Family Space Day Overview

Family Space Day is a three hour event. The activities are set up so that children and parents select the order in which they undertake activities. Parents and children are encouraged to learn, play, and explore *together*.

Objectives of the Day

Children will:

- learn what is necessary to sustain life in our solar system.
- learn where in our solar system the conditions necessary for life exist – or existed
- learn how Earth has changed since its formation 4.56 billion years ago.

Activities

- Station 1: Astrobiology Poster Information
  Children and their parents view 10 posters to build an understanding of life's needs, the extreme conditions in which live thrives on Earth, and the search for life on other planets.

- Station 2: What Life Needs Memory Card Game
  Children and their parents consider what is necessary to sustain life in the solar system. Children use a simple memory game to determine if life is possible in other places in our solar system.

- Station 3: Make a Critter
  Children create, using various craft items, a life form (extremophile) from either Mars or Europa. Children and parents explore the challenges and resources their extremophile may encounter on the planetary body they have chosen.

- Station 4: Earth's Life Timeline
  Children and their parents discover how the Earth has changed and how life has evolved since Earth formed over 4 billion years ago!

- Station 5: Coloring Sheets and Games
  Children relax and color and play simple games related to astrobiology.

- Station 6: Reading Room
  Children and their parents browse and read a selection of books about astrobiology (refer to book list for suggested reading).

Other Materials

- *Facilitator Information* – Astrobiology
- *Explore Astrobiology* – Book and Website References
- *All About Astrobiology* – An Astrobiology Fact Sheet

Facilitator Information

(All you need to know about Astrobiology to survive the day)

What is Astrobiology?

Astrobiology is a branch of biology concerned with the search for life outside the Earth and with the effects of extraterrestrial environments on living organisms.

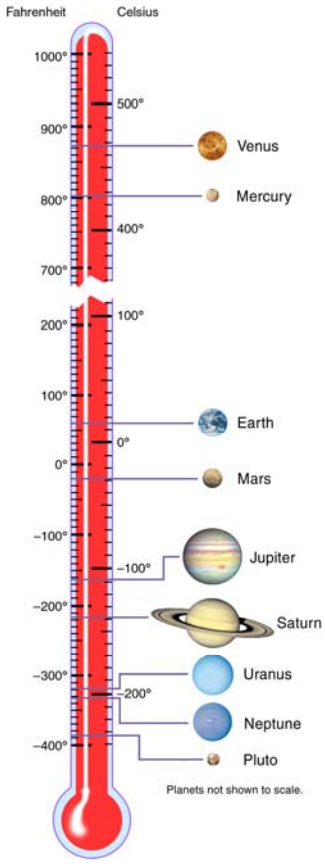
What is an extremophile?

An extremophile is a living thing that thrives in "extreme" conditions, such as very high temperatures or very salty or acidic water. They can live where most organisms cannot because they have adapted special mechanisms for survival.

What does life need?

Life as we know it needs an energy source, nutrients, protection from the elements, and liquid water. For this day, we are simplifying these to include three things - liquid water, something to eat, and protection.

We find organisms only where **liquid water** exists. Liquid water is special. It remains a liquid over a wide range of temperatures - between 0 C (32F) and 100 C (212F) in its pure form – and can be liquid outside of this range under special circumstances. Water under high pressure, such as that in the deep sea, can remain a liquid at higher temperatures, and saline water has a lower freezing temperature – a good thing for fish in the Antarctic! Water expands when it freezes, unlike most other liquids, which means it floats and keeps our oceans from freezing from the bottom up. A lot of important things dissolve in liquid water and chemical reactions abound. In addition, liquid water moves, and can transport nutrients within cells or across global oceans.



All organisms require some **form of energy** to run their life processes (for example to break down nutrients or remove waste). Organisms with which we are familiar use either light energy or chemical energy. Plants get their energy from light. Microbes at deep-sea vents do not have access to light; they get their energy by breaking down chemical compounds dissolved in water circulating from Earth's interior. Light energy available to a planet diminishes with distance from the Sun. It also diminishes with distance from a planet's surface (for example the ocean bottom or in deep caves).

All organisms also require **nutrients**, the raw materials used to maintain their bodies. Plants get the nutrients from soils and the atmosphere. Animals get them from food. Like energy sources, nutrients must be replenished. This occurs on planets that are geologically active – those that have tectonic and / or volcanic processes – that constantly recycle materials to make the chemical nutrients available.

Finally, all organisms require **protection** from the extremes of the space environment. Existing underground or in deep water are ways that organisms can protect themselves. Atmospheres can offer protection at the planet's surface from harmful ultraviolet radiation, extreme changes in temperature, and small- and medium-sized meteorite impacts. Atmospheres also moderate day-night and seasonal temperature swings. However, to serve as an effective shield or insulator, the atmosphere has to be fairly substantial, as it is on Earth, Venus, and Titan. A planet or moon depends on its interior processes to make an atmosphere (is it hot enough to have volcanic activity, which replenishes the atmosphere?) and its gravitational field to hold an atmosphere. A small-sized body such as Pluto or Earth's Moon has too little gravity to hold onto an atmosphere, making life on or near the surface difficult.

What are the extreme environments where we find life?

Based on what we know, life exists in just about any environment with liquid water. The water can be intermittently or constantly available. It may be at the surface, or beneath the surface. The range of temperatures between which life is active is about –15C (5F) to +121C (250F). Higher temperatures break down cellular material. Lower temperatures cause chemical reactions to be too slow to maintain life functions.

Organisms that live in conditions that would kill most living things are called "extremophiles." These are organisms that thrive at extreme temperatures, such as *Pyrolobus fumarii*, the vent dweller that lives at temperatures of 113C (235F), or the *Cryptoendoliths* that live at temperatures of –15C (5F) just under the surfaces of sandstone rocks in the Antarctic. Extreme environments include extreme depths; certain bacteria dwell 3.2 kilometers below Earth's surface. There also are organisms that live under extreme pressures deep in the ocean trenches, in extremely acidic or alkaline or saline waters, or under severe radiation conditions. The majority of these are microbes and they belong to an ancient domain of life, recently identified, called the Archaea (the other two domains are the bacteria and the eukaryotes).

What other planets may have – or have had – life?

From: Windows to the Universe, Life on Other Planets
http://www.windows.ucar.edu/tour/link=/life/life_other_planets.html&edu=mid

Venus - Venus is very hot, almost 800 degrees (Fahrenheit) at the surface. Venus also has a very heavy atmosphere. With a heavy atmosphere, there is a lot of pressure (about 91-94 times sea level pressure on Earth). Venus also has corrosive clouds of sulfuric acid. We know, however, that there are life forms on Earth which can survive in very harsh environments. Bacteria and very simple plant life can survive in unexpected places. However, because of the very high temperature, pressure, and corrosive atmosphere the environment of Venus seems unfriendly toward life as we know it on Earth.

Mars - In spite of the fact that Mars has an atmosphere, the environment of Mars seems unfriendly toward life as we know it on Earth. Mars is small, so there is not much gravity and it is geologically inactive. For this reason, much of the atmosphere of Mars has drifted away. With little atmosphere, and no ozone layer, there is less protection from the ultraviolet radiation of the Sun, which is very harmful to life.

With little atmosphere, there is a only a small buffer between the surface and space itself. This means that the temperature above the surface is cold. With little atmosphere, there is only a little pressure, which sophisticated life forms such as humans need to keep blood from boiling. We know, however, that there are life forms on Earth which can survive in very harsh environments.

In the past, liquid water flowed on the surface of Mars. With a liquid water habitat and a thicker atmosphere, life may have once thrived. More exploration of Mars is needed to determine if life was once present there.

Jupiter's Moon Europa - At first glance Europa may seem unfriendly to life as we know it on Earth. Like other icy moons, Europa is small, with no air to breathe, with direct exposure to space and the charged particle environment of Jupiter's magnetosphere. On the surface, the temperature is very very cold. Nevertheless, the interior of Europa may have been warm enough at one time to contain a liquid layer just under the surface. On Earth, we know that there are some creatures which can survive in an environment of very cold water, such as under the ice of the north pole. This means that, if the conditions are just right, there may be living creatures on Europa under the icy surface!

Saturn's Moon Titan - Titan's atmosphere is a lot like the Earth's, except that it is very cold, from -330 degrees to -290 degrees! Like the Earth, there is a lot of nitrogen and other complex molecules. There also may be an ocean of methane, or perhaps a liquid water layer inside the moon. Except for the cold, these signs

would be favorable for some sort of life. Some creatures on Earth are known to live in an environment of very cold water.

In the atmosphere there are layers of clouds composed of complex molecules such as methane. Moreover there is energy from ultraviolet light, and the charged particles of the magnetosphere. This type of environment, aside from the cold, is the kind of environment in which scientists think life began.

Overall, the environment sounds unfriendly to life as we know it on Earth, because of the cold. Since not much is known about the moon Titan, up close exploration of this moon, with a probe, as shown in this drawing, would help scientists better understand if life could survive there.

Why is Earth special?

Earth falls in the "Habitable Zone," the region of space where conditions are favorable for life as it is found on Earth. In general, in the habitable zone, the temperatures are just right for liquid water to exist. Closer to the Sun, the temperatures are too high and the water would vaporize. Farther from the Sun, the temperatures are too low and the water would freeze. Scientists can define the habitable zone for other stars – where it is depends, in part, on the mass of the star. If the star is small, the habitable zone is closer, if the star is big, the habitable zone is farther away. Scientists can help to focus their efforts on identifying places likely to have life by looking for planets in the habitable zones of other stars.

Poster Information

In this activity, you and your child will learn about what life needs and what planets may meet these needs by viewing the information provided on the posters.

What You Need:

- 10 sheets of bright poster board
- Print-outs of the information below in bright colors
- Tape or glue to adhere information to the poster boards
- Scissors
- Images related to Astrobiology
- Hand-outs of *Search for Life on Other Planets*
- Crayons or pencils for children to mark hand-outs.

What to Do:

Attach the information below on bright poster board and place posters around the room for the parents and children to view.

Invite the parents and their children to view the posters and answer the questions. The children can record their findings on the "*Search for Life on Other Planets*" sheet.

Poster 1:
What do you need to be able to live?

Answer: Water, food, shelter or protection from being too cold or too hot.

Do you think all living things need these same things?

Answer: Yes! Life as we know it needs water, nutrients, and some form of protection.

Poster 2:
Where do you get your nutrients and energy to make your body run?

Answer: The food you eat!

Where do plants get their nutrients?

Answer: From the soil.

Where do plants get their energy to grow?

Answer: Plants get energy from the Sun!

Poster 3:
What surrounds our world and protects us from dangerous rays from the Sun, and helps to keep our temperature on Earth just right?

Answer: The Atmosphere!

Poster 4:
An **extreme environment** is one where conditions are "extreme", such as very hot or very cold. Can you think of others? What about deserts?

Answer: a few might be:

- Very acidic
- Very salty
- Very dry
- Very high radiation
- Very high pressure

Can you think of where some extreme environments might exist on Earth?

Poster 5:

An **extremophile** is a living thing that thrives in an extreme place – like one that is really hot or really acidic. They can live where most organisms cannot because they have adapted special mechanisms for survival. They still need water, energy and nutrients, and protection!

Do you think that extremophiles can live in:
(Facilitator: have Yes and No printed on the answer cards that cover the image and information).

Geothermal hot springs where temperatures can get as hot as – or hotter than boiling water?

Yes.

Grand Prismatic Spring; Hot Springs, Midway & Lower Geyser Basin; M Storey; 1966 / http://www.nps.gov/archive/yell/slidefile/thermalfeatures/hsandterraces/midwaylower/Images/06118.jpg

Hot springs, like those in Yellowstone National Park, have a range of temperatures, and a range of organisms that live at different hot temperatures. These are called **thermophiles**. *Each different color in the pond in the picture is a different kind (species) of microorganism living at a different temperature.*

The hottest temperatures are in the middle of the hot spring pool. As long as the temperature is less than about 115 degrees Celsius (~240 degrees Fahrenheit), life can live in hot springs!

No.

Sorry – some organisms are very hardy – even at these very high temperatures! Look under "Yes!"

Poster 6:
Do you think that extremophiles can live in:
(Facilitator: have Yes and No printed on the answer cards that cover the image and information).

Really really salty water – maybe 10 *times* saltier than the ocean?

http://science.nasa.gov/newhome/headlines/lms/owenslake.htm

The Great Salt Lake in Utah is 10 times saltier than the ocean but it brims with halophiles – organisms that thrive in extreme conditions of high salinity. Diverse life such as algae, brine flies, brine shrimp live here. The halophiles give the salty water the pink color.

No.

Sorry – some organisms are very hardy – they can live in very salty water where most organisms cannot! Look under "Yes!"

Poster 7:
Do you think that extremophiles can live in:
(Facilitator: have Yes and No printed on the answer cards that cover the image and information).

Really really acidic water – like vinegar?

Yes

Image courtesy of Carol Stoker, NASA Ames Research Center, http://www.nasa.gov/centers/ames/news/releases/2003/03images/tinto/tinto.html

The Tinto River, in Spain, is very, very acidic, with a pH between 1.5 and 3.1 – or an acidity between vinegar and stomach acid. It also has lots of metals in the water, which make the color red. Acid-loving extremophiles live even here!

No.

Sorry – some organisms are very hardy – they can live in very acidic water where most organisms cannot! Look under "Yes!"

Poster 8:
Why are we interested in knowing the extreme conditions in which life exists on Earth?

How might this help us as we explore our solar system?

Answer: Different planets have different conditions. Knowing where life can exist can help us figure out which planets and moons in our solar system – if they have similar extreme conditions – may have, or have had, life!

Poster 9:
What is one thing that ALL life as we know it needs?

Answer: Water!

Look at the pictures of the different planets. Do you see evidence of water? Evidence for water in the past? Which planets or moons in our solar system have – or had - liquid water at their surface?

a) Earth only
b) Earth and Mars
c) Earth and Venus
d) Earth, Mars, and Jupiter's moon Europa
e) Pluto only

Answer: d) Earth, Mars, and Jupiter's moon Europa. Mars may have had water in the past, and Europa has liquid water beneath its icy surface. Venus is too hot, and Pluto is too cold.

Poster 10:
What planets in our solar system may have – or once had – life?

a) Earth only
b) Earth and Mars
c) Earth and Venus
d) Earth, Mars, and Jupiter's moon Europa
e) Pluto only

Answer: d) Earth does! And Mars, with evidence of past water, may have had life in the past. Europa has water under its icy surface; life *may* live here now!

The Search for Life on Other Planets

To live, I need _____ and

_____

and _____.

ALL organisms need _____ and

_____ and _____.

I get my nutrients from _____.

The _____ protects me from bad radiation from the Sun and helps to keep Earth's temperature juuuuuuuuuuuuuuuuuuuust right!

Extremophiles can live in extreme environments.
They can live where most organisms cannot.

Organisms **can** / **cannot** live in very hot hot-springs, like in Yellowstone National Park.

Organisms **can** / **cannot** live in very salty seas, like in the Great Salt Lake.

Organisms **can** / **cannot** live in water that is more acidic than vinegar, like the Rio Tinto in Spain.

On what planets might conditions be - or have been - right for life? Circle them!

Earth? Mars? Venus? Pluto? Europa?

LUNAR AND PLANETARY INSTITUTE

Possible Images for Posters

Planetary Photojournal
http://photojournal.jpl.nasa.gov/index.html

Titan - http://photojournal.jpl.nasa.gov/target/Titan

Europa - http://photojournal.jpl.nasa.gov/target/Europa

Mars - http://phoenix.lpl.arizona.edu/images.php?gID=0&cID=4
And http://themis.asu.edu/theme-channels
And http://themis.asu.edu/theme-mts__chaos

Extreme Environments
http://www.lpi.usra.edu/education/fieldtrips/2007/ (photographs)

Micro*Scope
http://starcentral.mbl.edu/microscope/portal.php?pagetitle=assetfactsheet&imageid=88

Astronomy Picture of the Day Search
http://antwrp.gsfc.nasa.gov/cgi-bin/apod/apod_search

What Life Needs Memory Card Game

To exist, life needs liquid water, nutrients and a source of energy, and protection. While the ways that organisms get their nutrients, energy sources, and protection can be different, ALL life as we know it needs WATER!

Earth is juuuuuuuuuuuuuuuust right! It is not to close to the Sun to be too hot for life, like Mercury and Venus. It is not too far from the Sun to be too cold for life, like Mars and the outer planets. It has a wonderful thick atmosphere that protects us from incoming radiation (unlike the thin atmosphere of Mars), but it is not too thick, like the atmosphere of Venus which traps too much heat and makes Venus too hot for life.

Mars- Mars once had liquid water on it, as dried river channels show us. Mars no longer has liquid water. The Martian polar caps do contain water ice and there probably is water ice under the surface. Mars has a very thin atmosphere that does not protect from solar radiation - but lots of bright Sunlight. Mars can be very windy (dust storms), and very cold (freezing temperatures on the warmest days).

Europa – a salty ocean lies beneath the icy surface. Europa may have deep-sea vents like on Earth. It is far from the Sun and has little Sunlight.

This memory activity will teach children what is necessary to sustain life in extreme environments. First, discover and explore what an extreme environment consists of by reading the background information below.

What You Need:

- Memory Cards
- Crayons
- Scissors
- Sheet of card stock

What to Do:

- Have your child color all squares on the card template.
- Cut out each square along the bold lines.
- Mix the playing cards and place them face down on the table.
- Have them pick two cards and place them face up on the table.
- If the cards do not match, turn them back over (face down)
- Have them continue trying to match two identical cards.

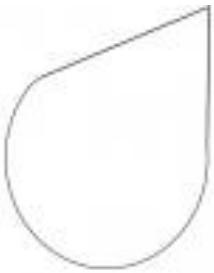
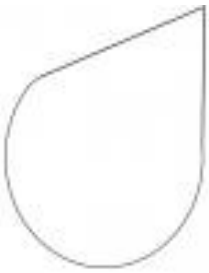
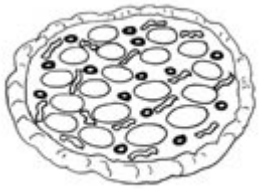
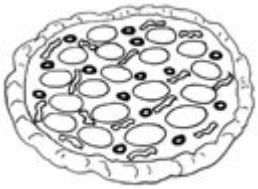
Parent Prompts:

Use the background information above to help your child investigate what all life needs and where life could possibly exist in our solar system.

- When they match the **Mars** cards ask them **"Could there be life on Mars?" Why?**
- When they match the **Earth** cards ask them **"What conditions allow life to exist on Earth?"**
- When they match the **Europa** cards ask them **"Could there be life on Europa?" Why?**
- When they match the **water** cards ask them **"What does all life need?"**
- When they match the **protection** cards ask them **"What protects you?" "Give me an example of what protects other creatures".**
- When they match the **food** cards ask them **"Why do we need food?"**

Using a sheet of cardstock (any color), invite your child to create their own cards, cut them out and try to match them!

Memory Cards

 Earth	 Earth	 Mars
 Mars	 Europa	 Europa
 Liquid Water	 Liquid Water	 Food
 Food	 Protection	 Protection

Make a Critter

Could our solar system harbor other life forms? This is a question many scientists ponder. Two possible places in our solar system that may have or once have had conditions for life to exist are Mars and Jupiter's moon Europa.

Mars- Mars once had liquid water on it, as dried river channels show us. Mars no longer has liquid water. The Martian polar caps do contain water ice and there probably is ice under the surface. Mars has a very thin atmosphere that does not protect from solar radiation - but lots of bright Sunlight. Mars can be very windy (dust storms), and very cold (freezing temperatures on the warmest days).

Europa – a salty ocean lies beneath the icy surface. Europa may have deep-sea vents like on Earth. It is far from the Sun and has little Sunlight.

To exist, life needs liquid water, nutrients and a source of energy, and protection. While the ways that organisms get their nutrients, energy sources, and protection can be different, ALL life as we know it needs LIQUID WATER!

In this activity, your child will use various craft items and the background information to create an extremophile from one of these two places! You can help them by talking about the challenges and resources their organism may find on whichever planetary body they choose.

What You Need:

- Various craft items such as Styrofoam balls, felt, foil, pipe cleaners, small milk cartons, empty small water bottles, colored card stock, old CDs, pom-poms, colored yarn, tape, glue, etc.
- Critter Card
- Colored pencils or markers

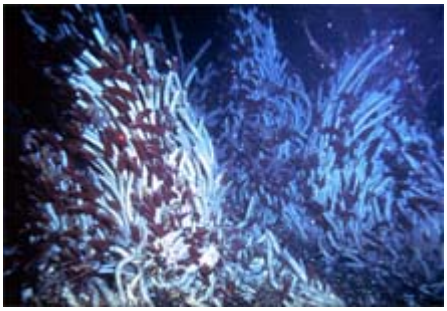
What to Do:

- Create a extremophile out of various craft items. As your child makes his or her extremophile, have them share where the organism gets its food and water and how it is protected.
- Complete the critter card with your child and attach it to your child's extremophile.

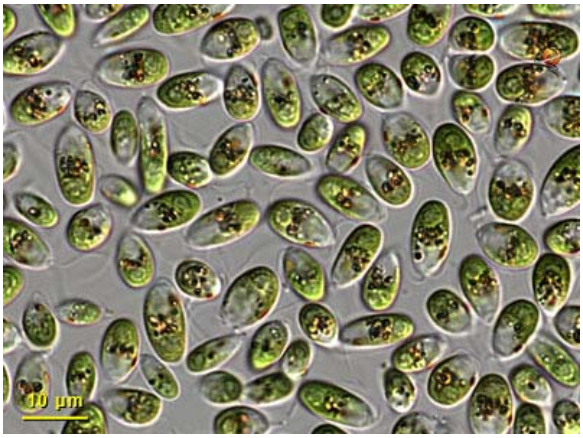
A few examples of some real-life extremophiles appear below.

Microscopic tardigrades are found in freshwater environments (you can find them in pond scum, or water around lichens); they can survive everything from freezing temperatures to drying out for periods of time.

Seawhips in the deep ocean can survive extremely cold temperatures and high pressures.



Tubeworms at a deep sea vent can survive extremely hot water temperatures and high pressures.



Green algae that thrives in extremely salty water.

Critter Card

I am a

I live on

I eat

I get water from

What protects me from space radiation and getting too hot or too cold is:

Critter Card

I am a

I live on

I eat

I get water from

What protects me from space radiation and getting too hot or too cold is:

Earth's Life Timeline

Early Earth was HOT! Our planet was not conducive for life to exist until things 'cooled off'.

It took a long time to form our oceans and to get a thick atmosphere. Based on fossil records, it took at least a half a billion years after Earth formed for life to begin.

Single-celled organisms dominated for a long, long time! Life changes the environment. Earth's earliest organisms lived in a world with no oxygen! Oxygen was added later by photosynthesizing organisms. Once oxygen built up in the atmosphere, an ozone layer formed, adding a layer of protection from UV rays.

This activity will help your child gain an understanding of the timing of events – and the events themselves that shaped our planet Earth.

What You Need:

- Printed images of events from http://www.lpi.usra.edu/education/timeline/gallery/
- 25 feet of string or tape
- Scissors

How to Create the Timeline:

- Select and print images of the events described below.
- Make a timeline along a wall or sidewalk that is 25 feet long. Mark off each 5 feet as a billion years.
- Arrange the events in the appropriate position along the timeline.
- Walk the timeline with your child and examine how Earth's environment has changed over time.

What to Do:

Invite the children to step through the timeline one event at a time as you read the questions below together. They need to answer your question before they go to the next event.

Earth's Time Line

- 4.6 billion years ago dust and gas clumped together and formed our _____ and _____ _____ . (Earth and solar system)!
- Just after it formed, a planet, half the size of Earth, struck Earth, spewing dust and debris from Earth and the impactor into space. This stuff clumped together to form our _____ (Moon).
- Early Earth was covered by lava. It was very cold/hot (choose one) – Hot! Eventually the molten lava cooled forming _____ (crust or land).
- Volcanoes spewed water vapor and gases into the atmosphere the whole time – when things finally cooled down the _____ (water) became our oceans and the gases became our atmosphere.
- Lots of _____ (big asteroids) hit early Earth! (A few tiny ones still hit today.)
- Earth's oldest *fossils* are about 3 to 3 1/2 billion years old, telling us that _____ _____ (living things) were on Earth. Life may be older, but we do not have a fossil record. The first life was simple photosynthesizing bacteria – single celled organisms. They used energy from the Sun. They also produced oxygen, which helped to change the atmosphere so that we can breathe it!
- The first _____ (animals) did not appear until about 700 million years ago … it took a looooong time for complex life to form (again, these are the first fossils; animals may have existed a little before this, but we do not have a record)! These first animals were soft and squishy – like jellyfish.
- It wasn't until 400 million years ago that the land became green because of the first _____ (plants). Soon, insects inhabited the land, eating the plants. Then amphibians made it on land, eating the plants and insects.
- A bit over 200 million years ago, the first _____ (dinosaurs) appeared. Just like those seen in Jurassic Park!
- T-Rex saw the first colorful _____ (flowers) on plants about 100 million years ago.
- A big _____ (asteroid) hit Earth, causing Earth to change and the dinosaurs to go extinct.
- The most recent event in Earth's history is _____ YOU!

Coloring Sheets and Games

Enchanted Learning: Earth's Atmosphere
http://www.enchantedlearning.com/subjects/astronomy/activities/label/atmosphere/

Enchanted Learning: Moon
http://www.enchantedlearning.com/subjects/astronomy/activities/coloring/Moon.shtml
http://www.enchantedlearning.com/subjects/astronomy/activities/coloring/Earthmoon.shtml
http://www.enchantedlearning.com/subjects/astronomy/activities/findit/qmoon.shtml

Enchanted Learning: Mars
http://www.enchantedlearning.com/subjects/astronomy/activities/coloring/Mars.shtml
http://www.enchantedlearning.com/subjects/astronomy/activities/findit/qmars.shtml

Explore Astrobiology!

Websites

http://commtechlab.msu.edu/sites/dlc-me/zoo/
Visit the Microbe Zoo! Learn about microbes that live in soil, animals, food, space, and water and their important functions. Find out how microbes help us in our everyday lives and how they might be used on space missions and in space colonies.

http://www.exploratorium.edu/origins/index.html
The Exploratorium's portal to websites that contain information on the people, explorations and theories involved in the search for life.

http://www.lpi.usra.edu/education/timeline/
The Lunar and Planetary institute offers this site that provides the changes that occurred on Earth over the last 4 and a half billion years in timeline form. The timeline and all images are downloadable! Appropriate for all ages.

http://nai.arc.nasa.gov/
NASA's Astrobiology Institute Website offers feature stories, most recently answered questions and Alien Safari to help kids discover some of the most extreme organisms on our planet, and find out what they are telling astrobiologists about the search for life beyond Earth. Appropriate for ages 7 and up.

http://quest.arc.nasa.gov/projects/astrobiology/astroventure/avhome.html
NASA's Astro-Venture helps students ages 6 and up to explore NASA careers and astrobiology research by offering activities that allow them to "search for and build a planet with the necessary characteristics for human habitation."

http://www.cellsalive.com/cam2.htm
Watch bacteria grow in real time! This site offers images of bacteria growing over a period of time. Learn about the make-up of cells and play games offered by the site. Appropriate for ages 6 and up.

http://www.nasa.gov/audience/foreducators/topnav/materials/listbytype/Astrobiology_Educator_Guide.html
This NASA site offers activities that allow 5-12 year olds the opportunity to think like an astrobiologist. The activities encourage the children to consider and test the possibility of life elsewhere in the solar system.

Explore Astrobiology!

Books

Is There Life on Other Planets? Asimov Isaac, Gareth Stevens Publishing, 1989, ISBN: 1-55532-359-6. This book for ages 6-10 covers the basic concepts from life on Earth, life in our Solar System, and life in extreme environments.

Alien Lifesearch. Jefferis David, Crabtree, 1999, ISBN: 0-7787-0049-6. The author presents the idea of life on other worlds showing evidence such as a meteorite that some scientists believe contains fossils of past life on Mars. Also included are sections on the origins of life, a look throughout the universe and designing an alien. Appropriate for ages 8-11.

Life in Outer Space. McDonald Kim, Raintree, 2001, ISBN: 0-7398-2223-3. The topics covered in this book include: what is astrobiology, life's raw materials, extreme biology and searching for ET. This is a great book for kids ages 7-12.

Is There Life in Outer Space? Branley Franklyn, HarperTrophy, 1999, ISBN-10: 0064451925, ISBN-13: 978-0064451925. The author encourages children ages 4-8 to consider that life may exist on other planets with the right conditions. New illustrations make this an easy read.

Life in Outer Space: The Search for Extraterrestrials. McDonald Kim, Steck-Vaughn, 2000, ISBN-10: 0739822136, ISBN-13: 978-0739822135. Appropriate for ages 4-8. The readers follow the latest explorations seeking the possibility of life on other planets.

Extremophiles: Life in Extreme Environments. Breidahl Harry, Chelsea House Publications, 2002, ISBN: 0791066177. The author explores Extremophiles and their environments. Appropriate for ages 12-15.

Looking for Life in the Universe. Jackson Ellen, Houghton Mifflin, 2002, ISBN: 0618548866. Grades 5-8 will enjoy this book about Dr. Jill Tarter, Director of the Phoenix Project of the Search for Extraterrestrial Intelligence (SETI), and her search for life outside Earth.

Life on the Edge. Winner Cherie, Lerner Publications Company, 2006, ISBN: 0822524996. Life on the Edge is a colorful, reader-friendly text for grades 4-6 replete with images, information, and fun facts about the amazing world of microbes that go where no man - or woman - dare.

All About Astrobiology

- Astrobiologists are scientists who search for evidence of life on planets and planetary bodies beyond Earth.
- To exist, life needs liquid water, nutrients and a source of energy, and protection. While the ways that organisms get their nutrients, energy sources, and protection can be different, ALL life as we know it needs WATER!
- An extremophile is a living thing that thrives in "extreme" conditions, such as very high temperatures or very salty water. They can live where most others cannot because they have adapted mechanisms for survival.
- Some extremophiles are found in geothermal springs like the ones found at Yellowstone Park. Extremophiles can be found living at temperatures as high as 121 degrees C (250 degrees F).
- Some extremophiles survive in conditions – such as the desert or Antarctica - that have very, very little water, or only get water rarely.
- Anaerobic extremophiles can exist without oxygen – the first life on Earth lived without oxygen in the atmosphere. The microscopic *Methanococcus jannaschii* lives in hydrothermal vents on the floor of the Pacific Ocean. Thriving at pressures that would crush a conventional submarine, this heat-loving, methane-producing microbe lives without sunlight or oxygen.
- Some extremophiles may be similar to early life that has remained essentially unchanged for more than three billion years; these give us hints about conditions and life on early Earth.
- Scientists once thought that all life on Earth obtained its energy from the Sun – the life forms either photosynthesized (turning water and carbon dioxide and the energy from the Sun into food) – or the life forms ate the organisms that photosynthesized.
- Scientists now know that life forms can get their energy from other sources without sunlight, like chemical sources**.** Deep in the ocean, far from sunlight, ocean hydrothermal vents spew super-hot, mineral-rich water; entire ecosystems of bacteria, huge clams, crabs, and other organisms live here, consuming chemical energy.
- Extremophiles are important for many reasons. They help industry make new products, like detergents that clean better. They have expanded our knowledge of conditions in which organisms may live – and help our search for conditions on other planets that may be suitable for life.
- Two possible places in our solar system that may have or once had conditions for life to exist are Mars and Jupiter's moon Europa.