Pinnacle Educational Research & Development
ISSN: 2360-9494

http:/www.pjpub.org

Research Article Vol. 3 (4), 2015

What if Fossils Are Discovered On The Planet Mars? Collection of Related Learning Activities for Promoting Active Learning

Gerald Adams, Ph.D.[1], Abour H. Cherif, Ph.D[2]*, Jeremy Dunning, Ph.D[3], & Farahnaz Movahedzadeh[4]

[1]Associate Professor of Geology,
Science and Mathematics Department,
Columbia College Chicago,
600 S. Michigan Ave., Chicago, IL 60605,
U.S.A.

[2]*National Associate Dean,
Math, Science, and Clinical Lab Sciences,
DeVry University,
3005 Highland Parkway,
Downers Grove, IL 60515-5799,
U.S.A.

[3]Dean Emeritus,
Indiana University,
Bloomington IN 47401,
U.S.A.
Founding Partner, Arjuna Learning Designs.

[4]Associate Professor & Co-Chair,
Biology Department,
Harold Washington College,
30 E. Lake Street, Chicago IL 60601,
U.S.A.

Accepted 23 April 2015

ABSTRACT

This paper describes a collection of student learning activities related to the themes of space exploration and its implications for a wide variety of human endeavors. The activities involve numerous disciplines, including atmospheric science, biology, chemistry, earth science, economics, environmental studies, physics, planetary science, political science and other physical and life sciences and social studies areas. The activities can be used in combination with each other, and with the role play described in the previous paper.

Keywords: Role-play, Fossil, Planetary Science, Space Exploration, Human Settlement on Planets, Student Motivation and Engagement, Students Learning, Civic and Community Engagement, Deep Learning.

Introduction

In the previous paper (*What if Fossils Are Discovered on Mars? A Learning Activity for Promoting Critical Thinking and STEM Education*) a role playing activity was outlined, with assessment strategies, for engaging students' imaginations and creativity by exploring the many implications of such a discovery. We recognize, however, that the fully implemented role play may not be an ideal match for some classroom situations, or for some particular areas of study. We have therefore assembled a collection of learning activities, each related in some way to the primary themes of space exploration and its implications for numerous other areas of human endeavor. These activities are designed to be suitable for a range of disciplines including atmospheric science, biology, chemistry, earth science, economics, environmental studies, physics, planetary science, political science and other physical science, life science and social studies areas. Each activity is designed as a stand-alone, but they may also be used in combination with each other, and with the role play described in the previous paper. Instructors are advised to select those learning activities which are more relevant to what they are teaching and to what they want their students to achieve.

Activity: Oldest Known Fossils of Various Life Forms

Fossil microorganisms discovered in Australia by an American scientist prove that life was already thriving and diversified 3.5 billion years ago on planet Earth. The microorganisms, "representing 11 distinct types, are more than 1.3 billion years older than any comparable fossil group ever found" (Malcolm W. Browne, cited in Wade, 1998, p. 8). Conduct internet research to find out the oldest know fossils for the following life forms, based on our current and available scientific data and information: bacteria, archaeobacteria, protists, fungi, plants, and animals. Use table 1 below to record you findings.

1. Which domain contains a significant number of fossil records and in turn a rich life history record? What do you think the reason is behind this abundance of fossils?
2. Which domain contains a poor number of fossil records and in turn a poor life history record? What do you think the reason is behind this scarcity of fossils?

Corresponding Author: Abour H. Cherif, Ph.D.[2]*
National Associate Dean, Math, Science, and CLS, University Academic Affairs, DeVry University, 3005 Highland Parkway, Downers Grove, IL 60515-5799, U.S.A.
Email address: acherif@devry.edu / abourcherif@att.net

3. Which part of the world has more abundance of fossils and which has scarcity of fossils? Explain
4. What have you learned from engaging and completing this activity?

Table 1: The Oldest Known Fossils of Various Life Forms Based on Our Current and Available Scientific Data and Information

	Life form	Example of the life form	Oldest known fossil	Origin or the place of the fossil	Discovered or found by
1	Bacteria				
2	Achaea				
3	Protists				
4	Plants				
5	Fungi				
6	Animals				

Activity: Patterns of Life on Planet Earth

Even life as we know it on planet Earth, if it did exist on other planets, most likely evolved differently and developed different survival mechanisms to meet the challenges of the environment in which it existed. In their beautifully illustrated book "*The Way Life Works*", Hoagland and Dodson (1998) have identified sixteen patterns of life as we know it on planet Earth. They are: "*Life builds from the bottom up; Life assembles itself into chains; Life needs an inside and an outside; Life uses a few themes to generate many variations; Life organizes with information; Life encourages variety by reshuffling information; Life creates with mistakes; Life occurs in water; Life runs on sugar; Life works in Cycles; Life recycles everything it uses; Life maintains itself by turnover; Life tends to optimize rather than maximize; Life is opportunistic; Life competes within a cooperative framework; and Life is interconnected and interdependent."(p. 1-34)*.

1. Conduct Internet research to find out the meaning of each pattern of life identified by Hoagland and Dodson (1998).
2. Do you agree or disagree with each one of them? Explain.
3. Can you think of one more pattern of life on planet Earth that Hoagland and Dodson might have missed? If yes, explain and add into the end of table 2.
4. If you had to eliminate one of these sixteen patterns of life on Earth, which one would you eliminate? Explain.
5. If life existed or does exist on the Red Planet, predict the patterns of life on Planet Mars. Use table 2 below to record your findings.
6. What have you learned from engaging and completing this activity?

Table 2: Hoagland and Dodson's Pattern of Life on Earth, Their Meanings and Student's Prediction of Patterns of Life on Mars

	Patterns of life on Earth	Pattern's meaning	Agree/ disagree Explain	Predicting patterns of life on Mars (if it exists)
1	Life builds from the bottom up.			
2	Life assembles itself into chains.			
3	Life needs an inside and an outside.			
4	Life uses a few themes to generate many variations.			
5	Life organizes with information			
6	Life encourages variety by reshuffling information.			
7	Life creates with mistakes.			
8	Life occurs in water.			
9	Life runs on sugar.			
10	Life works in cycles.			
11	Life recycles everything it uses.			
12	Life maintains itself by turnover.			
13	Life tends to optimize rather than maximize.			
14	Life is opportunistic.			
15	Life competes within a cooperative framework.			
16	Life is interconnected and interdependent.			

How to Cite this Article: Gerald Adams, Ph.D., Abour H. Cherif, Ph.D., Jeremy Dunning, Ph.D. & Farahnaz Movahedzadeh. "What if Fossils Are Discovered On The Planet Mars? Collection of Related Learning Activities for Promoting Active Learning" Pinnacle Educational Research & Development ISSN: 2360-9494, Vol. 3 (4), 2015, Article ID perd_190, 637-648, 2015.

Activity: Mass Extinctions on Planet Earth

Extinction is a catastrophic event resulting in the complete disappearance of a species or higher taxonomic group from Earth at a point in geological history. Biologically speaking, extinctions occur when an organism becomes unfit for survival in its natural habitat usually to be replaced by another, better-suited species. An organism becomes ill-suited for survival because its environment is changed or because its relationship to other organisms is altered. For example, a predator's fitness for survival depends upon the availability of its prey (Adams and Cherif 2001; Clark, 2004).

> *Extinction is the greater part of life on planet Earth. Nearly all of the things that have lived here are gone. We, who are left, the 40 million species alive today, represent less than 1 percent of all the species that occupied the planet. Every year a hundred or more species disappear, a pattern that has continued steadily since the emergence of life on earth. This ongoing background extinction occurs for any number of reasons, but primarily because of changing climate, the loss of food and habitat, or the invasion of some new predator. (Shroyer, 1993, p. 144).*

Conduct internet research to find out:

1. Whether or not through their current behavior, humans have the capacity to profoundly alter many habitats of organisms and thus can significantly contribute to the extinction of species.
2. How many species have disappeared from planet Earth in the last 100 years?
3. How many living species are listed by the US government and or the World Conservation Union on the critically endangered species list?
4. How many living species have been removed by the US government and or the World Conservation Union from the critically endangered species list?
5. List two species that lived on the Earth during the 1900s, but are now extinct.
6. Which animal was the first to be reported as being driven to extinction by climate change?
7. Which animal earned the distinction of being global warming's first casualty?
8. The geological Earth history has shown that earth experienced at least five great mass extinctions. Extinctions are thought to be "cyclical, occurring every 28.7 million years, and have been attributed to cosmic activity, such as showers of large asteroids or comets, although neither the periodicity nor its causes are at present universally accepted." (Clark, 2004, p. 276) Conduct internet research to find out:
    a. The major five episodes of mass extinctions.
    b. The needed information to complete the missing information in table 3 below.
    c. Which of these five major mass extinctions wiped out up to 96 percent of plant and animal species?
    d. What is the current understanding of the cause of that major episode of mass extinction in which up to 96 percent of Earth's plant and animal species were wiped out?
    e. Do you think our human species is capable of directly or indirectly causing mass extinction on the planet Earth?
9. What have you learned from engaging and competing this activity?

Table 3: Earth's Mass Extinctions

	Extinction era or period	Millions of years ago	Characteristics	% of Marine Families Lost	% of Marine Genuses Lost

Activity: Biodiversity, Conservation, and Humanity

In their article, "Conservation for the People", Peter Kareiva and Michelle Marvier (2007) have strongly argued that focusing on preserving biodiversity for its own sake has not yet worked as an efficient conservation strategy. It is also not enough motivational factor for people to do so. What we really need, and which also makes more sense, is to focus on protecting those ecosystems vital to people's health, well being, and material needs, and thus should be central to conservation efforts. It is only when we use the interconnectedness of people and the natural world as principles for guiding our conservation efforts that will enable us to save the whole ecosystem and in turn protect poor communities, habitats, drinking water, and wildlife, which can lead to preserving biodiversity and ensuring that people are a priority. This sentiment was echoed by the former U.N. Secretary-General Kofi A. Annan, who crystallized it very well when he was quoted saying that: "our fight against poverty, inequality and disease is directly linked to the health of the earth itself." (Cited in Kareiva and Marvier, 2007, p. 57). Read Kareiva and Marvier's article in the October 2007 issue of Scientific American. Do you agree or disagree with their argument? Explain. Then write an open letter, including your explanation, to the author that can be read in the classroom.

Activity: Saving Time, Energy and Resources, the Essential Things to Do in Space

Reflecting the shared views of many planetary scientists, George Musser has articulated five essential things to do in space exploration. Read Musser's (2007) article The Essential Things to Do in Space in the October 2007 issue of Scientific

How to Cite this Article: Gerald Adams, Ph.D., Abour H. Cherif, Ph.D., Jeremy Dunning, Ph.D. & Farahnaz Movahedzadeh. "What if Fossils Are Discovered On The Planet Mars? Collection of Related Learning Activities for Promoting Active Learning" Pinnacle Educational Research & Development ISSN: 2360-9494, Vol. 3 (4), 2015, Article ID perd_190, 637-648, 2015.

American and then answer the following questions using table 4 and table 5 below.

1. Do you agree or disagree with the author's five essential things to do in space? Explain.
2. How do you rank them on the basis of their importance to USA and the whole world? Explain.
3. If you have to add two more essential things to do in space, what will you propose? Explain.
4. If you have to eliminate two things to do in space, which two will you take out from Musser's list? Explain.
5. What have you learned from engaging and completing this activity?

Table 4: Essential Things to Do in Space

	Essential things to do In Space	Author's reason for why this is essential	Agree or disagree with the author	Reason for agreeing or disagreeing with the author
1	Monitor Earth's climate			
2	Prepare an asteroid defense			
3	Seek out new life			
4	Explain genesis of the planets			
5	Break out of the Solar System			

Table 5: Essential Things to Add to and to Eliminate from Musser's (2007) List of the Essential Things to Do in Space

	Essential things	Explanation
Essential things to add		
Essential things to add		
Essential things to eliminate		
Essential things to eliminate		

Activity: Minute Creatures in Primordial Waters

The chemical clues in living creatures indicate that "long before animal organisms grew bones, shells and spines that left a clear mark in the fossil record, minute creatures crawled or slithered between grains of mud or sand in primordial waters. They had no skeletons to be fossilized and uncovered by paleontologists, not even enough substance to leave detectable burrows and tracks." (Wilford, 1998, p. 104). Conduct internet research to find out:

1. How molecular scientists and geochemists use genes and chemical clues to trace the history of life on planet Earth back to a billion years ago?
2. Explain how this method could be very useful to trace the history of life on other planets.
3. Since DNA is a large unreactive molecule that can stay intact for hundreds of years, do you think that one day in the future, scientists will be able to find out a way to extract DNA or get information related to the DNA from a given fossil? Explain.
4. What have you learned from engaging and completing this activity?

Activity: Determining the Roles of Several Factors in the Development of Space Exploration in the United States

Since the time humans found themselves on planet Earth, they have never stopped gazing upon the cosmic ocean and wondering about its wanderers in the sky and how it can be reached. Later on, ancient astronomers who were able to observe how some celestial objects seem to move among the stars, called these objects planets. Thanks to the development of science and technology, not only have more planets and stars been discovered, but humans have been able to wander in the cosmic ocean and study those objects. On October 4, 1957, the Soviet Union started the golden age of solar system exploration by launching the first artificial satellite, Sputnik 1, into space. Then, again, on April 12, 1961, Russian Lt. Yuri Gagarin became the first human to orbit Earth in Vostok 1 for 108 minutes, reaching an altitude of 327 kilometers (about 202 miles). The first American to orbit Earth was John Glenn on February 20, 1962. But the grip of Earth's gravity was first broken by the American astronaut Neil Armstrong on July 20, 1969 who took "one giant leap for mankind" by stepping onto the moon in the first of a series of landmark human-crewed expeditions to explore the Moon. Seven Apollo missions were made to explore the Moon between 1969 and 1972 (including the failed Apollo 13 mission). This has started a new chapter of human history in the space exploration. Since then, the United States' and Soviet/Russian automated spacecraft and machines have:

> *Orbited and landed on Venus and Mars, explored the Sun's environment, observed comets and asteroids, and made close-range surveys while flying past Mercury, Jupiter, Saturn, Uranus, and Neptune. These travelers brought a quantum leap in our knowledge and understanding of the solar system. Through the electronic sight and other "senses" of our automated spacecraft, color and complexion have been given to worlds that for centuries appeared to Earth-bound eyes as fuzzy disks or indistinct points of light. And dozens of*

previously unknown objects have been discovered. http://www.solarviews.com/eng/histintr.htm; ¶. 4&5)

This was and still is possible because of our rapid advances in science and technology and our ability to use them to serve our purposes. But sadly, however, since 1972, no human has made successful footsteps on the Moon or beyond.

1. Conduct research to determine the important roles the following factors played and/or can play in the development of the space exploration in the United States: Political, social, scientific, technological, and the human curiosity and desire to know. Use table 6 below for your answers.
2. Do you think the role that these factors played in the development of space exploration is similar in Russia, French, China, Indian, Japan, England, etc? Explain.
3. What have you learned from engaging and completing this activity?

Table 6: Determining the Roles of Few Factors in the Development of the Space Exploration in the United States.

Critical Factor	The role of the factor in the initial stage of space exploration.	The role of the factor in the current stage of space exploration.	The role of the factor in future space exploration.
Political			
Social			
Scientific			
Technological			
Human Curiosity			

Activity: Food from Weightless Agricultural Farms in Outer Space

Since 2002, astronauts have started successfully taking up residence in the International Space Station in outer space. There, the astronauts and their other scientific colleagues have been working and conducting numerous types of scientific research and experiments including a series of agricultural experiments in the weightless environment of outer space. Recently, a team of astronauts from Japan and Russia were successfully able to grow and cultivate barley aboard the International Space Station. The harvest made it back into the Earth and "Japan's Sapporo Breweries produced more than 25 gallons of 'space beer' from the barley. ... Space agriculture is an important area of research for future colonies on the Moon, Mars or beyond, and the Okayama University researchers [in Japan] say the barley proved no different from that grown on Earth." (Science Update 2009, p. 22). Research such as this is very important for any country or group of adventures who are seriously thinking about the possibilities of human settlement on other planets (Herath 2010). Today, we know and have enough evidence that gravity, which is an important influence on root growth in plants, plant roots can develop in a weightless environment and thus plants can grow fine without gravity. Experimenting with growing the seeds of these small, white flowers-called *Arabidopsis thaliana in the International Space Station in 2010, scientists* found that their space plants didn't need it to flourish (Owen 2012).

Conduct internet research to find out more information about space agriculture in general and the space barley agriculture that took place recently in outer space, and then answers the following questions:

1. What was the taste of the beer that was made by brewing the space barley?
2. Did any humans try the beer that was made by brewing the space barley?
3. Ask a beer drinker, “Would you be willing to try this beer which was made by brewing the barley in space?” Explain.
4. What are other crops that have been grown and cultivated in outer space?
5. Do you feel comfortable eating crops which are cultivated in the outer space? Explain.
6. Industrial agriculture farms on enormous amounts of land and requires quick and precise information about the environment status, meteorological conditions, crop status, etc., in order for them to make the appropriate decision for farm production. How can space exploration be used to manage agriculture from the space?
7. What have you learned from engaging and completing this activity?

Activity: Quick Lunch with Carl Sagan

In 1976, the Viking I spacecraft landed on Mars and gathered up a fist-size pile of red dirt for chemical testing. After careful testing and scientific analysis by the probe's built-in lab, the news was not so good regarding clear signs of biological activity and in turn life on the Red Planet. That was over 39 years ago. And what a difference 39 years makes.

Back then, Mars seemed the only remotely plausible place beyond Earth where biology could have taken root. Today our conception of life in the universe is being turned on its head as scientists are finding a whole lot of inviting real estate out there. As a result, they are beginning to think not in terms of single places to look for life but in terms of "habitable zones" - maps of the myriad places where living things could conceivably thrive beyond Earth. Such abodes of life may lie on other planets and moons throughout our galaxy, throughout the universe, and even beyond. The pace of progress is staggering [indeed]. (Frank, 2009, p. 48)

Today, you have been asked to meet for a quick lunch with Dr. Carl Sagan, the famous American scientist and champion of space exploration who until his death continued to be one of the few champions among academic leaders for supporting space exploration. The good news is that you have just finished reading three of his books Pale Blue Dot (Sagan, 1994), The Demon-Haunted World (Sagan, 1996), and Billions, and Billions (Sagan, 1998), only to discover that he was not aware of all the development that took place in space explorations and the search for signs of life on other planets

in the last 39 years. You have only 15 minutes to get him up-to-date and convince him that you are the best person to update his books for re-publication.

1. How would you prepare for this important lunch with the prestigious Dr. Carl Sagan?
2. What type of information would you concentrate on?
3. What types of question would you expect Dr. Sagan to ask you?
4. What type of questions you would like to ask Dr. Sagan?
5. How would you start your lunch meeting?
6. What have you learned from engaging and completing this activity?

Activity: Numerous Stars and Planets Out There

Today, we know that the Milky Way alone contains about 200 billion stars, and a significant number of these stars have their own planets.

1. From your own understanding and perspective, could life potentially take hold on planets not much like the planet Earth?
2. The astrobiologist Charley Lineweaver of The Australian National University argued that the crucial factor in the formation of galactic habitable zones is not the presence of water, but the presence of heavy elements that could affect the possibilities and dangers for alien biology in the galaxy. Do internet research to find out whether or not there is support within the related scientific community for Charley Lineweaver's proposal.
3. Does doing more research about Charley Lineweaver's proposal influence your own perspective on this matter?
4. What have you learned from engaging and completing this activity?

Activity: Very Soon Nine Billon People Will Be on Fragile Planet Earth

There are more than 6 billon human beings on planet Earth right now and predictions indicate that three to four more billion people will be added by the year 2050 with most likely almost all of the population growth will occur in poor nations. Given the current status of climate, famine, and food shortage, the world needs to provide abundant and accessible food for the soon to be 9 billion people. This however requires more than just increasing the production of foods by "putting the latest science-based tools in farmer's hands, including advanced hybrid and biotech seeds, fertilizers, water and farming techniques, etc. We need to also start aggressively traveling to outer space, practically colonize the suitable planets and use them as our new farm lands, homes, and part of our daily thinking and psyche (Mars One 2015). Failure to do so, some scientists have argued, will not only cause our human civilization serious problems, but could endanger life on Earth itself. (e.g. Brown, 2009; Cherif and Adams, 1994). For example, today's critical food shortages in the world, which is considered the central cause of state failure and the decline of civilization, "is not the result of one-time, weather-driven crop failures but rather of four critical long-term trends: rapid population growth, loss of topsoil, spreading water shortages and rising temperatures." (Brown, 2009, p. 53). Adding to this is the growing number of corrupt nations which put the interest of their own leaders and ruling parties over the interest of the countries and their citizens by acquiring and developing all the natural resources to be used by an elite few. To put it in real numbers, some scientists predicted that to make it, humans "need to produce as much food in the next 40 years as we have in the last 8,000." (http://news.discovery.com/earth/global-warming/earth-unrecognizable-2050-resources-110220.htm).

1. The number of humans on planet Earth is increasing rapidly; do you think the number of other living species is also increasing? Explain.
2. From your own perspective, could food shortages world-wide bring down human civilization and in turn, life on Earth?
3. From your own perspective, when it comes to today's spreading scarcity of food world-wide, how can these four trends (rapid population growth, loss of topsoil, spreading water shortages and rising temperatures) be interconnected and interdependent? And does their interaction intensify the effects of any one factor acting alone?
4. Do you agree with the statement that the only way to save the human race on the planet Earth is to reduce the number of people? Explain.
5. It has been argued that there is no such thing as food shortage in the world in which we live, but rather there is/are a number of corrupt countries who put the interest of their people second. Socioeconomic world strategies are built on the idea of unlimited economic growth, which requires unlimited global population growth as well as the lack of willingness and effort from those who have to help those who don't have. Do you agree or disagree? Explain.
6. What have you learned from engaging and completing this activity?

Activity: How Well Do You Know Your Planets' Atmospheres?

A planet's atmosphere is a thin envelope of a mixture of gases held in place around a planet by the gravitational pull of the planet's mass. However, and for various reasons, many of the gases that make up planets' atmospheres, including Earth, have been slowly leaking into outer space, which could explain many of the mysteries of the solar system (e.g., Catling and Kasting, 2007; Catling and Zahnle, 2009). Conduct research to determine the following, and enter your findings in table 7 below:

1. What type of gases make up Earth's current atmosphere, Mars' atmosphere, Venus' atmosphere, etc.?
2. What types of gases made up the Earth's past atmosphere, Mars' past atmosphere, Venus' past atmosphere, etc.?
3. How does a given planet lose its atmosphere?
4. What prevents a given planetary atmosphere from escaping a planet?
5. On planet Earth, scientists have been using ice cores to study snowfall and the atmosphere of a given time

period. How do you think scientists were able to discover what was in the air thousands of years ago and determine whether it was from volcanic eruptions or human activities?

6. What have you learned from engaging and completing this activity?

Table 7: How Well Do You Know Your Planets' Atmospheres

Planet	Past atmosphere (primordial)	Present atmosphere	Main layers of current atmosphere	Predicted future atmosphere
Mercury				
Venus				
Earth				
Mars				
Jupiter				
Saturn				
Uranus				
Neptune				
Titan				
Pluto				

Activity: The True Earth's Hallmark

It is not that hard for astronomers to clearly distinguish planet Earth from the other planets that we already know exist, including those reasonably cool, rocky planets among the 100 billion stars in the Milky Way. To detect life on other planets and find a true second Earth, the Swiss astronomer Greg Laughlin (2008) has convincingly argued that this is not going to happen from Earth, but it must happen from outer space. This is simply because, as she strongly continues to argue, "the hallmark of Earth, after all, is not its mass, nor rockiness, nor the fact that it is potentially habitable." (Cited in Kunzig, 2008, p. 32).

1. Do internet research to find out what the hallmark of Earth is from Laughlin's perspective.
2. Do you agree or disagree with Laughlin's view on Earth's hallmark?
3. In addition to Laughlin's Earth's hallmark, what else do you think should be Earth's hallmarks?
4. What have you learned from engaging and completing this activity?

Activity: Going Back for Footsteps on Space

On July 20, 1969, the first footsteps in outer space were made by the American astronaut Neil Armstrong on the moon. Since then, Americans have been to the moon six times. However, since 1972 no one has successfully made footsteps on the moon or beyond. Astronauts "have been stuck close to the Earth, mostly circulating a few hundred miles overhead in a spacecraft that's little more than a glorified cargo truck."(Watson 2009, p. 1). Today, American astronauts and politicians have been debating whether to go back to the moon by the year 2020, land on Mars, visit asteroids that orbit the sun, explore other planets, or do none of these activities in a time of economic hardship with numerous jobs losses. There are both supporters and those who oppose further space exploration. Conduct research to find out the supporting views and the opposing views for each proposal. Then provide your own view and explain why. Use table 8 below for your findings and answers.

Table 8: Going Back for Footsteps on Space

	Supporting views	**Opposing views**	**Where you stand**	**Explaining your stance**
Moon				
Mars				
Asteroids orbiting the sun				
Other planets				
Nowhere				

(Hint: Students may be recommended to start their research by reading Watson's article (2009) What's our next step? 40 years after Apollo 11. USA Today, Friday, July 17, 2009, pp. 1-2.)

How to Cite this Article: Gerald Adams, Ph.D., Abour H. Cherif, Ph.D., Jeremy Dunning, Ph.D. & Farahnaz Movahedzadeh. "What if Fossils Are Discovered On The Planet Mars? Collection of Related Learning Activities for Promoting Active Learning" Pinnacle Educational Research & Development ISSN: 2360-9494, Vol. 3 (4), 2015, Article ID perd_190, 637-648, 2015.

Activity: Is There a Misconception with Our Modern Agriculture

In his short article "Food Boom", Rodger Doyle (2007) wrote that:

> *One of the least appreciated but most remarkable development of the past 60 years in the USA is the extraordinary growth of American agriculture. Farming now accounts for about one tenth of the gross domestic product yet employs less than 1 percent of all workers. It has accomplished this feat through exceptionally high growth in productivity, which has kept prices of food low and thereby contributed to rising standards of living. Furthermore, the exportable surplus has kept the trade deficit from reaching unsupportable levels. Agriculture not only has one of the highest rates of productivity growth of all industries, but this growth appears to have accelerated during the past two decades. ... Over the period from 1848 to 2004, the total farm production went up by 166 percent. But as the chart shows, productivity per person improved so much that only one quarter as many hands were needed in 2004 as in 1948. Furthermore, the arable land used for farming dropped by one quarter over the 56-year period, and other investment in heavy farm equipment and other capital expenditures decreased by 12 percent." (p. 34).*

And still yet, scientists predict that "we'll "need to produce as much food in the next 40 years as we have in the last 8,000." (http://news.discovery.com/earth/global-warming/earth-unrecognizable-2050-resources-110220.htm).

Conduct research to:

1. Identify the developmental factors that drove these changes in the USA.
2. Determine the role that each of those developmental factors played in driving these changes in the USA.
3. Determine how these developmental factors could be used to guide future potential agriculture productivity in space.
4. It has been stated over and over again that modern agriculture is not sustainable because it encourages erosion and topsoil lost. What evidence is available to support this claim? What evidence is available to discredit this claim?
5. What is the USDA, and what is its role in agricultural and soil erosion?
6. What is strip cropping and what is its relationship to modern agriculture and soil erosion?
7. What are the social and ecological side effects of modern American agriculture?
8. What have you learned from engaging and completing this activity?

Activity: There is Methane Gas, But So What!

Methane (CH_4), which is the simplest hydrocarbon of the paraffin series, is colorless, odorless, lighter than air, and the major constituent of natural gas. It is a flammable gas that burns with a bluish flame and explodes when mixed with air or oxygen. Methane "causes about 38% of the warming of the globe through the greenhouse effect; weight for weight it is 60-70 times more potent than carbon dioxide at trapping solar radiation in the atmosphere and in turn heating the planet." (QPB 1998, p. 483). Because of human activities, scientists have discovered that the amount of methane in the atmosphere has doubled in the last 300 years with the rate of 1 percent per year which makes it a major contributor to the greenhouse effect. Indeed, scientists are predicting that the amount of methane in the atmosphere will also double over the next 60 years if we keep the current types of industries, trends and life styles.

The discovery of methane gas in Mars' atmosphere has been confirmed by the Curiosity robot which may hint that existed life. The existence of methane has given Mars enthusiasts, including astrobiologists, more evidence of the possibility of life on the red planet; in other words, Mars is not a dead planet. This is simply because, biologically speaking, an estimated 15% of all methane gas in the earth's atmosphere is produced by the digestive tracts of animals, including the over 3.5 billion domesticated cows, sheep, goats, camels and other cud-chewing animals that have proliferated around the world as humanity expanded throughout the years. In addition, 20% of all methane gas in the atmosphere is produced by termites that abound in deforested areas, coal mines and feed on soil. (e.g., Brennan, 1992, Lovelock, 2000).

Conduct internet research to answer the following questions and to complete the missing information in table 9 and table 10 below.

Table 9: The Atmosphere of Planet Earth, Mars, and Venus

	Mars Atmosphere	Earth Atmosphere	Venus Atmosphere
Atmospheric Pressure			
Carbon dioxide			
Argon			
Nitrogen			
Oxygen			
Carbon Monoxide			
Other gases			

How to Cite this Article: Gerald Adams, Ph.D., Abour H. Cherif, Ph.D., Jeremy Dunning, Ph.D. & Farahnaz Movahedzadeh. "What if Fossils Are Discovered On The Planet Mars? Collection of Related Learning Activities for Promoting Active Learning" Pinnacle Educational Research & Development ISSN: 2360-9494, Vol. 3 (4), 2015, Article ID perd_190, 637-648, 2015.

Table 10: The Significance of Methane Gas in Planets

	Earth	Mars	Significant Differences	Significant similarities
Its formation process				
Early climate history				
Present climate history				
Its volcanoes activity				
Its other geological process and activities				
Its known fossils of life forms				

1. Scientists believe that of the major greenhouse gases, methane may be the easiest to control. Explain why and how scientists hold this belief?
2. Explain how human activities contribute to the increase of methane gas in the atmosphere and, in turn, to the greenhouse effect?
3. Explain why astrobiologists are very excited about the discovery of methane gas in Mars' atmosphere?
4. Why do we often smell methane gas around sewage treatment plants and hot springs?
5. Chemically speaking, which types of chemical bonds are involved in the construction of a methane molecule?
6. What have you learned from engaging and completing this activity?

Activity: Global Changes: Their Nature and Potential Consequences

It has been argued that human activities are transforming the entire world's environment and ecosystems. These global changes have many faces and serious consequences. Frank Press, one of the former presidents of the National Academy of Science has clearly stated that "Understanding the nature and possible consequences of global change which is interwoven with the complex web of social, economic, political, and scientific implications, is an urgent challenge to the natural sciences, social sciences, and engineering, and to the world community of nations and their citizens." (Silver, 1990, p. iii). Press added, "The diverse faces of global environmental changes are linked both scientifically and politically. Scientifically, the ability to predict future changes in the environment requires an understanding of the physical, chemical, biological, and social processes that govern the Earth, and of the interaction of these processes throughout the earth's system. Politically, policy options to address these problems highlight the need for coordinated international policies relating to energy, technology, land use, and economic development." (p.vi) Conduct investigative research to answer the following questions:

1. What do you think are those human activities that Frank Press referred to?
2. What are those forces behind global environmental changes?
3. Do you think that human activities have reached a level that even surpasses natural processes as agents of global change in the planetary environment? Explain.
4. Determine the roles of the physical, chemical, biological, and social systems that are making the Earth's environment as uniquely hospitable to life as we know it. Then write a short story for your local newspaper illustrating how this indispensable role of dynamic interactions among the physical, chemical, biological, and social systems are making the Earth's environment as uniquely hospitable to life as we know it.

Activity: The Time Has Come To Migrate to Other Planets

Let us assume that we were able to go to other planets, inhabit them and even alter them.

1. How do you think the planet earth would look like 100 years from now?
2. How do you think our species' characteristics would look like 100 years from now?
3. How long do you think it would take our species to acclimatize so as to live comfortably on other planets?
4. What do you think is the most important factor in the acclimatization of humans on other worlds?
5. How should we make the selection for who should go first in our future mass immigration onto other planets?

Activity: Loss of Human Life: (adopted from Brinckerhoff, 1992).

Like most living organisms on this planet, our body is made up of water, carbon, hydrogen, nitrogen, and other trace elements. But can a dollar value be put on a human life or the life of any other life form? If yes, how much money is our own life worth? For example, about fifteen years ago "The Environmental Protection Agency (EPA) puts the value of a human life at between $475,000 and $8.3 million. The Federal Aviation Agency (FAA) assumes $1 million, while the Consumer Product Safety Commission (CPSC) puts it at $2 million" (Brinckerhoff, 1992, p. 3).

1. In terms of dollars, how much is your life worth today? Explain
2. Do you agree or disagree with the FAA, EPA, and CPSC values of Human life in terms of dollars? Explain.
3. Is your answer determined by a human being's responsibilities?

How to Cite this Article: Gerald Adams, Ph.D., Abour H. Cherif, Ph.D., Jeremy Dunning, Ph.D. & Farahnaz Movahedzadeh. "What if Fossils Are Discovered On The Planet Mars? Collection of Related Learning Activities for Promoting Active Learning" Pinnacle Educational Research & Development ISSN: 2360-9494, Vol. 3 (4), 2015, Article ID perd_190, 637-648, 2015.

4. By his or her contribution to the economy or to society?
5. By sentiment?
6. What is the most unique thing about the human species?
7. What is the most unique thing about individual human being?
8. What have you learned from engaging and completing this activity this activity?

Activity: The Essential Necessary Trouble in Making Most of What Is

Life as we know it is based on carbon compounds immersed in water. This means that carbon-based molecules are the basic compounds of life. Carbohydrates, proteins, lipids, and nucleic acids are known as biological molecules or life molecules. Life's molecules are complex, large in size, and have lots of energy in their chemical bonds that hold them together. However, "day in and day out, round the clock, organisms routinely take apart their own perfectly good working molecules and then reassemble them. Each day about 7 percent of your own molecules are "turned over." That means virtually 100 percent have "turned over" in about two weeks." (Hoagland and Dodson 1998, p. 25)

1. Why do you think living organisms go through this type of trouble everyday reassembling their complex molecules?
2. Why do you think living organisms are engaged in the continuous and dynamic building and destroying, ordering and disordering, of life's molecules and parts?
3. It has been strongly argued that because of the nature of the genetic code and the protein structure of all living things which permit a marvelous flexibility, life forms flourish even in the world's harshest places. They are simply opportunistic creatures who don't wait around for the right conditions, but adapt to what is, and they make use of whatever they find around them. (Hoagland and Dodson 1998).
   a. Identify 3-4 examples of life forms that live in the world's harshest places, and then explain how they do it?
   b. If life forms are very opportunistic on the planet earth, do you think the same could be said about life forms on the planet Mars? Explain.
4. What have you learned from engaging and completing this learning activity?

Activity: Term's literacy - How well do you know your terms?

Conduct internet research, then compare and contrast the terms and or phrases listed in table 11 below. When you finish, write one paragraph on each term and give it to one of your classmates to read.

Table 11: Compare and contrast the terms and or phrases listed below

Terms	Definition/meaning	Examples of well known supporters
Biocentrism		
Biologos		
Biological determinism		
Biota		
Competition		
Deism		
Digital Life		
Gaia		
Genome		
Seismology		
Software of Life		
Supercritical fluid		
Symbiosis		
Terraformation		

Activity: The Road to Determining the Age of the Earth

Since the early days of humankind, many have attempted to speculate the age of the Earth, which was and still is the only planet in which life is known to exist so far. The majority of early speculations perceived the Earth as being a very young planet that is made specifically for the purpose of mankind for a long time. These two views persisted for a long time regardless of the fact that biological diversity was obvious at various degrees even to people in the earlier stages of human history. It is only in the last century that serious attempts have been made to measure the real age of the Earth.

Off all the objections that were raised against Darwin, be they religious, biological, or geological, one of the most troubling to him was over the age of the planet. It came not from a bishop, a biologist, or geologist, but from an unexpected source: a physicist (who thought geology is sloppy in comparison to physics). William Thomson (better known as Lord Kelvin) was one of the world's leading physicists when Darwin first published the Origin of Species. For Kelvin, the universe was a swirl of energy, electricity, and heat. He demonstrated how electricity acted like a fluid, just like water. He also showed how entropy dominates the universe; everything goes from order to disorder unless it receives energy to

keep it organized. Burn a candle down to its stump, and the soot, gasses and heat that it releases will never spontaneously join back together into a candle... Kelvin was a devout man, but he didn't accept that Earth was a few thousand years old simply because someone decided that the Bible said so. He thought that it should be possible instead to put an upper bound on the age of the Earth scientifically, by studying its heat. (Zimmer 2001, 58-59)

At the end, Kelvin managed to give the Earth 20 million years of age which didn't satisfy the supporters of Darwin's theory who believed that the Earth is much older and that evolution by natural selection requires the Earth to be older than 20 million years. While we really don't know whether he died believing that the Earth is really only 20 million years old or if he changed his mind with the enormous evidence that was brought about by scientists (specifically physicists and geologists), today scientists believe that the Earth is 4.5 billion years old.

Conduct internet research to complete the following repeated phrase as stated in table 12 below: If scientists think the earth is 4.5 billion years old, then they must have .....?

Table 12: If scientists think the earth is 4.5 billion years old, then they must have .....?
(*Adapted from Cherif, Adams, and Loehr: "What on Earth Is Evolution?", 2001*)

No.		
1	**They must have found or discovered. . .**	
2	**They must have interpreted...**(Explaining logically the meaning of information that has been collected.)	
3	**They must have measured . . .**(Finding out how long it takes for an event to happen by comparing it to a unit of measure.)	
4	**They must have observed. . .** (Using senses to learn about the world around them.)	
5	**They must have calculated. . .**	
6	**They must have classified. . .**(Putting objects into groups)	
7	**They must have experimented...**(Testing their hypotheses and predictions by designing and carrying out controlled experiments)	
8	**They must have predicted. . .**(Using earlier observations and inferences to propose possible outcomes of an event or experiment)	
9	**They must have hypothesized...**(Making an educated guess about how or why something happens.)	
10	**They must have inferred. . . .**(Using what they observe to explain what has happened)	

Activity: On Our Way to Settle on Mars

Many have argued that the human settlement on Mars must become the next giant leap for mankind. Indeed, the "Mars One" project which aims to establish a permanent human settlements on Mars by 2026, is proposing to lunch the first unmanned mission to Mars by 2020 to start the creation of a reliable living environment for astronauts who will leave Earth starting on 2026. The idea is that the first crews of four will depart in one-way journey to start the first human settlement on Mars. After the initial crew has left for Mars, a new crew will depart every 26 months. (Mars One 2015). *As it has been reported by CNN*, "Mars One, a group that plans to send humans on a one-way trip to Mars, has announced its final 100 candidates. They have been selected from 200, 000 applicants and will go on to further testing later this year, which they expect to include team-building exercises and later, isolation. Eventually, 24 will be selected to make up six crews of four, which Mars One says they hope to launch to the Red Planet every two years from 2024, with the aim of starting a colony there" (Cruddas, 2015, ¶, 1). You have been one of those lucky people who made it all the way to be selected. But first, and in additional to all the other physical and mental requirements, a few remaining questions that needed to be answered by you.

1. What type of justification that you have to make you one of the best candidate to be selected to be one of the first settlers on the planet Mars?
2. What name would you give to:
    a. the first unmanned mission that will be lunched with the purpose of creating a reliable living environment for astronauts on the planet Mars? Explain
    b. the first human settlement on Mars starting by 2026? Explain.
3. Since you have been selected to be one of those 24 people to start the settlement on Mars:

a. What are the three things that you will take with you on this one-way journey to settle on Mars? Explain why!
b. What type of communication will you send back to the planet earth when you arrive there? Explain why.
c. If, for whatever reason, you have to comeback or to leave the planet Mars, what will you take with you on the three things that you brought with you to the planet Mars? Explain.

4. In your way to Mars, how would you react if you encounter alien being? Explain
5. When you arrive to Mars, how would you react if you encounter alien being? Explain.
6. What will you look for the first time you arrive to the Planet mars? Explain.

References

1. Adams, G. and Cherif, A. (2001). Stories Fossils Tell. Workshop presented at Midwest Ecology & Evolution Conference, Miami University, Oxford OH, March 16-18, 2001, and at the 2001 National Convention at St. Louis, MO, March 22-25, 2001.
2. Brinckerhoff, Richard. (1992). *One-Minute Readings: Issues in Science, Technology, and Society.* Menlo Park: California: Addison-Wesley Publishing Company.
3. Brennan, Richard P. (1992). *Dictionary of Scientific Literacy*. New York: John Wiley & Sons, Inc.
4. Brown, Lester R. (2009). "Could food shortages bring down civilization?" *Scientific American*, 300 (5):50-57.
5. Catling, D. C., and Kasting, J. F. (2007). Planetary Atmospheres and Life. *In Planets and Life: The Emerging Science of Astrobiology*. Edited by W. T. Sulliven and J. A. Baross. Cambridge University Press.
6. Catling, David and Zahnlev, Kevin J. (2009). "The Planetary Air Leak." *Scientific American*, 300 (5): 36-43.
7. Cherif, A. and G. Adams. (1994). Planet Earth: Can Other Planets Tell Us Where We Are Going? *The American Biology Teacher*; 56 (1): 26-36.
8. Cherif, A., Adams, G., and Loehr, J. (2001). "What on Earth is Evolution?" *The American Biology Teacher*, 63 (8): 282-288.
9. Cherif, A., Adams, G., and Jeremy, D. (2015). What If Fossils Are Discovered on Planet Mars? A Learning Activity for Promoting Critical Thinking and STEM Education. *Pinnacle Educational Research & Development*, Vol3(3), 625-636.
10. Clark, John O.E. (Ed.) (2004). *The Essential Dictionary of Science*. New York: Barnes & Noble.
11. Cruddas, Sarah (2015). Mars One: 'We're all going to die, but it's important what you do before you die'. CNN, Turner Broadcasting System. Updated 9:26 AM ET, Wed February 18, 2015. http://www.cnn.com/2015/02/17/tech/mars-one-final-100/index.html
12. Doyle, Rodger. (2007). "Food boom: Agricultural productivity sustains the U.S. Economy." *Scientific American*, 296 (5):34.
13. Frank, Adam. (2009). "Cosmic abodes of life." *Discover*, May, 2009, pp. 46-51.
14. Herath, Anuradha K. (2010). Could Space Farmers Grow Crops On Other Planets? Astrobiology Magazine, November 26, 2010 08:50am ET. http://www.space.com/9597-space-farmers-grow-crops-planets.html
15. Hoagland, Mahlon and Dodson, Bert. (1998). *The Way Life Works*. New York; Times Books, Random House.
16. Kareiva, Peter and Marvier, Michelle. (2007). Conservation for the people. *Scientific American*, 297 (4):50-57
17. Kunzig, Robert. (2008). Quest for a second Earth." *Discover*, November, 2008, pp. 31-37.
18. Lovelock, James. (2000). GAIA: *The Practical Science Planetary Medicine.* London: Oxford University Press.
19. Mars One (2015). Human Settlement on Mars. (http://www.mars-one.com/#sthash.eJmoizp0.dpuf; http://www.mars-one.com/; http://www.mars-one.com/about-mars-one
20. Musser, George (2007). Essential things to do in space: Planetary scientists have articulated goals for exploring the solar system. *Scientific American*, 297 (4): 69-75.
21. QPB (1998). *QPB Science Encyclopedia*. New York: Quality Paperback Book Club.
22. Owen, James (2012). Plants Grow Fine Without Gravity. National Geographic News. PUBLISHED December 07, 2012. http://news.nationalgeographic.com/news/2012/121207-plants-grow-space-station-science/
23. Sagan, Carl. (1994). *Pale Blue Dot: A Vision of the Human Future in Space*. New York: Random House.
24. Sagan, Carl. (1996). *The Demon-Haunted World: Science as a Candle in the Dark*. New York: Random House.
25. Sagan, Carl. (1997). *Billions and Billions: Thoughts on Life and Death at the Brink of the Millennium*. New York: Random House.
26. Science Update. (2009). Space beer makes its debut. *Science Illustration*, July, August 2009, p. 22)
27. Shroyer, Jo Ann. (1993). *Quarks, Critters, and Chaos*. New York: Prentice Hall General Reference.
28. Silver, C.S. (1990). One Earth, One Future: Our Changing Global Environment. Washington, D.C.: National Academy Press.
29. Wade, Nicholas (1998). *The Science Times Book of Fossils and Evolution*. New York: The Lyons Press.
30. Watson, Traci. (2009). "What's our next step? 40 years after Apollo 11." *USA Today*, Friday, July 17, 2009, pp. 1-2.
31. Wilford, J. N. (1998). Using genes as a clock, study traces animal life back a billion years. In Nicholas Wade (ed). *The Science Times Book of Fossils and Evolution.* New York: The Lyons Press. (pp. 104-107).
32. Zimmer, Carl .(2001). Evolution: *The Triumph of an Idea*. New York: HarperCollins.

How to Cite this Article: Gerald Adams, Ph.D., Abour H. Cherif, Ph.D., Jeremy Dunning, Ph.D. & Farahnaz Movahedzadeh. "What if Fossils Are Discovered On The Planet Mars? Collection of Related Learning Activities for Promoting Active Learning" Pinnacle Educational Research & Development ISSN: 2360-9494, Vol. 3 (4), 2015, Article ID perd_190, 637-648, 2015.