

Exploring Astrobiology

Module 1: Ancient Storytellers

Arizona Astrobiology Center

Warm Up Questions

- Have you ever seen a fossil?
- What are fossils? How did they form?
- What are the different types of fossils?
- What do fossils tell us about their past?
- Where can we find fossils?
- Are there different kinds of fossils?
- How old are fossils?



What is Astrobiology?

Astrobiology is the study of life in the universe, including its origins, evolution, distribution and future of life.



What is Astrobiology?

Astrobiology studies many things such as:

1. Extraterrestrial Environments
2. Analogs (Places on Earth that are like environments outside of Earth)

Extraterrestrial Environment



Is there life on Mars?

Earth Analog

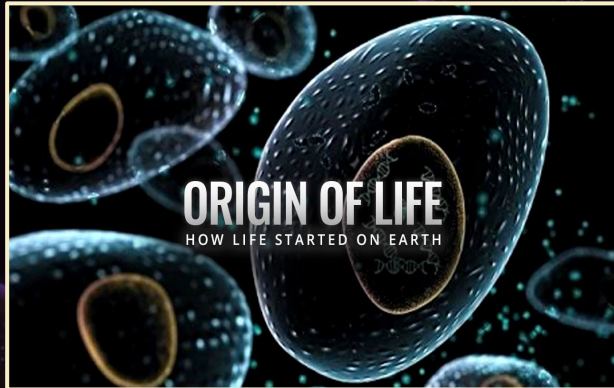


How is the Atacama Desert (Chile) similar to Mars?

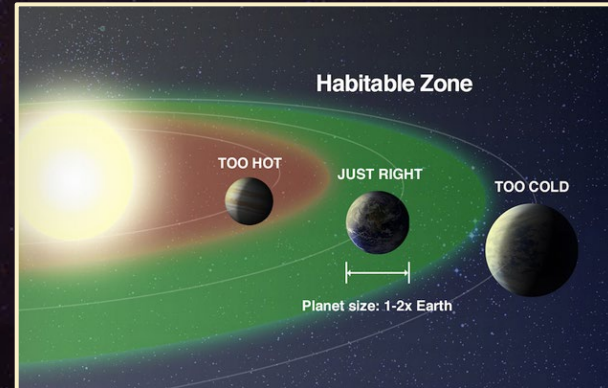
What is Astrobiology?

Astrobiology asks questions about...

3. Origin of life
4. Habitability



How did life start on Earth?



Is Earth the only livable planet?

What is Astrobiology?

Astrobiology also studies...

5. Ancient Fossils

Ancient fossils give us clues about early life on Earth

Stromatolites



Oldest fossils on Earth

Microfossils



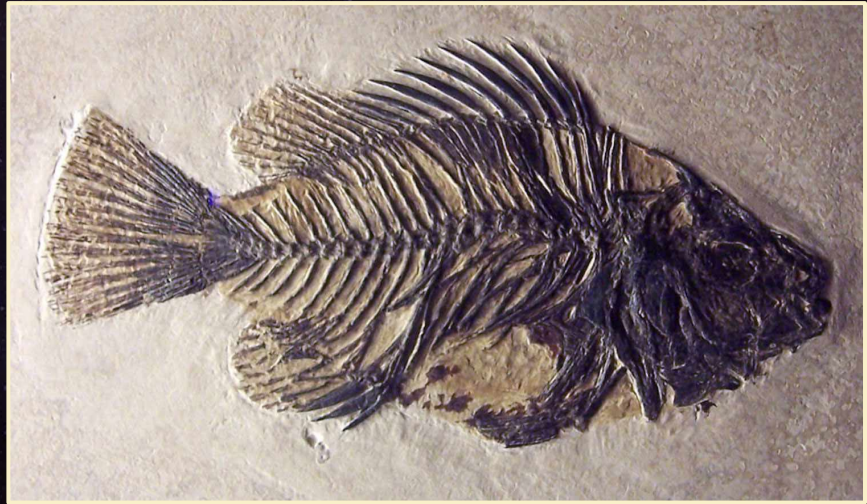
Ancient microbial fossil

What are fossils?

Fossils are preserved remains or traces of ancient organisms.



Tyrannosaurus rex fossil



Fish fossil

What are fossils?

Fossils form when organisms are quickly buried by sediment and **mineralized** over time.

DEATH



BURIAL



LITHIFICATION



PETRIFICATION



EXPOSURE



Fossilization begins with death of an organism.

Burial is essential for the remains to fossilize.

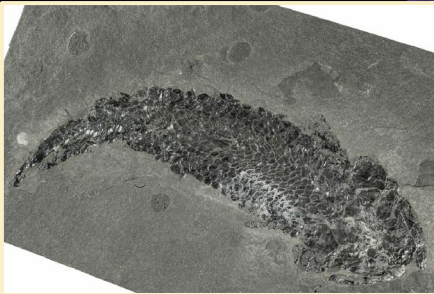
Over time, the sediment around the organism turns into rock.

Minerals replace organic material cell by cell. Turning remains into a stone replica.

Natural processes like erosion can bring fossils to the surface and allow discovery.

What are fossils?

Fossils provide evidence of how life evolved and adapted to different environments.



Lobe-finned fish fossil

- Lived in water
- Fins were thicker and stronger than most fish



Tiktaalik fossil

- Had fins but also wrist bones
- Could support body in shallow water



Frog skeleton

- Can live in water and on land
- Has elbow and fingers
- No more fins

Evolution happens in small changes over millions of years.

What are fossils?

Different types of fossils tell us different things

Preserved Remains



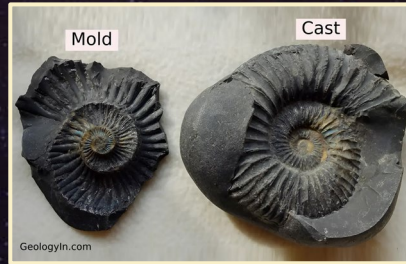
- Can be in amber, ice or asphalt
- Organism is trapped and protected

Trace fossil



- No body, just evidence of activity
- Show organism behavior

Mold/Cast Fossil



- Mold = empty imprint (shape)
- Cast = minerals fill imprint and harden (copy)

Parts of the body



- Can be bone, tooth, shell or wood
- Helps us study body structure

Clay Time



Let's create some fossils

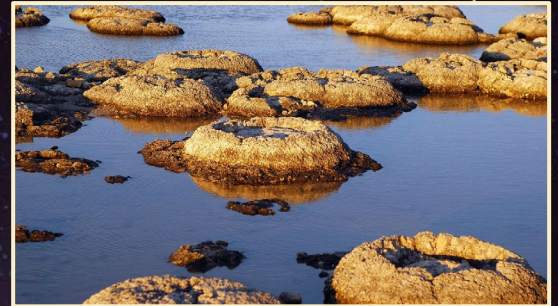
Fossils and Astrobiology

Stromatolites are layered rock structures built by ancient cyanobacteria in extreme environments billions of years ago. They are considered key biosignatures in astrobiology.



Shark Bay, Australia

Lake Thetis, Australia



Fossils and Astrobiology

A **biosignature** is any feature that indicates past or present life. Stromatolites have several features that qualifies them :



Fine,
repeated
laminations



Upward growth pattern



Domes that compete for light

These patterns reflect biological behavior.

Fossils and Astrobiology

Stromatolites date back over 3.4 billion years. If similar structures were found elsewhere in our solar system, they could be evidence of past life.

Collapsed
stromatolite on Earth

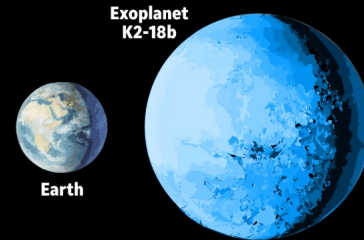


Potential biosignatures?

- Potential surface-covering ocean?
- In “Goldilocks” zone



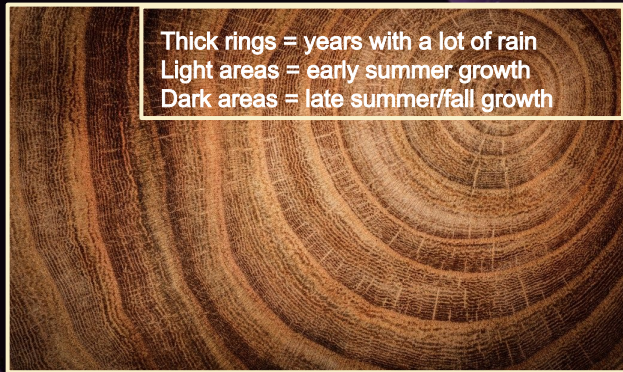
Leopard spots on Mars



Exoplanet K2-18b

What story do fossils tell?

Fossils are **clues from the past** . They tell us what life was like millions of years ago and help us understand how plants and animals adjusted to changes in climate and their environment.



Thick rings = years with a lot of rain
Light areas = early summer growth
Dark areas = late summer/fall growth

Just like tree rings tell us about rainfall patterns...



A tropical plant fossil in a cold place like Alaska, tells us about what the weather in the area a long time ago.

What story do fossils tell?

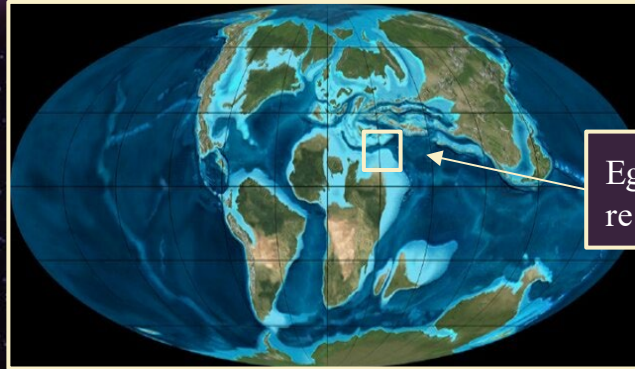
A **fossilized fish** in a desert tells us that the area was once underwater.



Whale fossil in Egypt's Whale Valley

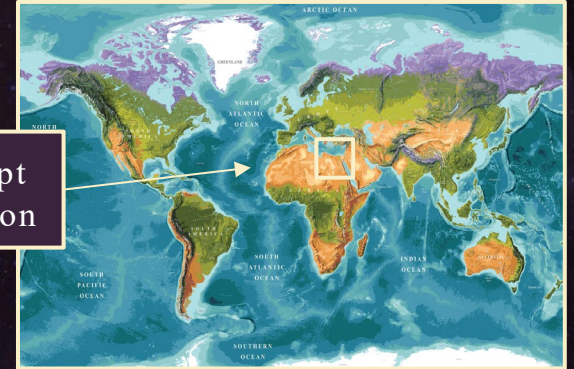
Fossil age: ~55.8 - 33.9 million years ago

Earth 100 million years ago



Egypt
region

Earth Today



What story is astrobiology trying to understand?

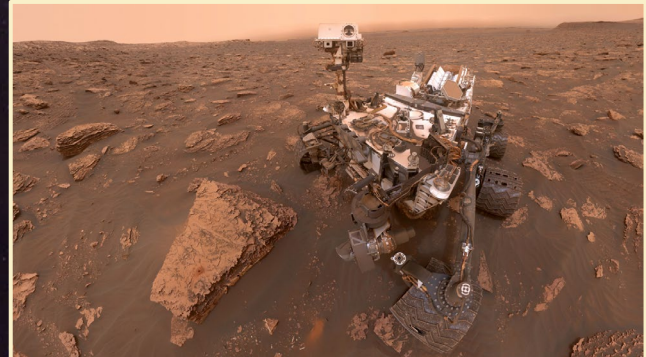
Astrobiologists will continue to:

Look for signs of past or present life - **biosignatures**



Perseverance rover is collecting Martian rocks that may hold ancient signs of life.

Look for conditions that could support life - **habitability**



Curiosity rover confirmed that ancient Mars had the right ingredients for life.

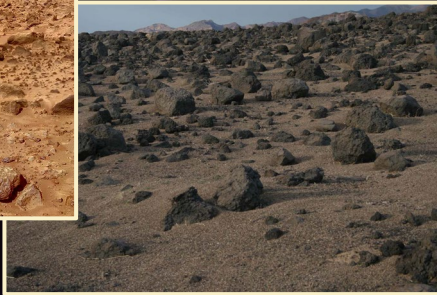
What story is astrobiology trying to understand?

And will continue to...

Study Earth to learn from it - **research analogs**

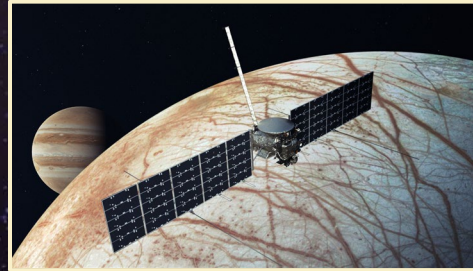


Mars



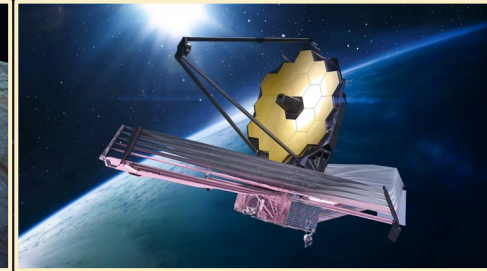
Death Valley, California

Send missions to gather more clues - **explore**



Europa Clipper

On its way to the **Jupiter's moon, Europa** to explore it's subsurface saltwater ocean



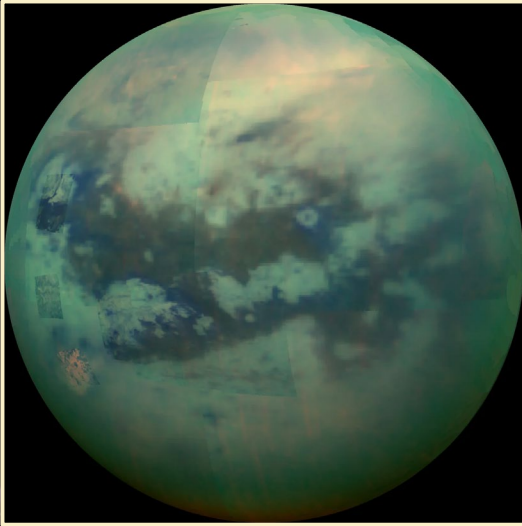
James Webb Space Telescope

JWST reads the atmospheres of distant planets, searching for the fingerprints of life.

What story would a different world tell?

Imagine a different world...

What kind of life could exist there?



Saturn's moon **Titan**

- Bigger than the planet Mercury
- Extremely cold
- Has rivers, lakes and rain but not water, METHANE

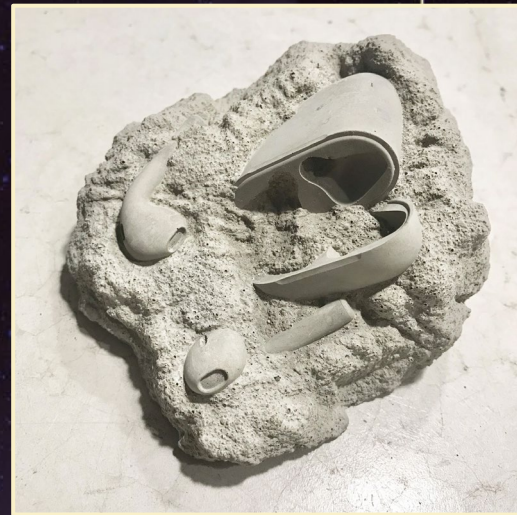
What story would a different world tell?

If humans visited another planet , what fossils would we find?



What story would a different world tell?

What will Earth's fossil record say about **us** millions of years from now?



Clay Time II



Let's create future fossils !