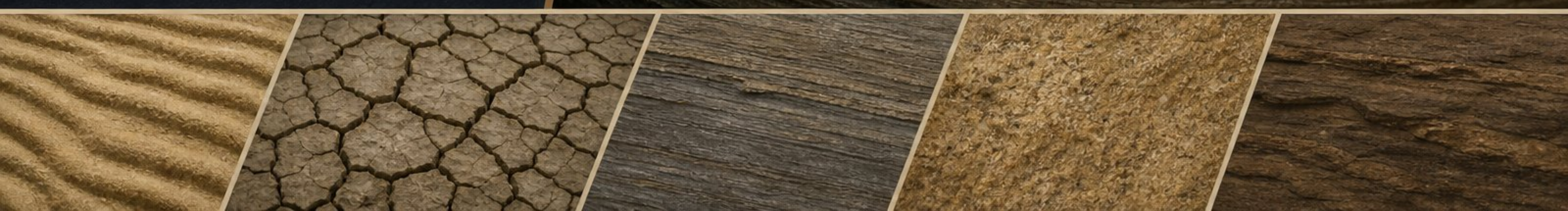
Interactive examples: Classify each image as body or trace.

Geological Context: Why the Rock Matters

- A fossil without its rock is a clue without its crime scene.
- Stratigraphy uses layer position to provide a timeline.
- In-situ orientation reveals transport and environmental energy.
- Loss of context can misrepresent age, environment, and identity.

Sedimentary Environments and Their Fossils

- Fast-flowing rivers preserve heavy bones, not delicate leaves
- Low-energy lake beds can preserve fine anatomical details
- Fine mudstone signals quiet water; coarse sandstone signals high energy
- Ripple marks and mud cracks reveal ancient depositional settings
- Fluvial, lacustrine, shallow marine, deep marine, and terrestrial contexts



How Fossils Become Fossils: The Process

- Fossilization has three steps: death, rapid burial by sediment, and mineral alteration over time.
- Rapid burial protects remains from scavengers and decay, especially in oceans, lakes, and floodplains.
- Hard parts like bones and shells have far greater preservation potential than soft tissues.
- Exceptional preservation (Lagerstätten) can retain soft tissues and whole ecosystems.

Integrated Case Study 1: A Jurassic Tidal Flat

- Explore Cabeço da Ladeira, a Middle Jurassic tidal flat in Portugal
- Body fossils: starfish, gastropods, crinoids, and ammonites, many articulated
- Trace fossils: crinoid trails, crab trackways, fish trails, and ray feeding burrows
- Carbonate sediment context integrates all evidence into a vibrant ecosystem reconstruction

Integrated Case Study 2: A Cretaceous River Ecosystem

- Velaux-La Bastide Neuve, France: a Late Cretaceous fluvial system
- Body fossils dominated by titanosaur *Atsinganosaurus*, crocs, turtles
- Trace fossils: abundant shed crocodile teeth and deep bite marks
- Sedimentology reveals channel sandstones and floodplain silts
- Together, body, trace, and context reconstruct predation and scavenging

Integrated Case Study 3:
A Late Pleistocene Lakeshore

- Vertebrate trace and body fossils found together on the same surface
- Body fossils capture small mammals absent from the footprint record
- Footprints record giant *Diprotodon*, absent from the skeletal record
- Predator *Thylacoleo* appears in skeletal, footprint, and bite-mark records
- Combined records reveal biases and give the most complete community picture

PALEOECOLOGICAL CENSUS: A LAKESHORE COMMUNITY

	BODY RECORD SKELETAL & BITE-MARK EVIDENCE	TRACE RECORD FOOTPRINT & BITE-MARK EVIDENCE
Small Mammals	✓	☐
Diprotodon	☐	✓
Thylacoleo	✓	✓

Pseudofossils: When Nature Imitates Life

- Pseudofossils are inorganic structures easily mistaken for true fossils by beginners and experts.

- Common examples: manganese dendrites (fern-like mineral growths), concretions (egg- or bone-shaped masses), slickensides.

- Real plant fossils show regular branching; dendrites are fractal, irregular, and cross layers in 3D.

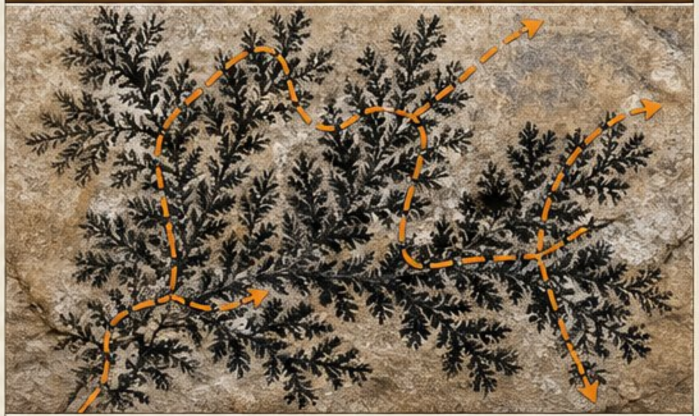
- Bone has internal porous structure; concretions lack this. Consider geological context—a 'fern' in lava rock is suspicious.

SPOT THE DIFFERENCE

TRUE FOSSIL FERN (ALETHOPTERIS)

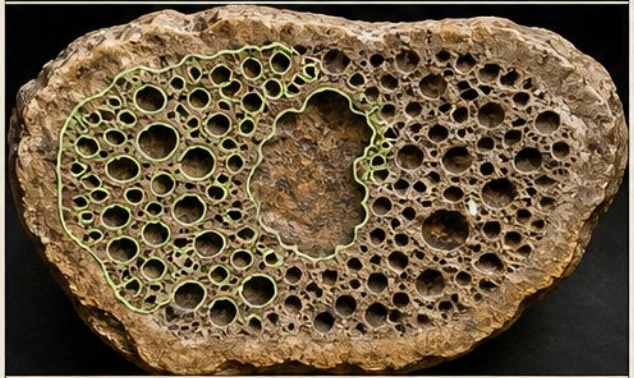
Organized, regular branching in a consistent pattern

MANGANESE DENDRITE



Fractal, irregular branching that crosscuts layers in 3D

SAUROPOD BONE (CROSS-SECTION)



Internal porous structure with vascular spaces

CONCRETION (IRONSTONE)

Solid interior with concentric layers; no pores or canals

Practice: Fossil or Fake?

- Identify each example as body fossil, trace fossil, or pseudofossil
- Check: Is it a body part (body) or evidence of activity (trace)?
- Pseudofossils lack biological structure—look for irregular mineral patterns
- Justify your choice using form, internal structure, and geological context

The Three-Part Evidence Model

Body fossils:
remain evidence of existence and basic anatomy

Trace fossils:
record activities and behaviors while alive

Geological context:
answers where, when, and how organisms lived

Together they reconstruct ancient ecosystems

Conclusion and Your Next Steps

- - Fossil = body or trace + geological context
- - Ask: Was this the organism, or what it did?
- - Visit museum exhibits to see fossils in context
- - Join projects like Fossilfinder or Shark Tooth Forensics
- - Use NPS and university online guides for deeper dives