JSC Astrobiology

Research

In this PowerPoint slide presentation viewers will receive information about the new area of scientific research called Astrobiology.

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JSC Astrobiology Research

Teacher's Script

for PowerPoint Slide Show

Learning Objective

In this PowerPoint slide presentation viewers will receive information about the new area of scientific research called Astrobiology. Slides will depict some specifics about research at Johnson Space Center's Institute for the Study of Biomarkers in Astromaterials. The topics will cover aspects of biomarker research – the study of the traces of life left behind by microbes. Some of the intriguing research involves microbes living in extreme environments, fossils preserved in ancient Earth rocks, minerals that may be indicators of life, and chemical traces left behind by early life.

Slide 1: Astrobiology Logo

Slide 2:

Astrobiology is the study of life in the universe. The mission of the NASA Astrobiology Institute is to study the origin, evolution, distribution, and future of life on Earth and in the universe.

Astrobiology is the study of life in the universe. The mission of the NASA Astrobiology Institute is to study the origin, evolution, distribution, and future of life on Earth and in the universe. Important new insights are likely to result as space-age technology is applied to the different fields of research. This cross-disciplinary study addresses many fundamental questions and goals that help focus research underway all over the world. In this emerging field, scientists are still formulating many of the questions -- research is wide open and ready for young minds!

NASA Johnson Space Center (JSC) in Houston, Texas is the home of the Institute for the Study of Biomarkers in Astromaterials. Scientists at JSC are looking for biomarkers – trace indicators of life. These traces of life are likely to be very small – microbe size. Scientists are not looking for little green men.

Slide 3: JSC Astrobiology Research Focus

Johnson Space Center Astrobiology Institute for the Study of Biomarkers in Astromaterials is located at NASA Johnson Space Center, Houston, TX. David S. McKay is the Principal Investigator with a local team of scientists and an extended team of colleagues at universities and other research facilities**.**

Biomarkers are specific properties of a rock, soil, or other sample which prove that biogenic activity is taking place, or has taken place. Biomarkers include chemical, isotopic, spectral, and morphological signatures. As the number of independent biomarkers in a sample increases, so does the confidence that life is or was present.

The Institute's main goal is to develop, characterize, and document a set of reliable biomarkers that can be used to identify present or past forms of microbial life. These major areas of research will be depicted in the slides that follow. The main research areas are listed below

· Biomarkers in Extraterrestrial Samples
Researchers are looking for signs of past life in meteorites from Mars.

· Biomarkers in Terrestrial Samples
Scientists are investigating samples from extreme environments on Earth as analogues for Mars and Europa. They also research samples from Earth's oldest rock formations.

Slide 4: What are biomarkers?

Biomarkers are indicators of life – like fingerprints left behind. They may be in the form of fossil shapes, minerals formed only by living organisms, minerals weathered by microbes, biofilm left by microbes, or chemical traces of previous life.
The JSC laser desorption mass spectrometry lab will provide analyses of minute amounts of organic chemicals contained in rocks. A low energy laser beam will heat the rock's surface just enough to boil off the organic molecules into a cloud of vapor. Then the molecules will be given an electrical charge by another laser beam and drawn into a mass spectrometer. This instrument separates the molecules according to their mass, to show how much of each type of molecule is in the sample.

Slide 5: Scientists are not looking for little green men!

They will look for microbes on other bodies in our solar system. Microbes are supremely successful here on Earth and fill about every niche where water is found. Scientists are studying microbes here on Earth to better understand the origin of life and the extreme environments where microbes can live.

What do microbes need to live? . . . ….. **Water and a source of energy**.

Slide 6: Hot Springs – Yellowstone

Do you think this carbonate hot spring environment provides water and energy? Do you think anything lives here?

Slide 7: Hot Spring Diatoms

Yes, happily! – even in water at the boiling point!

Slide 8: Bacterial Chain

Here is a chain of round bacteria being mineralized in a hot spring – a future fossil!

Slide 9: Frozen Lake

How about the cold ice – any life? Yes, believe it or not, in Antarctica microbes thrive in frozen ice and in lakes below the ice.

Slide 10: Acid Cave – Mexico

What about in a cave filled with poison gas? Hydrogen sulfide is deadly to humans. Louise Hose, a cave biologist, must wear a gas mask to explore this cave in Mexico.

Slide 11: Acid Cave Bacteria (snottites)

This cave is teeming with life. Here we see what looks like snot dripping from the cave ceiling and walls. Microbes, living in colonies called snottites (snot tītes), feed on the hydrogen sulfide and have a pH of 0.5 or less – that's very acidic! Midge flies feed on the microbes and fish live on the flies. This ecosystem is totally chemosynthetic – that is, its energy source is a chemical, the hydrogen sulfide so deadly to most life.

Slide 12: Salt Spring – Canada

Here is a hypersaline environment where the water is 10 times saltier than seawater. Do you think life exists here? Yes! The colors are caused by the microbial colonies that thrive here.

Slide 13: Glacier Spring – Canadian Arctic

Most life would not want to live in a sulfur spring environment, especially in glacial ice!

Slide 14: Sulfur – Eating Bacteria Filament

Microbes enjoy it -- this filament is a sulfur-eating microbe living in a sulfur environment in Yellowstone National Park.

Slide 15: Desert Varnish

Desert varnish is a dark mineral coating that forms on rocks in many deserts around the world. Bacteria may be part of the desert varnish process. Astrobiologists are studying this coating as a possible analogue to rock coatings on Mars.

Slide 16: Interior Biofabric inside Desert Varnish

Bacteria and fungi are found on the surface and within desert varnish coatings. This image shows molds of bacteria that have been preserved by the mineral deposits. JSC scientists are researching the association of bacteria, fungi and desert varnish.

Slide 17: Ancient Earth

Before we can say much about life in environments beyond Earth, we need to study ancient Earth rocks for traces of early life.

Slide 18: Stromatolite

These images show ancient sediments. The images on the right are of ancient layered mats of microbes that are now fossils – they once lived in what is now South Africa and Australia.

Slide 19: Bacteria

Here are some of the Biomarkers that scientists see in those ancient rocks – Biochemical Signatures – Morphological features (indicative shapes) – and Colonial features. Note the faint scale bar at the bottom of the image. It corresponds to a length of one micron – that is one millionth of a meter. Microbes are very small.

Slide 20: Fossils v. Non-Fossils

The really difficult part about looking for fossils in ancient rocks is that life-like shapes do not always mean ancient fossilized life. Much more research and testing is needed to verify if something was alive or if it was a mineral that just formed that way -- the shapes in the bottom two images are minerals not formed by life. The small size makes research very difficult!

Slide 21: Biofilm

Another challenge of looking for microbes in ancient rocks is that bacteria often do not fossilize easily. Some bacteria, though, form a protective film that does fossilize. The filmy material in this image is biofilm – we see this in modern and ancient rock—and some scientists are looking for this biomarker in extraterrestrial rocks.

Slide 22: Mars

Where are we looking for possible past or present life? -- Mars – Why?

Slide 23: Olympus Mons

The volcanoes gave off lots of heat that could have been an energy source for microbes.

Slide 24: Valleys on Mars

The valley systems that can be seen in the photos of Mars seem to be evidence of water on ancient Mars.

Slide 25: Frost on Mars

The white material seen in this Viking image from Mars is ground frost. It indicates a very small amount of water in the atmosphere now.

Slide 26: Water on Early Mars?

Maybe there were oceans on ancient Mars – we don't know for sure but our present missions to Mars are trying to identify where water was and where frozen water might be now. This is an artist's conception of the ancient terrain of Mars. If there really was liquid water on Mars – then that is where to look for signs of life!

Slide 27: The Most Famous Meteorite from Mars

There are at least 24 rock samples from Mars in laboratories around the world. They were blasted off Mars by meteorite impacts and then landed on Earth. If water existed on early Mars, then do you think that we might find fossil evidence of life in the rocks from early Mars? That is the question that scientists asked at Johnson Space Center – and much research is in progress.

Slide 28: SEM Image of ALH84001

The features shown in this image were observed by scientists in Mars meteorite ALH84001 using the Scanning Electron Microscope (SEM).

Slide 29: Features is ALH84001 compared to Earth microbes

This comparison of features shows why the scientists became excited when they saw microbe-like forms in this Mars meteorite.

Slide 30: Possible Mars Microbe in Nakhla

This is a possible fossil bacteria form observed in the Mars meteorite called Nakhla, named for a place in Egypt where it fell. Again, this is an SEM image and the question scientists are trying to answer is whether this form fossilized on Mars or if it entered the rock after its landing on Earth. Microbes can invade just about any space – so the scientists will need to use special techniques to test these features. But remember that they are really small and studying really small things is hard!

Slide 31: Another Possible Mars Microbe in Nakhla

Another image of Nakhla shows a rounded form completely surrounded by clay – scientists identified that the clay formed on Mars. What do you think, does that observation make it more or less likely that the feature almost encased by Mars clay is from Mars or not? Observations alone are not enough – much more research is needed.

Slide 32: Carbonate disks in ALH84001

In Mars meteorite ALH84001, scientists found these small orange carbonate minerals surrounded by black and white rims. They called the carbonates pancakes and the rims Oreo cookies. Carbonate can form from inorganic mineral deposits or it can be formed in association with living organisms. Several of the features in the slides above were observed near the rims of the carbonates. Scientists also found magnetite minerals that looked a lot like ones seen in Earth bacteria.

Slide 33: A single magnetotactic bacterium with internal magnetites

This is an Earth bacterium that manufactures magnetite minerals inside its body. Look for the chain of little black dots inside the bacterium. Scientists think the microbes may use the magnetites to help them stay at certain layers in the ocean.

Slide 34: Minerals – from living organisms or not?

The image at the top shows a string of magnetites formed by Earth bacteria. The image on the right below also shows the forms of magnetites made by Earth bacteria. The image on the left, however, is of magnetites found in ALH84001.
What do you think? …….They look identical! Could these magnetites be mineral biomarkers? Can you see why scientists are conducting further research to see if there really were bacteria on Mars that made the magnetites? Stay tuned – new research is coming all the time!

Slide 35: Non-biological formation of minerals in the laboratory

To test the possibility that the features seen in ALH84001 could have formed inorganically, scientists have conducted experiments to produce carbonates with rims that contain magnetite. Now the testing is continuing to see if the magnetities are in the same special form that was found in ALH84001. There is good science being done on both sides of the magnetite research – and much of the research on both sides is being done at Johnson Space Center.

Slide 36: Biological Weathering

Scientists are researching how the secretions of microbes affect minerals. The little pits that are left by microbial activity are physical biomarkers. Scientists are looking at Mars meteorites to see if they can see any of these biomarkers.

Slide 37: Possible Microbial Weathering of Minerals

The honeycomb structure on the minerals in this SEM image may also be formed by biological activity.

Slide 38: Implications for Mars and Beyond

So what will we be looking for on Mars as we go there with our robotic missions? We will look for places where water existed in the past and we will look in the rock samples for biomarkers that will give us clues about Mars life -- if it ever existed.

Slide39: Instrument Tests on Mars

Some instruments that will go to Mars on spacecraft landers over the next ten years will be life-detection experiments. Johnson Space Center is leading the development of one of the instruments that may fly to Mars.

Dr. David McKay leads a team developing the Mars Immunoassay Life Detection Instrument (MILDI), which they hope will one day be sent on a spacecraft to Mars. MILDI will use sensors that react to the chemicals in living things, in much the same way that the human immune system reacts to chemicals and germs coming into the body. Reactions in the MILDI instrument will make the sensors glow in ultraviolet light, giving a direct indication if some of the chemicals of life are present in the Martian soil.

Slide 40: Mars Sample Return

Even with the wonderful data we will get from the Mars orbiters and the landers, we want to have samples in our laboratories from specific locations on Mars. The only way to get those is to send a robotic mission to gather rocks and soil and deliver the samples to Earth. Research is underway to prepare for this expedition.

Slide 41: Destination Mars

It is possible that we will not know the answers about life on Mars until humans go there. We are still the best tools in science research! Students, there is a future for you in the exploration of Mars!