ASTRONOMY FINAL PROJECT

PHY 1060

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LIFE IN THE UNIVERSE

Is there life in the universe beyond Earth? Chapter 30 explores this topic, and the questions and information that follows is based on Chapter 30.

The Milky Galaxy: Home to Planet Earth and only one of *many* galaxies in the universe.

THE COSMIC CONTEXT FOR LIFE

What Made Earth Habitable to Life?

To answer the ancient question of if life exists elsewhere in the universe, first we have to look at several areas: how life began on Earth, if it's possible that this same process could conceivably occur on another planet, and how to go about finding life if it does exist.

Question 1:

What is the name for the field of study that examines how life began on Earth, if it's possible that this same process could occur on another planet, and how to go about finding life if it does exist?

a.) Astrophysics
b.) Astral biology
c.) Astrobiography
d.) Astrobiology

Answer: d

Something important to understand about the search for life beyond Earth is that it is not necessarily the same as the search for intelligent, sentient life. It is much more simply the search for any form of life at all, no matter how basic. To do this, we must begin at the beginning of the Earth.

The Big Bang is the name scientists have for the event that gave birth to the universe. At its most basic level an unimaginably hot "fireball," the Big Bang is when it all started.

Question 2:

According to the textbook, approximately how many years ago did the Big Bang occur?

a.) 14 billion years ago
b.) 1400 years ago
c.) 140 billion years ago
d.) 14 million years ago

Answer: a

After the universe cooled down and atoms existed, *all* matter in the universe consisted mainly of two elements with a small amount of a third.

Question 3:

What were the three elements that all matter in the universe consisted of directly after the Big Bang?

a.) Hydrogen, carbon, helium
b.) Lithium, hydrogen, carbon
c.) Hydrogen, helium, lithium
d.) Oxygen, nitrogen, magnesium

Answer: c

The elements that essentially "make up" Earth were created as the universe continued to age and processes in stars began to take place. In fact, the three elements crucial for life as we know it to exist were created during this period of the universe's growth.

Question 4:

What are the three elements required for life as we know it?

a.) Hydrogen, helium, lithium
b.) Oxygen, nitrogen, carbon
c.) Silicon, neon, sodium
d.) Lead, sulfur, nitrogen

Answer: b

In combination with these three essential elements, a “key unit” also provides a base for life to be built. This molecule is “a combination of carbon and other atoms—primarily hydrogen, oxygen, nitrogen, phosphorus, and sulfur—some of which serve as the basis for our biochemistry.”

Question 5:

What is the name of the molecule that is a “key unit” to life as well as a combination of carbon and other atoms—primarily hydrogen, oxygen, nitrogen, phosphorus, and sulfur?

a.) Unorganic molecule
b.) Disorganic molecule
c.) Organic molecule
d.) there is no such molecule

Answer: c

As life continued on Earth, it developed and became more complex. During the evolution of life on Earth, there were occasional impacts with smaller space bodies. This impacted the course of evolution of life on Earth. For example, the collision that ended the dinosaurs and most other living things at that time.

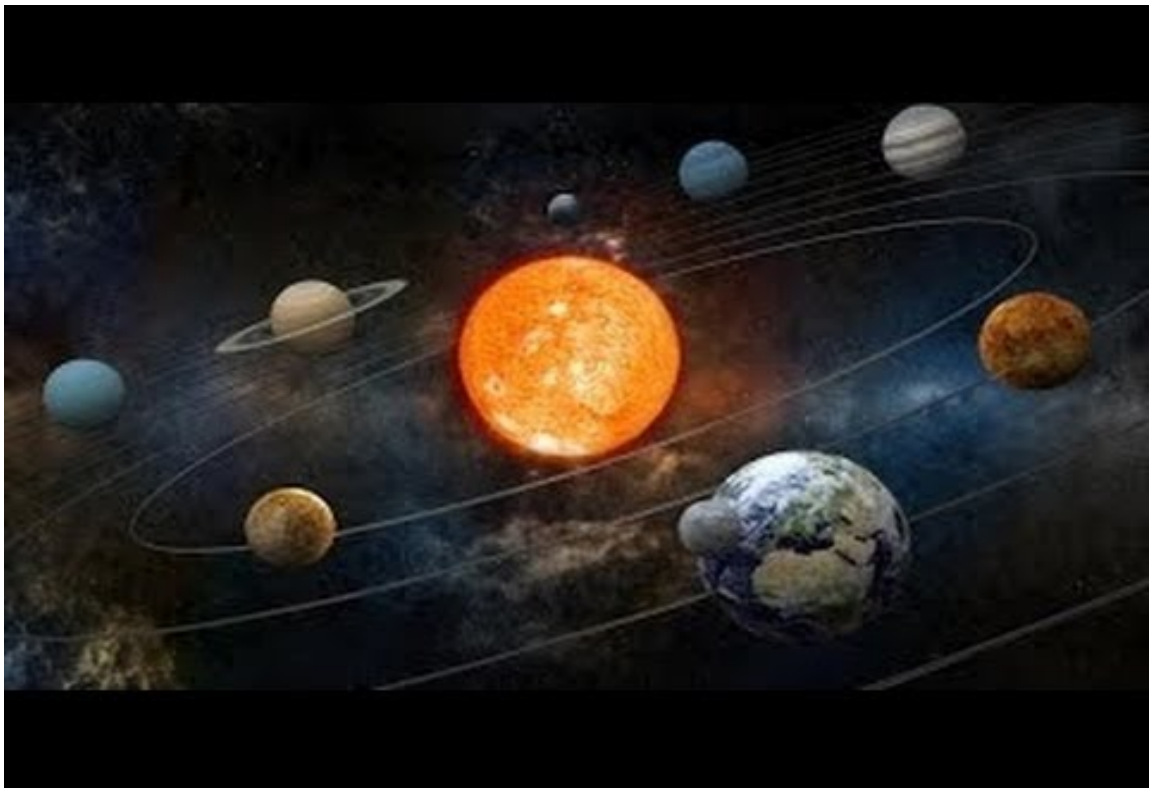
Question 6:

Approximately when did the collision that caused the dinosaurs—and many other species—to go extinct occur, which also likely led to mammals “dominating” the Earth?

a.) 5 million years ago
b.) 2000 years ago
c.) there never was such a collision
d.) 65 million years ago

Answer: d

The Copernican Principle



Astronomy has always been a field of curiosity for humans, leading us to new discoveries. It has shown us that the Earth is not always as “unique” as we think it is. In the past, it was believed that Earth is the center of solar system and all the planets and the Sun moves around the Earth. Eventually, one scientist put to use the telescope—a new technology during his time—to prove that the Earth is not at the center.

Question 7:

Who is the scientist that, using the new technology of the telescope, revealed that Earth is not at the center of our solar system?

a.) Copernicus
b.) Galileo
c.) Tycho
d.) Newton

Answer: b

Because we have found planets around stars all across the galaxy, we know that the formation of stars can often lead to the formation of planets. The planets that we have discovered vary vastly in size and type.

Question 8:

Fill in the blank.

A(n) _____ is a planet that orbits around other stars.

a.) Exoplanet
b.) Ectoplanet
c.) There is no specific term for this
d.) Gas giant

Answer: a

There are even numerous kinds of exoplanets, ranging in size from huge planets to planets smaller than Earth. Recently, scientists have started to frequently discover exoplanets. Through their discoveries, we have gained the knowledge that earthlike planets are not as unique as previously thought. In fact, it is estimated that there are billions of these earthlike planets in just the Milky Way.

Question 9:

Scientists have speculated that there are possibly billions of earthlike planets in the Milky Way alone. What are these earthlike planets called?

a.) Earth-esque planets
b.) Earthly planets
c.) Exo-Earths
d.) Ecto-Earths

Answer: c

Question 10:

The idea that earthlike planets are not unique and that there is nothing special about Earth's position in the universe is called the _____.

a.) Galilean Principle
b.) Copernican Principle
c.) Exo Earth Principle
d.) Specialty Principle

Answer: b

Because of all this information, the majority of modern scientists likely expect that life is not limited to Earth. This is especially easy to believe when considering the innumerable number of galaxies, stars, and planets in our universe—even just in the Milky Way. That being said, there is still one major, unanswered question as to if there is life elsewhere: is the organic biochemistry that has led to our forms of life on Earth a normal, common occurrence in the universe or is it a rare happenstance? Though this question has not yet been answered, scientists hope that finding any manner of evidence of chemical evolution on other planets or other galaxies will someday shed light on this question.

So Where Are They?

Taking the Copernican principle into account, it is sometimes thought that even intelligent life like humans may not be uncommon. However, there is one criteria that makes intelligence like the intelligence possessed by humans special.

Question 11:

True or False.

Intelligence like ours is special and includes the ability to make progress through the application of technology.

Answer: True

Though it may sound like the beginning of a science fiction novel to some, the idea that life may have began a long, long time ago around other and older stars is often considered when thinking of the Copernican principle. One physicist questioned this idea. Enrico Fermi asked about older intelligent life: “Where are they? If life and intelligence are common and have such tremendous capacity for growth, why is there not a network of galactic civilizations whose presence extends even into a ‘latecomer’ planetary system like ours?”

Question 12:

Enrico Fermi’s question about “older” life in the universe is called:

a.) Fermi Principle
b.) Fermi’s Question
c.) The Fermi Proposal
d.) Fermi Paradox

Answer: d

Because the Fermi paradox poses such an interesting and loaded question, there are numerous theories that propose an answer.

Question 13:

Solutions to the Fermi Paradox include:

a.) Life is common but intelligence/technological civilization is not
b.) Such a network will come about in the future but hasn’t yet developed
c.) Invisible streams of data are flowing past us, but we don’t know it due to our lack in technology
d.) Advanced species do not interfere with developing ones such as ours
e.) Civilizations like those “died” or came into destruction
f.) All of the above

ASTROBIOLOGY

Question 14:

Sometimes referred to as exobiology or bioastronomy, this field of scientific study examines the "origin, evolution, distribution, and ultimate fate of life in the universe."

a.) Astrophysics
b.) Astronomy
c.) Astrobiology
d.) Astrology
e.) None of the above

Answer: c

The field of astrobiology is not maintained by just one "type" of scientist. Astrobiology is a mix of many different disciplines of science.

Question 15:

True or False.

Astronomers, planetary scientists, chemists, geologists, and biologists are among some of the scientific disciplines that contribute to the field of astrobiology.

Answer: True

It may seem that astrobiology could never be focused on certain scientific issues because of all of the different areas within astrobiology. The opposite, however, is true. Because of the various areas of expertise, astrobiology is able to answer questions that would otherwise perhaps remain unanswered. Specifically, astrobiologists study the conditions in which life arose on Earth and the reasons for the extraordinary adaptability of life on our planet. Astrobiologists also involved in identifying habitable worlds beyond Earth. They also try to understand how to look for life—in practical terms.

The Building Blocks of Life

Concrete evidence for life outside of Earth has not been discovered yet. Nevertheless, the basic chemical "building blocks" needed for life on Earth has been "detected" in various environments outside of Earth. For example, amino acids and sugars—two such substance required for life—have been found on a meteorite. Notably, the amino acids and sugars found had specific chemical structures that indicate they did indeed come from outside Earth. There have also been organic molecules discovered in clouds of gas and dust in space.

Question 16:

Fill in the blank.

More than _____ different molecules that are important stepping stones in the development of life on Earth have been found in clouds of gas and dust between the stars.

a.) 1,000,000
b.) 600
c.) 100
d.) 12

Answer: c

To collect the information about the amount of these molecules that are present in the space clouds, astronomers use radio telescopes and radio spectrometers.

Question 17:

Fill in the blanks.

Organic molecules are found most often in regions where the interstellar dust is most _____. These are, in fact, the regions where _____ and _____ formation happen most easily.

a.) Rare, stars, planets
b.) Rare, black holes, planets
c.) Abundant, black holes, stars
d.) Abundant, stars, planets

Answer: d

Scientists have attempted to duplicate the chemical pathways that led to life on Earth since the 1950s. The Miller-Urey experiments is a series of experiments that attempted to do just that and was led by Stanley Miller and Harold Urey at the University of Chicago. They were in fact, successful at simulating conditions on early Earth.

Question 18:

Though Miller and Urey were successful at simulating conditions on early Earth, were they successful at producing some of the fundamental building blocks of life, including those that form protein and nucleic acids?

a.) Only partially successful; they were unable to produce any nucleic acids.

b.) Entirely successful; they were able to produce some fundamental building blocks, including nucleic acids.

c.) Entirely unsuccessful; future review of the Miller-Urey experiments revealed that they had not, in fact, simulated early conditions on Earth and never produced any form of fundamental building block for life.

Answer: b

The Miller-Urey experiments definitely produced interesting and encouraging results. However, there are some issues that scientists have found with the experiments. The early atmosphere of Earth was likely largely composed of carbon dioxide. It likely did not contain many hydrogen-rich (also known as reducing gases) gases as was used in the Miller-Urey experiments. Also, hydrothermal vents—seafloor systems in which ocean water is superheated and circulated through crustal or mantle rocks before reemerging into the ocean—are considered possible contributors to the organic compounds that were present early on Earth.

Question 19:

True or False.

Assuming that hydrothermal vents did indeed contribute to the organic compounds on Earth, there still would have absolutely needed to be a hydrogen-rich atmosphere in order for life to develop.

Answer: False

The question of how life began is still somewhat a mystery. Scientists have concluded that both earthly and extraterrestrial sources likely contributed to life on Earth. That being said, there has been more "direct" evidence for extraterrestrial influences. It has also been proposed that life began elsewhere in space and was "seeded" onto Earth. That, of course, still does not answer the question of how life begins.

The Origin and Early Evolution of Life

Though it is clear that the carbon compounds that are essential to forming life is fairly common in the universe, that is not the same as an actual living cell. Genes—the basic functional units that carry the genetic material in a cell—themselves contain millions of molecular units. Each of these molecular units are then arranged in a very precise sequence. Also, the most primitive forms of life must possess a means of extracting energy from its environment, and a way to encode and replicate information in order to make copies of itself.

Question 20:

A much simpler way of explaining "a way to encode and replicate information in order to make copies of itself" is

a.) The ability to reproduce
b.) The ability to remember/have memory
c.) The ability to breathe

Answer: a

The search for the answer of how life began is only complicated by the fact that, truthfully, the only decently solid evidence we have for the origin of life on Earth is through the biochemistry of modern life. There is also very

little evidence of even what Earth was like in its early years because the process of plate tectonics has, simply put, destroyed rocks from the early years of Earth.

Interestingly, even if life had begun at the earliest years of Earth's existence, the heavy impacts that Earth underwent approximately 4 billion years ago would have almost certainly wiped out any existing life due to their vast amounts of energy and heat. Because of this reason most of all, it is likely that life on Earth did not begin until the period after the impacts were over. Unfortunately, this period of time is still an unsolved mystery as scientists do not know how molecules led to biology.

Question 21:

Though scientists do not know how molecules led to the development of biology, there is evidence of microbial life in rocks that are approximately how old?

a.) 4.5 billion years with no possible evidence for any earlier
b.) 5 billion years with possible evidence for 5.5 billion years
c.) 3.5 billion years with possible evidence for 3.8 billion years
d.) 1.5 billion years with no possible evidence for any earlier

Answer: c

Deoxyribonucleic acid (DNA)—molecules that store information about how to create the cell and its chemical and structural components—and proteins are definitely the two main molecular systems needed for life.

Question 22:

Because proteins and DNA cannot work without the other and it is essentially impossible to know "which came first," it is often thought of as a

a.) "chicken and egg problem"
b.) "duck duck goose problem"
c.) "ring around the rosie problem"

Answer: a

Due to this deficit in understanding, scientists who specialize in researching the origin of life have developed the theory that there were molecules that could serve both the function of DNA and the function of protein. In other words, a molecule that could store information and do the chemical work of the cell. Ribonucleic acid (RNA) potentially could have served this purpose as its main job is to "aid in the flow of genetic information from DNA to proteins."

Photosynthesis—the chemical reactions through which some living things can use sunlight to manufacture products that store energy and releasing oxygen as one by-product—is often considered one of the most important innovations in biology. Where previously life on Earth had to depend on chemical energy, it could now use the abundant energy that sunlight provides. The energy from sunlight allowed for, among other things, more biochemical reactions to take place that had been impossible before photosynthesis.

Question 23:

True or False.

Photosynthesis was not in any way important in increasing the atmospheric levels of oxygen in Earth's atmosphere.

Answer: False

Question 24:

What are stromatolites?

a.) Solid, layered rock formations
b.) Solid, un-layered rock formations
c.) Crumbling, layered rock formations
d.) Crumbling, un-layered rock formations

Answer: a

Stromatolites are important in that they contain chemical evidence of fossils of oxygen-producing photosynthetic bacteria that are almost 3.5 billion years old. One idea often "thrown about" by scientists is the idea that there was a "simpler" form of photosynthesis that does not produce oxygen. In fact, some bacteria still uses this process today.

Question 25:

What is the major difference between the simpler, earlier form of photosynthesis and the "modern" form?

a.) Just the age/when each developed
b.) The way they functioned; the earlier form used chemicals and not sunlight to produce oxygen
c.) The earlier form did not produce oxygen and the "modern" form does
d.) There really is no difference between the two; they're basically the same

Answer: c

Question 26:

The simpler form of photosynthesis that does not produce oxygen is estimated to have begun how many billion years ago?

a.) 6 billion
b.) 8 billion
c.) 8.3 billion
d.) 3.4 billion

Answer: d

Question 27:

Beginning after the simpler form of photosynthesis, the form of photosynthesis that produces oxygen began how many billion years ago?

a.) 6 billion
b.) 2.4 billion
c.) 3.4 billion
d.) 6.5 billion

Answer: b

Another important contribution to the atmosphere made by the process of photosynthesis—not the simple photosynthesis—was the production of ozone.

Question 28:

What benefit does the ozone layer provide that has allowed life to colonize the land of Earth instead of developing only in the ocean?

a.) Protection from the Sun's infrared lights
b.) Protection from the Sun's ultraviolet radiation
c.) Protection from the Moon's radiation glow
d.) Protection from starlight radiation

Answer: b

Though the rising oxygen levels allowed life as we know it today to exist, it was deadly to some microbes. Oxygen is a highly reactive chemical that is capable of damaging some of the biomolecules that had developed without oxygen. One reason that oxygen was so fundamental in the formation of life as we know it is because of the large amount of energy created when oxygen is combined with organic matter. The oxygen-rich environment led to the diversity of life present today.

Habitable Environments

Question 29:

What kind of environment is "an environment capable of hosting life"?

a.) Inhabitable environment
b.) Lively environment

c.) Habitable environment

d.) Livable environment

Answer: c

It is crucial for understanding how widespread habitable environments may be in the universe to understand if there is life somewhere other than Earth. It is also important for the search of life beyond Earth. It is important to stress that it is more than possible that if there is life elsewhere, it may not be life "as we know it." In other words, life outside of Earth may have structures of biochemistry that differ from life on Earth.

Another crucial piece for life is a solvent—a liquid in which chemicals can dissolve. The solvent for life as we know it is water. Water is present throughout the universe.

Question 30:

True or False.

Life does not require that water be in liquid form. It "works" just as well if frozen (ice) or is in a gaseous form.

Answer: False

Because water must be in liquid form rather than ice or gas, one important step in trying to find life outside of Earth is to find water in liquid form. Liquid water occurs in a narrow window of several different factors, and most water found in the universe is not, in fact, liquid.

Our understanding of life is founded on biochemistry composed of carbon, hydrogen, nitrogen, oxygen, phosphorus, and sulfur. Carbon is especially important.

Question 31:

Fill in the blank.

Carbon is able to form _____ bonds, both with itself and with the other elements of life.

a.) 5
b.) 6
c.) 2
d.) 4

Answer: d

Carbon's ability to form bonds with itself and with the other elements of life allows for the formation of potential molecules on which our biochemistry is based.

Question 32:

Carbon, hydrogen, nitrogen, oxygen, phosphorus, and sulfur are sometimes referred to with the acronym CHNOPS. What are these elements called?

a.) Biogenic elements
b.) Genetic elements
c.) Biochemical elements
d.) Biology elements

Answer: a

These elements and their availability is a second requirement of habitability. Additionally, CHNOPS are created by fusion with stars. Then, when those same stars die, they are distributed out into the universe. Of course, the manner in which they're distributed and the processes of the planet where they "land" greatly affects the distribution of life. This is, of course, then extremely important in figuring out possible habitable environments.

Perhaps most important to life is energy. Putting the assembly of life into practice and keeping up the machinations of life takes a vast amount of energy. People and animals provide the energy they require by eating, drinking, and breathing. If this does not make sense, imagine if a person or

animal stopped eating, drinking, or breathing. That person's or animal's life would end.

Life in Extreme Conditions

Life needs more than just water, raw materials, and energy. It also requires a "safe" environment for these various components. In other words, life needs an environment that will allow those components to be stable.

The limit for human existence is fairly narrow in terms of temperature among other requirements. There are, however, other organisms that can live far outside of the human-life range. The suffix –*phile* means "lover of." Therefore, the name for these organisms makes perfect sense.

Question 33:

What is an organism (often a microbe) that tolerates or even thrives under conditions that most of the life around us would consider hostile, such as very high or low temperature or acidity?

a.) Extreme life forms
b.) Exotremists
c.) Extremophiles
d.) Extremo-organism

Answer: c

One factor that can "cause a problem for life" is temperature. Though larger life forms are generally able to regulate their heat and keep their bodies at an acceptable temperature, smaller life forms such as microorganisms are unable to do this. Whatever the temperature is around the microorganism is the temperature it has to be able to survive in. Hot temperatures especially are detrimental to complex life forms. Heat can "break down" molecules which does not allow there to be a stable environment—one of the required components for life to be successful.

Question 34:

Based on our understand that the root –*phile* means "lover of," what does the term thermophile means?

a.) Organisms that cannot survive in hot temperatures
b.) Organisms that only sometimes are able to live in hot temperatures
c.) Organisms that thrive in hot temperatures

Answer: c

Question 35:

The high temperature record holder is a methane-producing microorganism that can grow at what temperature? Hint: it is above the boiling temperature of water in Celsius.

a.) 112 degrees Celsius
b.) 300 degrees Fahrenheit
c.) 122 degrees Fahrenheit
d.) 122 degrees Celsius

Answer: d

It is not just heat that can be an issue for life forms. Cold also has the potential to inhibit life forms because it slows metabolism down to extremely low levels. It also is capable of causing physical changes in biomolecules. Cell

membranes are, basically, molecular “envelopes” that surround cells and allow their exchange of chemicals with the world “outside.” These cell membranes are composed of fat-like molecules.

Question 36:

True or False.

If the temperature around an organism is cold enough, cell membranes can crystallize.

Answer: True

When a cell membrane crystallizes, its ability to function changes. For example, cell membranes can no longer function properly in their ability to exchange material in and out of the cells. Psychrophiles have adapted and changed the chemical composition of their cell membranes.

Question 37:

True or False.

Psychrophiles are cold-adapted cells.

Answer: True

Question 38:

The coldest temperature at which any microbe has been shown to reproduce is how many degrees below the freezing point of Celsius?

a.) 30 degrees
b.) 27 degrees
c.) 25 degrees
d.) 32 degrees

Answer: c

Another set of conditions that can be very hostile to life are environments that are extremely acidic or alkaline. This is because proteins

and DNA—among other molecules critical to life—cannot "survive" under these kind of conditions.

Question 39:

Fill in the blank.

Acidophiles are acid-tolerant organisms are capable of living at pH values near zero. This is about _____ times more acidic than human blood.

a.) 12 million
b.) 10 million
c.) 1 billion
d.) 6 million

Answer: b

Question 40:

Fill in the blank.

Alkaphiles are at the opposite extreme of the pH scale from acidophiles and can grow at pH levels of about _____, which is comparable to the pH of household bleach and almost a million times more alkaline than human blood.

a.) 10
b.) 11
c.) 12
d.) 13

Answer: d

Another factor that can greatly reduce the levels of life present is salt. It blocks certain cellular functions that are key in life successfully developing—most life, that is.

Question 41:

Why do people use salt to cure foods/meats?

a.) **Trick question. They never have.**
b.) **The salt keeps the food from spoiling because the salt stops microorganisms from "living in" the food**
c.) **The salt keeps the food from spoiling because it allows certain microorganisms to "live in" the food**

Answer: b

Question 42:

What is the name for organisms that can survive in extremely salty environments that are ten times as salty as seawater?

a.) **Sodiumphiliac organisms**
b.) **Sodium-cholride philes**
c.) **The textbook does not give a specific name for this type of organism**
d.) **Saltophiles**

Answer: c

Question 43:

***Deinococcus radiodurans* is an organism that can survive in what kind of hostile environment?**

a.) **Extreme radiation**
b.) **Extreme ionizating radiation**
c.) **Plot twist. A and B are basically the same things and this is the correct answer.**
d.) **That is a made up organism.**

Answer: c

Deinococcus radiodurans can tolerate radiation a thousand times more intense than humans can withstand. This organism is also very good at living living despite levels of extreme dryness as well as metals toxic to humans.

Question 44:

How has the study of extremophiles proved important to the study of life outside of Earth?

a.) Knowing the extreme levels life can survive at has made scientists more optimistic in their search and thus more motivated.
b.) Knowing the extreme levels life can survive at has given scientists better parameters in which to search for life.
c.) Both A and B
d.) Neither A or B

Answer: c

SEARCHING FOR LIFE BEYOND EARTH

Despite the absence of irrefutable, concrete evidence for life elsewhere in the universe other than Earth, scientists still continue the search. The first step is the exploration of the planets in our own solar system which is challenging. The real challenge begins, however, in the second step: the search for evidence of life on planets circling stars other than our sun.

Question 45:

What is the scientific term for "evidence of life"?

a.) Life-marker
b.) Anatomarker
c.) Biomarker
d.) Biometer

Answer: c

Question 46:

What does the acronym SETI mean in the context of this chapter?

a.) SEarch for Terrestrial Intelligence
b.) Search for ExtraTerrestrial Intelligence
c.) Search for ExTra-planetary Intelligence

Answer: b

In the next section of this chapter, the search for extraterrestrial intelligence is discussed more thoroughly as a third step in the quest to find life outside of Earth. As for the first step—searching for life on other planets in our solar system—the main focus for many years has been Mars.

Question 47:

Fill in the blank.

The possibility that Mars hosts, or has hosted, life has a rich history dating back to the _____ that some people claimed to see on the Martian surface toward the end of the 1800s and the beginning of the 1900s.

a.) Craters
b.) Lifeforms
c.) Signals
d.) Canals

Answer: d

With the “space age” came the tools, technology, and knowledge to explore the possibility of life on a planet so close to ours. The first of the missions to Mars began with the first successful flyby of a un-manned spacecraft in 1964.

Question 48:

What was the name of the rover that landed on the surface of Mars in 2012?

a.) Explorer II
b.) Curiosity IV
c.) Curiosity
d.) Expedition

Answer: c

Since the early days of Mars exploration, evidence that water—liquid water—was once present on Mars was found. Later expeditions found the same evidence.

Question 49:

True or False.

NASA’s Viking landers—whose only purpose was to search for evidence of life on Mars—found evidence of organic molecules and evidence for biological activity in the soils it analyzed.

Answer: False

Though it is difficult to speculate if the surface of Mars was different in the past, knowing the surface as we know it today does not make the finding

of the Viking landers a surprise. The surface of Mars is unstable and—as mentioned earlier—stability is essential if life is to form. That being said, the results from the Viking landers' analyses did not show any evidence for or against the possibility that life may have been on Mars at one point in the past.

Question 50:

Fill in the blank.

Though there is a lack of liquid water on Mars, there is an abundance of _____ water not very far under Mars' surface.

a.) Frozen
b.) Gas
c.) Poisonous

Answer: a

Of course, it is important to understand that large leaps in technology has been made since 1976 when the Viking landers collected and analyzed their data. Since that time, orbiting spacecraft have collected detailed images of Mars' surface.

Question 51:

In addition to detailed images of the surface of Mars, orbiting spacecraft have also detected

a.) Minerals that could have formed without the presence of liquid water, but still indicative of life
b.) Minerals that could NOT have formed without the presence of liquid water
c.) Minerals that could NOT have formed without the presence of life
d.) Minerals that could NOT have formed without the presence of frozen and/or gaseous water

Answer: b

Question 52:

Before NASA's *Curiosity* Rover in 2012, there were two other rovers that also confirmed the data found by the orbiting spacecraft. What were these two rovers? (Hint: they both were in 2004)

a.) *Spirit* and *Optimism*
b.) *Spirit* and *Adventure*
c.) *Spirit* and *Opportunity*
d.) *Spirit* and *Life*

Answer: c

The newer rover *Curiosity* (2012) has found more than just "evidence for water." It has also searched for—and confirmed—the existence of habitable environments on Mars. Of course, this is the Mars of a long time ago.

Question 53:

Fill in the blank.

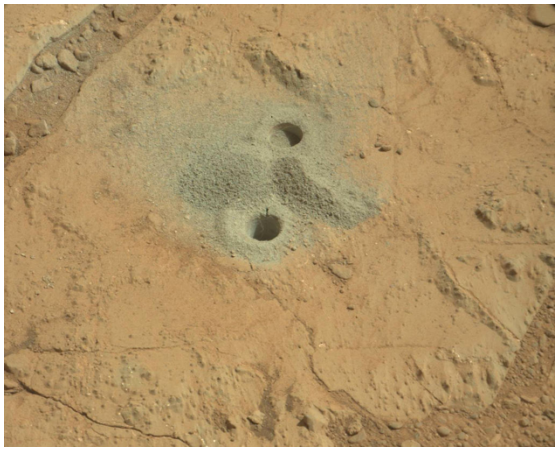
The term "habitable" does not only mean that liquid water is present. It also means that life's requirements for _____ and _____ _____ _____ could also have been met.

a.) Energy, elemental raw materials
b.) Fire, fundamentally charged materials
c.) Heat, fundamentally charged materials
d.) Heat, elemental raw materials

Answer: a

Question 54:

What is the image below?



a.) The first holes drilled by NASA's *Spirit* Mars rover into a mudstone.

b.) The first holes drilled by NASA's *Opportunity* Mars rover into a mudstone.

c.) The final holes drilled by NASA's *Curiosity* Mars rover into a sandstone.

d.) The first holes drilled by NASA's *Curiosity* Mars rover into a mudstone.

e.) The final holes drilled by NASA's *Curiosity* Mars rover into a sandstone.

Answer: d

After analyzing the mudstone, the strongest evidence of Mars having once been habitable was found. Interestingly, mudstone is a very fine-grained rock that is common and widespread on Earth. However, it was not known that mudstone was present on Mars as well until the *Curiosity* rover found and analyzed it.

Through advancements in technology and "robotic exploration," scientists have been able to sketch out a rough picture of the evolution of Mars. According to these scientists, early Mars had "epochs" of warmer and

wetter conditions. These conditions would have been beneficial to the development of life.

Question 55:

In simple terms, what is an "epoch"?

a.) A particular period of time in which nothing truly distinctive occurred
b.) A particular period of time in which a planet is created
c.) A particular period of time in which water is created on a planet
d.) A particular period of time marked by distinctive features, events, etc.

Answer: d

After that particular epoch, however, Mars' early atmosphere was almost completely lost. Because of the loss of its atmosphere, its surface water started to dry up. As this continued, the liquid water still on Mars began to become saltier and more acidic. Eventually, Mars' surface lost virtually all of its liquid water. After undergoing intense solar radiation, the surface of Mars became inhabitable. However, this is only on the surface. Scientists say that there may be ice and liquid water underground on Mars.

Question 56:

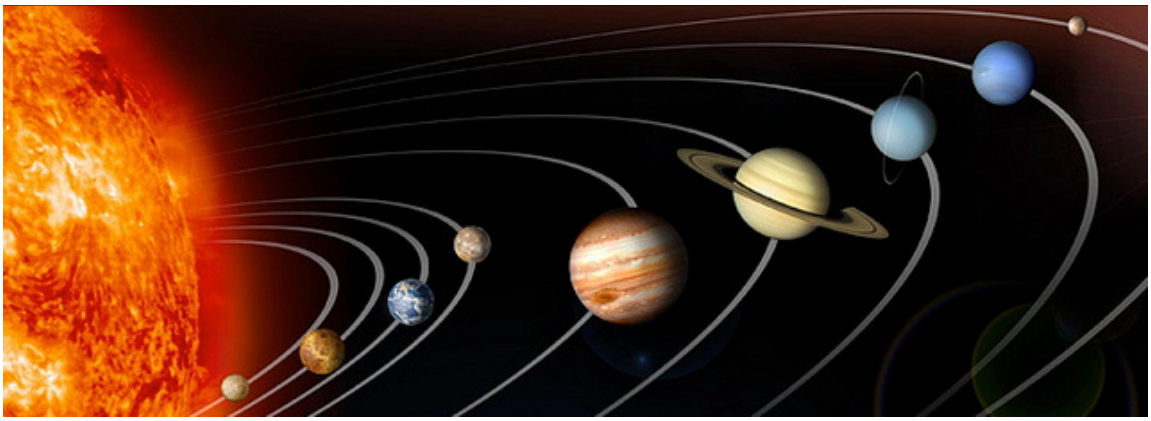
Why/How could there still be ice and/or liquid water underground on Mars?

a.) It can't. Though scientists once thought this was true, they have since disproved this idea.
b.) Pressure and temperature conditions make the underground stable
c.) Pressure and temperature conditions make the underground unstable

Answer: b

There is also some evidence that extremely salty water can sometimes flow on the surface of Mars for very brief intervals of time.

Life in the Outer Solar System



Jupiter, Saturn, Uranus, and Neptune are the gas giants of our solar system and are the outer planets of our solar system. Because of their nature, it can reasonably be assumed that they are not habitable to life. That being said, some of their moons could be.

The planets in the outer solar system do not lack in liquid water. However, next to no warmth from the Sun reaches these planets. For quite a while, it was even believed that these planets would be "geologically dead" and be nothing more than frozen ice and rock. Upon closer research and missions to the outer solar system, evidence for the contrary has been found.

Question 57:

What planet does the moon Europa orbit?

a.) Saturn
b.) Jupiter
c.) Uranus
d.) Neptune

Answer: b

On Europa there is an ocean underneath its surface of ice. This ocean has been estimated to be tens to hundreds kilometers deep.

Question 58:

What causes the tides in Europa's ocean?

a.) The pull of gravity of its own moon, called a "sub-moon"
b.) The pull of gravity of Neptune, the planet Europa orbits
c.) The pull of gravity of Jupiter, the planet Europa orbits

Answer: c

Question 59:

If the outer planets and their moons are so cold, how is it that Europa's ocean contains liquid water?

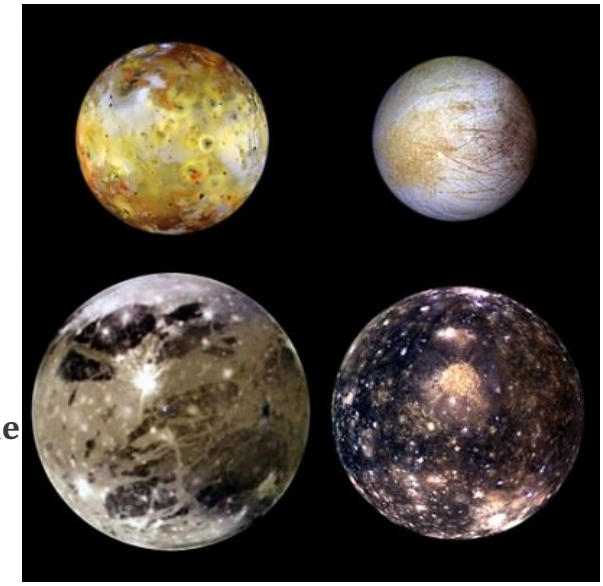
a.) Chemicals found in the ocean cause the water to remain a liquid
b.) Heat from Europa's core keeps the water warm enough to remain a liquid
c.) A mixture of the heat from Europa's core and certain chemicals found in the ocean cause the water to remain a liquid
d.) The friction of the pushing and pulling that causes the tides generates enough heat to keep the water in liquid form

Answer: d

Europa is possibly not the only moon that orbits an outer planet that has liquid water. Though they do not know for certain, scientists believe that there are possibly at least six other moons like Europa that have liquid water.

Question 60:

The picture to the right shows the moons of Jupiter—often called the Galilean moons. In the order of top left, top right, bottom left, bottom right what are the names of these moons?



a.) Callisto, Europa, Io, Ganymede

b.) Europa, Ganymede, Callisto, Io

c.) Io, Europa, Ganymede, Callisto

d.) Europa, Io, Ganymede, Callisto

Answer: c

Question 61:

Which of Jupiter's moons experiences the tidal heating effect to such a strong degree that it is though to be the "most volcanically active body in our solar system"?

a.) Europa

b.) Ganymede

c.) Callisto

d.) Io

Answer: d

As has been mentioned repeatedly, life needs energy to exist. Though Europa is much too far from the Sun to gain the needed energy from sunlight, chemical energy is an option. Because Europa's ocean is thought to be directly in contact with the mantle of Europa, it is thought that the interaction that takes place where the ocean meets the mantle yields a "reducing chemistry."

Question 62:

What does the term "reducing chemistry" mean?

a.) Molecules tend to give up electrons easily

b.) Molecules tend to withhold electrons, not giving electrons up

c.) Molecules tend to reluctantly give electrons up, but will do so

Answer: d

Though the reducing chemistry does indeed lead to energy's creation, it cannot function completely on its own. The book describes it as "half a battery."

Question 63:

What is the other "half of the battery" of reducing chemistry?

a.) **Oxidizing chemistry, where molecules tend to yield electrons readily**
b.) **Oxidizing chemistry, where molecules tend to accept electrons readily**
c.) **Addition chemistry, where molecules tend to accept electrons readily**
d.) **Anti-reduction chemistry, where molecules tend to accept electrons**

Answer: b

Question 64:

True or False.

The Galileo mission did not find any oxidizing chemicals on the icy surface of Europa.

Answer: False

The icy surface of Europa is around tens of millions of years old—relatively young, as far as geology is concerned. Understanding the impact of the age of the surface and the surface's interaction with Europa's ocean will help scientists in understanding if life could form on this moon of Jupiter.

The Cassini mission is another exploration into the possibility of life in the outer solar system. The Cassini mission took place in 2005 and involved a close flyby of a moon of Saturn.

Question 65:

Which moon of Saturn did the Cassini mission do a close flyby of in 2005? (Hint: this moon has a diameter of about 500 kilometers)

a.) **Dione**
b.) **Titan**

c.) Tethys
d.) Mimas
e.) Enceladus

Answer: e

Question 66:

How many moons orbit Saturn?

a.) 5
b.) 6
c.) 7
d.) 8

Answer: d

The Cassini mission found that there are plumes of gas and icy material were venting from Enceladus' south polar region. These plumes were venting at a collective rate of approximately 250 kilograms of material per second. Another observation showed that salts were present in this material being vented.

Question 67:

The fact that salts were found in the plumes on Enceladus suggests what about the source of the plumes?

a.) Their source is definitely not a liquid ocean beneath Enceladus' surface
b.) Their source is definitely the layer of ice that makes up Enceladus' surface
c.) Their source is likely a liquid ocean beneath Enceladus' surface

Answer: c

Though there is much that scientists do not know about this suggested liquid ocean beneath Enceladus' surface, they are fairly certain that there is indeed a liquid ocean beneath Enceladus' icy surface.

Perhaps most interesting about Enceladus is the fact that the icy plumes venting from its surface is the fact that spacecraft flying past can pick up the material sent by the plumes.

Question 68:

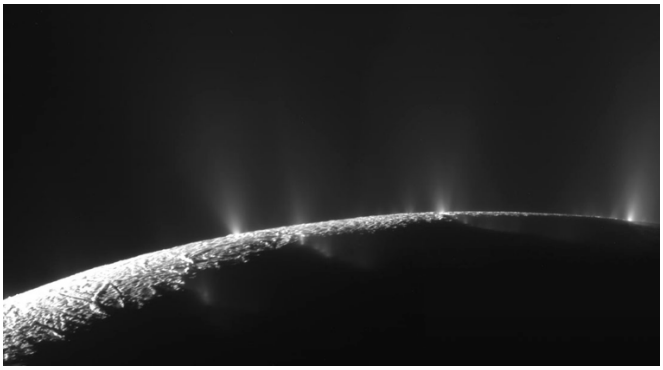
True or False.

A sample of the materials from the icy plumes from Enceladus could tell scientists if Enceladus is habitable AND if it is home to life.

Answer: True

Question 69:

What does the picture below show?



a.) The icy plumes of Jupiter's moon Enceladus
b.) The fiery plumes of Saturn's moon Enceladus
c.) The icy plumes of Saturn's moon Cassini
d.) The fiery plumes of Jupiter's moon Dione
e.) The icy plumes of Saturn's moon Enceladus

Answer: e

Titan—another of Saturn's moons—may also have a liquid ocean beneath its surface. However, this by itself is not necessarily scientifically interesting. What interests scientists is Titan's surface itself. Specifically, the surface's chemistry. Titan's atmosphere is composed of nitrogen for the most part and about 5% methane.

Question 70:

Fill in the blanks.

Titan's atmosphere is _____ and is the only one in the _____ of the solar system.

a.) Thick, the outer section
b.) Thick, moons
c.) Thin, the outer section
d.) Thin, moons

Answer: b

Question 71:

Fill in the blanks and explain.

In the upper atmosphere, the Sun's ultraviolet light _____ and _____ these molecules into more complex organic compounds that are collectively known as _____. What effect does the answer to the third blank have on Titan?

a.) Breaks apart, recombines, hurdles. They cloak Titan in an orange haze/glow/tint
b.) Destroys, recreates, tholins. They cloak Titan in a pink haze/glow/tint
c.) Breaks apart, recombines, tholins. They cloak Titan in an orange haze/glow/tint
d.) Destroys, recreates, hurdles. They cloak Titan in a pink haze/glow/tint

Answer: c

Also, it has been seen that heavier particles appear to accumulate on the surface, even forming "dunes" that are cut and sculpted by flows of liquid hydrocarbons—liquid methane, for example. This has led scientists to believe that some clues can be found in these "dunes" about early chemistry

in the solar system. Possibly, this chemistry could give more information on the support of the origin of life.

Habitable Planets Orbiting Other Stars

There is a vast amount of planets that have been discovered orbiting other stars. There are even instances much like our own solar system where multiple planets orbit one star. The question that scientists now have is if any of these planets are potentially habitable.

Question 72:

A region around a star where suitable conditions might exist for life is called what?

a.) Habitable zone
b.) Livable zone
c.) Life-supportive zone
d.) Inhabitable zone

Answer: a

As a general rule, the concept of habitable zones focuses on the presence of liquid water and life's requirement for liquid water. Also, habitable zones are generally thought of as the "range of distances from the central star in which water could be present in liquid form at a planet's surface. For example, the extreme temperatures on Venus and Mars are outside of the habitable zone. A planet's surface temperature and whether or not it is able to maintain liquid water depends on how much starlight energy it absorbs and retains.

Question 73:

What is the term for how much starlight energy a planet absorbs and retains?

a.) Starlight energy absorption and retention rate
b.) Starlight rate

c.) Radiation budget
d.) Radiation retention rate

Answer: c

Other influences include the process of winds and ocean circulation and how these processes distribute energy throughout the planet in question. Additionally, it is important how much sunlight the planet reflects back outward. Stars vary greatly, too, in their intensity and spectrum.

Question 74:

True or False.

Simply put, spectrum in reference to stars refers to the wavelengths of light.

Answer: True.

Question 75:

The color of stars varies depending on their temperatures. Which of the following lists the colors of the stars from brighter and hotter to dimmer and cooler?

a.) Bluer, redder
b.) Redder, bluer

Answer: a

Question 76:

There are many types of stars, including dwarf stars. Which classification of dwarf stars is the most common and long-lived?

a.) M-dwarf stars
b.) G-dwarf stars
c.) The numbers of the classifications of dwarf stars is approximately equal

Answer: a

Stars like our Sun increase in luminosity over their lifetime. Interestingly, this means that habitable zones move outward the older a star system gets. Our Sun, for example, has been estimated to have increased by approximately 30% over the last 4 billion years. Following this line of reasoning, Venus—now firmly outside the habitable zone—used to be within it. Also, Earth—now undoubtedly habitable—used to be outside the habitable zone. However, just because a planet is within the habitable zone of its star, does not mean it is habitable.

Unfortunately, scientists do not yet entirely understand what decides a habitable zone and the habitability of the planets orbiting in a habitable zone. Understanding and possessing this information will lead scientists in the quest to seek out other habitable planets and life outside of Earth.

Question 77:

Fill in the blanks.

According to the textbook, "of the confirmed or candidate exoplanets known at the time of writing, nearly _____ are considered to be orbiting within the habitable zone and more than _____% of those are roughly Earth-size."

a.) 100, 30
b.) 300, 10
c.) 500, 40
d.) 400, 50

Answer: b

Biomarkers

Question 78:

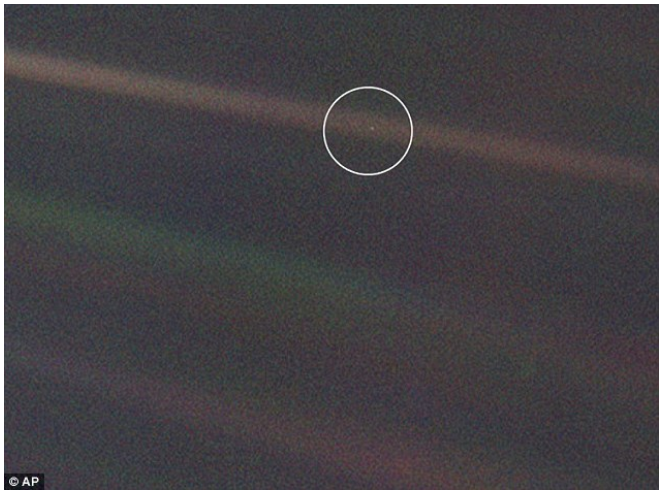
Because we are not able to send probes to investigate many of the Earth-size planets that have been found, scientists are using what to figure out if any of these planets have life?

a.) Light and other radiation
b.) Sound and other radiation
c.) Planetary pulses and other radiation

Answer: a

Question 79:

What appears as a pale blue dot inside the circle in the picture below that was captured by NASA's Voyager 1?



a.) Mars
b.) The Sun
c.) Uranus
d.) Earth

Answer: d

Scientists have been looking for evidence that a planet can support life without using probes, and it is important to understand what, exactly, they are looking for. In other words, what information or observations would tell the scientists that a planet could be inhabited.

One criteria is a "robust biosphere." This means that there are atmospheres, surfaces, and/or oceans that are capable of causing and creating planet-scale change.

Question 80:

Does Earth have a "robust biosphere"?

a.) Maybe. Scientists are still unsure.
b.) No, absolutely not. Earth is missing some crucial components.
c.) Yes, of course. Earth has atmospheres, surfaces, and oceans that can create planet-scale change.
d.) The term "robust biosphere" is a term only applied to planets that are uninhabitable.

Answer: c

Though other planets in our solar system could possible harbor some form of life, they are not considered to have a robust biosphere because it is "very unlikely that it could yield planet-scale changes." Earth is "special" in our solar system for other reasons as well. For example, Earth has a photosynthetic biosphere. This means that the planet—Earth—has liquid water on its surface, and organisms have direct access to sunlight on the surface as well. Earth has such an abundance of plants and photosynthetic microorganisms that Earth sends greener wavelengths from the light it reflects.

Question 81:

More than 20% of our atmosphere comes from our photosynthetic waste product. What is this "photosynthetic waste product"?

a.) Nitrogen
b.) Carbon Dioxide
c.) Helium
d.) Oxygen

Answer: d

High levels of oxygen are extremely indicative of life. Also, other gases—nitrous oxide and methane, for example—are also indicators of life, especially when found with oxygen. Scientists can tell if enough of these

gases are present in a planet's atmosphere if the planet's reflection of light or the light the planet emits if affected in a certain way.

Of course, it is difficult to obtain this knowledge, especially the further away the planet in question is. This is the reason that the search for Earth-like planets that may have life remains relatively close by.

Even the indicators from the light and atmosphere does not guarantee that life is on that planet. The first step scientists would take if this kind of planet was found is to try to think of other reasons that those indicators would be present. Carl Sagan, as cited by the textbook, said, "Life is the hypothesis of the last resort." This makes a lot of sense in this context because scientists need to exhaust every other possibility before believing that life exists on another planet.

Though the levels of oxygen on Earth are obviously created by our photosynthetic atmosphere, high levels of oxygen on other planets can possibly be explained by ultraviolet radiation and its affects on atmospheres of other planets. Just as important to understand is the fact that our current technology may not, in fact, be able to detect a biosphere on another planet, even if it were to exist.

THE SEARCH FOR EXTRATERRESTRIAL INTELLIGENCE

For the most part, the search for life outside of Earth is focused not on intelligent or even sentient life. The search for life—and this chapter so far—has been focused on finding the most basic forms of life, such as microbial life.

When most people are asked the question of if we are alone in the universe, they focus on life similar to human life that is capable of intelligent thought and developing and using tools. Assuming that is it possible for life like this to exist outside of Earth, the next question would be to figure out how to contact it. Much in the same way humans communicate with other humans, there are essentially two options for contacting intelligent life outside of Earth: travelling there or sending messages.

Interstellar Travel

An engineer named Bernard Oliver calculated the amount of energy travelling rapidly through space would take. He made his calculations assuming an engine that converted fuel into energy with 100% efficiency because we don't know the kind of technology that may one day develop.

Question 82:

According to Bernard Oliver's calculations, a round trip at 70% light speed using an engine with 100% conversion from fuel to energy would be equivalent to how many years' worth of total U.S. electrical energy consumption?

a.) Hundreds of years'
b.) Millions of years'
c.) Decades
d.) Several hundred thousand years'
e.) Single-digit thousands

Answer: d

Given the astronomical amount of energy that that scenario would take is one main reason why astronomers and other scientists do not readily believe that UFO sightings are legitimate and from extraterrestrial civilizations. These skeptics say that it is wildly unlikely that an alien civilization would be so interested in Earth as to spend all that energy to simply appear in our skies…or even to abduct someone, as some people claim.

Though it is true that not every UFO sighting has been completely explained, this is because those sightings are generally found to be dishonest, or, at the very least, "confused".

Question 83:

UFO sightings are almost always proven to be either IFOs or NFOs. What do these acronyms stand for?

a.) Identified Flying Objects, Non-identified Flying Objects
b.) Identified Flying Objects, Not-at-all Flying Objects
c.) Indigenous Flying Objects, Not-at-all Flying Objects
d.) Indigenous Flying Objects, Non-Flying Objects

Answer: b

As given by the textbook, some examples of what a UFO sighting really is are "bright planets, ball lightning, fireballs (bright meteors), or even flocks of birds that landed in an oil slick to make their bellies reflective." Of course, some are simply airplanes or other misidentified objects or a deliberate hoax. No UFO has ever left behind any physical evidence that can be tested in a lab, furthering leading people to believe there have been no legitimate UFO sightings that are extraterrestrial in origin.

Question 84:

Some people believe that extraterrestrial life has already visited Earth and impacted human history with their "alien technology". What are some examples that people like this use?

a.) The great pyramids of Egypt
b.) Statues on Easter Island (called Moai)
c.) Accomplishments of space exploration
d.) All of these choices are correct

Answer: d

Theories like the ones held by people who believe that human ingenuity is not great enough to have built the pyramids of Egypt have been disproven time and again by historical and archaeological evidence.

Messages on Spacecraft

Just because human travel in space is outlandishly expensive and complicated, it doesn't mean mechanical travel is. Robot probes can be sent far into space and for extended periods of time. Most notable are five spacecraft that are currently exiting the solar system.

Question 85:

What are the spacecraft that are leaving our solar system only now, carrying messages from Earth?

a.) Two Pioneers, two Vikings, and New Horizons
b.) Two Pilgrims, two Voyagers, and New Horizons
c.) Two Pioneers, one Voyager, and two New Horizons
d.) One Pioneer, two Voyagers, and New Horizons
e.) Two Pioneers, two Voyagers, and New Horizons

Answer: e

Question 86:

The spacecraft carrying messages may take hundreds of thousands or millions of years to reach another star, or to even begin approaching one. Assuming this is true, why would people put messages on these spacecraft?

a.) They are the first products of human technology to go beyond our solar system
b.) They are conceivably the last products of human technology that will go beyond our solar system
c.) No special reason besides wanting to contact intelligent life

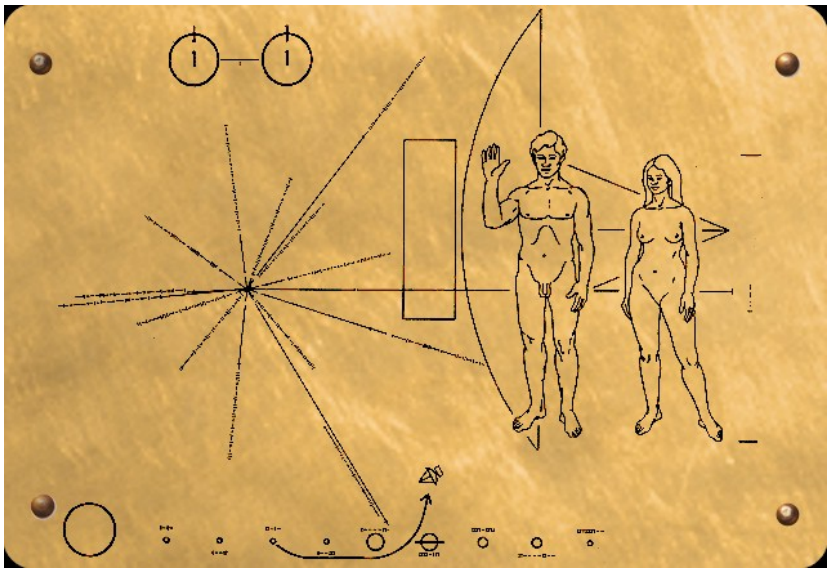
Answer: a

Each of the Pioneer spacecraft carry with it a plaque that is engraved with a picture. The plaque is made of gold-anodized aluminum plate. The Voyagers have audio and video records attached. There are over 100 photographs and music from around the world. Of course, only pictures and music recorded before its launch in 1977 were included.

It is undoubtedly extremely unlikely that these messages will ever be seen by any manner of intelligent life form. It was done, however, on the slim hope that someday they will be seen.

Question 87:

What is the illustration below?



a.) **The image/pictorial message engraved on a plaque on New Horizons**
b.) **The image/pictorial message engraved on a plaque on the Voyager spacecraft**
c.) **An illustration in a common anatomy textbook**
d.) **The image/pictorial message engraved on a plaque on the Pioneer spacecraft**

Answer: d

Question 88:

Who was the President that recorded a message on the Voyager Record on June 16, 1977?

a.) **Jimmy Carter**
b.) **Ronald Reagan**
c.) **Gerald Ford**
d.) **Richard Nixon**

Answer: a

An excerpt of the message left by President Carter as reported by the textbook is as follows:

> "We cast this message into the cosmos. It is likely to survive a billion years into our future, when our civilization is profoundly altered….If [another] civilization intercepts Voyager and can understand these recorded contents, here is our message:
>
> This is a present from a small, distant world, a token of our sounds, our science, our image, our music, our thoughts, and our feelings. We are attempting to survive our time so we may live into yours. We hope, someday, having solved the problems we face, to join a community of galactic civilizations. This record represents our hope and our determination, and our goodwill in a vast and awesome universe."

Communicating with the Stars

Because the likelihood of travelling through space in order to try to find extraterrestrial intelligent life is impractical and virtually impossible, our best route to take is messages. Sending or receiving messages is much easier and more practical.

Question 89:

What is the "messenger" that we already use in space?

a.) Sound
b.) Texture
c.) Light

Answer: c

Specifically, electromagnetic waves are a "messenger" that we already have and can use.

Question 90:

Light moves faster than anything else and is capable of moving through space. How fast does light travel?

a.) 3,000 kilometers per second
b.) 30,000 kilometers per second
c.) 300,000 kilometers per second
d.) 3,000,000 kilometers per second

Answer: d

Personal Aside: For the sake of understanding how fast light moves, let's compare it to the speed of sound. The speed of sound is approximately 300 meters per second. If we were to convert the speed of light into meters, it would be 300,000,000 meters per second. This is approximately 1 million times faster than sound. Certain planes can break the sound barrier, but no plane or other moving object even approaches the speed of light. It is also interesting to think about how people often perceive light and sound simultaneously when in fact light "reaches" them much faster than sound does.

Question 91:

How long would it take light to reach the nearest star?

a.) 7 months
b.) 14 years
c.) 4 months
d.) 4 years
e.) 7 years

Answer: d

Because of its speed, light can reach the nearest star in only four years, as compared to the millennia it would take humans to manually travel there. Though people have found a medium for communication, the specifics of that medium are the new problem. There are many different "kinds" of light. For example, there are long radio wavelengths and short gamma ray wavelengths. There is, of course, a way to weed out certain choices. The specific wavelength chosen to use as a "messenger" needs to be inexpensive to produce and it needs to be able to be produced in large quantities.

Question 92:

What kind of wavelength that is the lowest-frequency (and lowest-energy) band of the spectrum and is used already for communication on Earth has been decided as the best option for sending into space?

a.) Television waves
b.) Radio waves
c.) Ultraviolet waves
d.) Micro-waves

Answer: b

Radio waves are inexpensive to produce in large quantities. They are also not "significantly absorbed" in space by the interstellar dusts and gases. They also can—for the most part—pass easily through Earth's own atmosphere and the atmosphere of other planets.

The Cosmic Haystack

Naturally, the next question to be asked is if Earth should attempt to send messages or attempt to receive messages. This dilemma brings up questions concerning the age and advancement of other possible civilizations. Humans have only been able to send/receive interstellar radio messages for a few decades while another civilization may be far more advanced than us if they have existed "longer."

Personal Aside: One thought that has always interested me is the idea that humans are the "lesser" species. People always assume that other civilizations will be more advanced than us. Rarely does anyone make a mention of the fact that our planet may be the first to support intelligent life and that we *may be the ones who are more advanced. Though this isn't necessarily likely, it is not* unlikely *either. The truth is, we know next to nothing on this subject and are essentially making guesses in the dark.*

One interesting theory I came across some time ago is called the Great Filter Theory. Essentially, the Great Filter Theory proposes that the reason that there

appears to be no life anywhere else in the universe except for Earth is because there is a "Great Filter" that ends life before it advances too far. In other words, there is a pre-life stage and a later advanced life stage where a civilization would be capable of colonizing space. According to this theory, the Great Filter would end life somewhere before the advanced stage. This theory also offers these explanations as to why Earth and its life still exist: we have already passed through the Great Filter, unlike anywhere else; we are the very first ones to pass through this filter and, having passed through the filter, conditions are friendly to life and we—and other civilizations that are present—can progress and possibly colonize the stars; and we haven't made it to the point of the filter yet, meaning we may or may not pass through—though this theory would lean toward the latter.

There is another theory I learned about several years ago called the Fermi Paradox. At its most basic form, the Fermi Paradox says that the other civilizations we are searching for are so out of our league—so to speak—that we have no possibility of understanding them or even noticing them and that we are so below the other civilizations that they take no notice of us. An example commonly used to explain the essentials of the Fermi Paradox is the example of an anthill. If a highway was built next to the anthill, the ants would not truly notice the highway and certainly wouldn't recognize it for what it was. At the same time, people driving on the highway would never even notice the ant.

A third theory—and the final one I will discuss in this assignment—is the theory that Earth—and indeed our entire universe—is in what has been termed a "false vacuum". Simply put, this theory puts forth the idea that our entire universe is only part of a larger universe and that the existence of our universe is false in the sense that it may end at any time. This theory states that our universe is not the "real" universe and that eventually our universe will completely cease to exist without any warning whatsoever. In other words, if this theory were to be true, our universe could cease to be while I'm typing this sentence. Another way to think of this theory is to think of the proposed "real" universe as a pot of boiling water. Then, think of our universe as a bubble

formed in that boiling pot. The time the bubble "lives" in the pot as a bubble is the time that we exist. When the bubble pops, our universe ends.

Scientists decided the Earth's "best bet" is to listen for signals—perhaps also radio waves—to reach us. Most scientists believe that since radio waves are a fairly simple and effective means of communication, other civilizations are bound to have discovered it and be able to use it.

Question 93:

What are some of the questions that we are left with after choosing listening over broadcasting/speaking?

a.) What if an extraterrestrial signal can't be picked up by our present-day radio equipment?
b.) What if the channel the extraterrestrial civilization chooses to broadcast on is not one we're listening to?
c.) What if we do not understand their communication as being communication?
d.) All of these are concerns

Answer: d

Question 94:

What are some factors that scientists must consider when attempting to "tune in" to radio messages from extraterrestrial civilizations?

a.) From which direction (which star) is the message coming?
b.) Is the signal continuous, or does it shut off at times?
c.) Does the signal drift (change) in frequency because of the changing relative motion of the source and the receiver?
d.) All of these (and more!) are factors

Answer: d

Radio Searches

Question 95:

Who conducted the first radio search for intelligent extraterrestrial life and when?

a.) Frank Drake in 1950
b.) Drake Frank in 1960
c.) Frank Drake in 1960
d.) Drake Franklin 1970

Answer: c

In his search, Frank Drake used an 85-foot-long antenna located at the National Radio Astronomy Observatory. Drake named his experiment "Project Ozma."

Question 96:

True or False.

Frank Drake's experiment to search for intelligent extraterrestrial life was called "Project Ozma" after the queen of the Land of Oz, a place in Frank L. Baum's children's stories.

Answer: True.

Project Ozma looked at around 7200 different radio channels and two nearby stars. It did this over a period of 200 hours.

Question 97:

True or False.

Through his efforts, Frank Drake found a radio signal that some still consider a possible sign of an extraterrestrial civilization while others denounce it completely.

Answer: False

Despite the apparent “failure” of Project Ozma, the experiment did demonstrate that the technology to search for life did in fact exist and was usable. This then prompted the use of more advanced technology and “more sophisticated” projects.

As technology constantly makes advances, so does SETI (the search for extraterrestrial life). Modern technology also allows for searches on a vast number more channels than Frank Drake’s Project Ozma, which, remember, was around 7200 channels.

Question 98:

Approximately how many channels can modern radio technology search? (Remember, Project Ozma could search around 7200)

a.) 10,000
b.) 2000
c.) millions
d.) 7000

Answer: c

By searching such a large number of frequencies, obviously the chances of missing a signal decreases. A powerful telescope array that was funded with an initial contribution from Paul Allen, a Microsoft founder was built for SETI searches. This telescope is called the Allen Telescope in North California. Other such telescopes that conduct similar searches include the Arecibo radio dish located in Puerto Rico and the Green Bank Telescope in West Virginia.

Question 99:

Which of the following radio telescopes is the largest steerable radio telescope in the world?

a.) The Allen Telescope in North California
b.) The Arecibo radio dish in Puerto Rico
c.) The Green Bank Telescope in West Virginia

Answer: c

Earth sends out radio signals inadvertently through “leakage”. It is this same type of signal that we look for, as well as intentional signals. It is assumed that we would be able to detect leakage from other civilizations, given that they are within the area of the nearest stars. SETI searches are, though, mostly set to search for intentional searches because these type of signals will be stronger and easier to detect.

SETI outside the Radio Realm

In addition to radio searches, scientists are also conducting searches utilizing visible light. Because this is a recent technology, it is not entirely refined. Also, a civilization would have to make an extremely bright light in order to be seen over the light in its solar neighborhood.

Question 100:

True or False.

Engineers have not yet figured out how to make flashes of light brighter than the Sun.

Answer: False

With recent development, scientists have been able to make short bursts of light that are brighter than the Sun. These bursts of light can be coded into communication. Also, there is the technology to detect this same type of light bursts. Interestingly, using this type of light technology can be cheaper than continually searching for radio signals in the skies.

Though humans as a species have created technologies and ideas that we believe will help in SETI, we still do not know for certain that any alien life will use similar technologies that we will be able to detect.

Should We Transmit in Addition to Listening?

The debate of transmitting signals in addition to passively listening for signals is still ongoing. There are some scientists that feel it is "inconsistent" to search for signals from other possible civilizations if don't send similar signals ourselves.

There are scientists who believe that our civilization is too "immature" to handle contact with another civilization.

Personal Aside: Again, I'd like to draw attention to the idea that our civilization may be the more advanced one, because, truthfully, no one knows that we aren't.

Of course, then arises the issue of if Earth should reply if we do indeed receive a signal. And, who should be in charge of making this decision? This debate and others like it will undoubtedly continue into the future, maybe one day having to be resolved when Earth does pick up a signal.

Other Interesting Resources/Links/Notes

"Astronomers May Finally Have the First Picture of a Black Hole" *National Geographic*

http://news.nationalgeographic.com/2017/04/black-hole-event-horizon-telescope-pictures-genius-science/?utm_source=Facebook&utm_medium=Social&utm_content=link_fb20170411news-eventhorizon&utm_campaign=Content&sf69746428=1

NSTMF Labs

https://lab.nationalmedals.org/

Personally, I am more interested in the theoretical ideas of the universe, rather than mathematical theories. This is one reason I chose this chapter versus others. Also, if I were to complete another chapter, I would choose the chapter about Black Holes.

For all the information, I used Chapter 30 of the provided textbook. My goal was to provide quality questions that would both push students to learn yet not be too difficult to understand. Also, by providing the text that were not questions, my goal was to provide some level of context for the questions. Understanding the context is important in understanding and answering the questions.

Also, understanding about the possibility of life on other planets leads to a greater understanding of life on Earth. This information is rooted in basic scientific knowledge that most anyone can understand and reaches to difficult theories. It is because of this and personal interest that I chose this chapter. This subject provides a platform that gives opportunities of learning to students of all capabilities.

For all of the included pictures, I used Google Image Search and used pictures from various sources.