Early Earth, the Origin of Life, and Search for Extraterrestrial Life.

Conditions of Early Earth:

Lecture presented possible scenarios for the origin of the chemicals necessary for the evolution of early life on Earth. The 3 major hypotheses of the orgins of life and cells are?

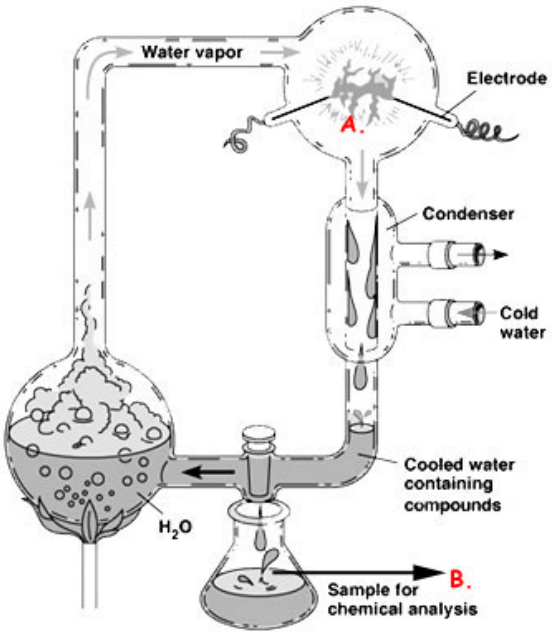
1. __Chemical Evolution____ 2. __Astrobiological____ & 3. ___Supreme Being (non-testable)_____

Radioisotope dating using ^{235}U decay indicates that the Earth is around ____4.0 and 4.5 billion years_____old and that life originated about ___3.5 billion years ago _____?

Most biologists believe that life evolved on Earth from nonliving materials (chemicals) that became ordered into collections of molecules capable of self-replication and metabolism. Conditions on the primitive Earth are thought to have favored the spontaneous formation of organic monomers, the linking of these monomers into polymers, the development of self-replicating molecules, and the grouping of aggregates of organic molecules into droplets called ___protobionts_____?

Stanly Miller and Harold Urey, of the University of Chicago in 1953's were the first to experimentally test the idea that chemical evolution may have given rise to the precursor molecules of life. Below is a picture of their experimental apparatus. Each member of your group should answer a part of the question, in turn. Discuss the important points of each question and its answer.

A. Consider the Stanley Miller apparatus. What was it meant to simulate __**early earth-like conditions**___?



B. What molecules are found in the reaction vesicle labeled "**A**."
methane, ammonia, hydrogen, and water

C. The atmosphere inside the vessel "**A**." is described as a chemically _**reducing**_? atmosphere?
Miller & Urey's atmosphere was probably more strongly reducing than the actual atmosphere of early Earth. Volcanoes today emit CO, CO_2, and N_2 and it is likely they were also abundant.

D. In the sample vesicle which they tested for various types of chemicals made… what molecules did they find in "**B**."
Hydrogen cyanide, formaldehyde, and many organic molecules, including amino acids, nucleotides, and sugars.

At the end of one week, Miller observed that as much as 10-15% of the carbon was now in the form of organic compounds. Two percent of the carbon had formed some of the amino acids. Perhaps most importantly, Miller's experiment showed that organic compounds such as amino acids, which are essential to cellular life, could be made easily under the conditions that scientists believed to be present on the early earth. The formaldehyde can spontaneously react to form a variety of sugars, including the five-carbon sugars fundamental to the formation of nucleic acids and such six-carbon sugars as glucose and fructose

In 1961, Juan Oro found that amino acids could be made from hydrogen cyanide (HCN) and ammonia in an aqueous solution. He also found that his experiment produced an amazing amount of the nucleotide base, adenine. Adenine is of tremendous biological significance as an organic compound because it is one of the four bases in RNA and DNA. It is also a component of adenosine triphosphate, or ATP, which is a major energy releasing molecule in cells. Experiments conducted later showed that the other RNA and DNA bases could be obtained through simulated prebiotic chemistry with a reducing atmosphere.

E. In their experiment, what energy source(s) were provided, and what was it likely meant to simulate?

Energy Sources on primitive Earth, especially electricity in the form of lightning. While it is believed lightning storms were extremely common on the primitive Earth, they were not continuous as the Miller/Urey experiment portrayed. Subsequent experiments have substituted ultraviolet light or heat as the energy source On the early Earth there was much more energy available in ultraviolet light than in lightning discharges.

F. How might each of the molecules made in the Miller/Urey apparatus have contributed to the formation of early cells?

All of these organics are extremely common metabolites and structural building blocks in contemporary organisms. Furthermore, the nucleotide bases as well as porphyrins have been produced in the laboratory under simulated primitive Earth conditions by several investigators. While there is still debate on the generality of the experimental synthetic pathways and on the stability of the molecules produced, most if not all of the essential building blocks of proteins, carbohydrates, and nucleic acids can be readily produced under quite general primitive reducing conditions.

Components of Life: Have one member, each in turn, define for the others in your Learning Community…

1. What is an abiotic molecule?

abiotic components are from nonliving chemical and physical factors in the environment.

2. What is the definition of a biological macromolecule?

biotic – a larger molecule formed by the joining of smaller molecules, usually by a condensation reaction. Polysaccharides, proteins, and nucleic acids are macromolecules that makeup living organisms

3. Have one member of your Learning Community, each in turn - Name two common examples of each of the following types of macromolecule:

a. nucleic acid	a.	**deoxyribonucleic acid**	and	b.	**ribonucleic acid**
b. protein	c.	**albumin**	and	d.	**petidase _(as well as many others)**
c. carbohydrate	e.	**glucose, etc**	and	f.	**sucrose (and many others)**
d. lipid	g.	**triglyceride**	and	h.	**phospholipids**

Where did the Chemicals of Life come from?

1. This idea is often known as _____**Panspermia**_____ ?

2. Pose an experimentally testable research question that might help to determine whether this idea might be correct. Have your Learning Community critique the experiment. Is the experiment really testable?

Determine if the precursor chemicals of life on Earth (amino acids, sugars, and nucleotides) exist on other planetary bodies in the Universe, such as planets like Mars.

And if not, why not? **This is experimentally testable, for we can sample Martian soil via remote sensing and sampling of by human astronauts. If, negative, they the experimental search can be expanded to other planetary bodies in the universe, including comets, asteroids, and planets.**

3. Possible extraterrestrial sources of early organic molecules that may have lead to life include:

a) __**comets**_____, b) __**meteorites**_____, and c)___**asteroids**_____.

4. Others believe that life is the result of divine creation over a very short period of time. Pose some experimentally testable questions which might help to determine whether this idea could be correct. Is this question really testable? And if not, why not?

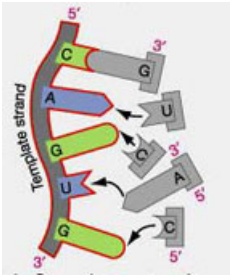
The difference between science and religious belief is that science is experimentally testable. At present, the existence of a devine creation is not experimentally testable and therefore is in the realm of faith.

5. What are the differences between a hypothesis that is scientifically verifiable and one that is not?
A hypothesis in science is a supposition, conjecture, guess, postulate, premise, proposition, speculation, supposition, thesis, or theory made as basis for reasoning that is testable by experiment. It is a tentative theory about the natural world; a concept that is not yet verified but that if true would explain certain facts or phenomena. A hypothesis is an idea or explanation for something that is based on known facts, has not yet been proved, but is subject to experimental testing. A hypothesis is a proposed explanation for a phenomenon. In the scientific method, a hypothesis should be falsifiable, meaning that it can be disproved by further observation.

6. Besides an extraterrestrial possible source for early cells and life, or its molecules, there is another terrestrial (Earth origin) source of primitive organic molecules for the chemical evolution of life. These sources are found in the deep sea in areas referred to as _____**hydrothermal vents**_____?

7. The currently accepted paradigm suggests that there were at least 4-steps or stages that contributed to the chemical evolution of life:
   a) the abiotic synthesis of ___**small organic monomer precursors of today's macromolecules**___?
   b) the joining of small organic monomers into ____**polymers**__?
   c) the origin of heredity via ____**complementary templating**___? molecules.
   d) and the packaging of these molecules into membrane-like enclosed bodies called _**protobionts**__?

8. In 1998 Robert Hazen's lab showed that minerals such as feldspar, magnetite, clay, and calcite may be able to play roles in allowing primitive organic molecules to react with each other, chemically forming more complex molecules. This is primarily because these minerals provide
   a. _**scaffolding support… minerals provides surfaces as an easy way to assemble molecules in dilute solution by concentrating the molecules on a flat surface,** _____?
   b. feldspars contain small pits that can protect molecules from __**U.V radiation and degradation** _____?
   c. _**magnetite (iron oxide)**_? triggers a combination of _**nitrogen**_? & _**hydrogen**__? into ammonia.
   d. layers of _**clays**_ allow molecules to be held in close proximity to form more complex molecules.
   e. calcite can attract different ____**optical isomers (enantiomers)**_____? to different crystal faces.



9. Autocatalytic assembly of polymers is catalyzed by a chemical reaction known as?
   a. ____**dehydration synthesis or condensation**___?
   b. The chemical reverse of this type of reaction is a reaction referred to as _____**hydrolysis**_____?
   c. The figure to the right is of an RNA molecule that is exhibiting _____**complementary templating**_____?

10. In 1989 Sid Altman and Tom Cech demonstrated that small RNA molecules have catalytic activity, i.e., the ability to break and/or form new covalent bonds. Such RNA molecules are known as ___**ribozymes**__?

Life: One member should answer one question of this section. Explain your answers to the whole group.

1. The idea of the origin of life via Spontaneous Generation was rejected in 1862 with who's experiments __**Pasteur's U-shape tube experiment** ____?
2. What is Spontaneous Generation?
   The incorrect notion that life can emerge from inanimate material spontaneously.
3. "All life arises from __**preexisting**___? life..." is often referred to as the Principle of Biogenesis.

4. There are 3 primary mechanisms by which cells can transform energy. They are:
   1) _capture of light energy__, 2) __redox reaction_____, and 3) __electron transfer_____?
5. The natural elements of the human body show that these 4 elements occur in the greatest amounts?
   1) __carbon_____, 2)__hydrogen_____, 3) __oxygen_____, and 4) __nitrogen_____
6. The evolution of the Eukarya may have been the single most important step in evolution of multi-cellular life forms and was a key step that lead from a primordial cell to plant & animal life. Name 4 important probable steps that would have to have occurred in the evolution or eukaryotes from a primordial cell?
   1. cell membrane encapsulates genetic DNA... development of nucleus internalized the genome.
   2. loss of a rigid cell wall... allowed cells to develop ability to do phagocytosis, engulfing of foods also allowed cells to clump together favoring multi-cellularity and formation of tissues.
   3. evolve a selectively permeable membrane... that protected cell, allowing uptake gases & nutrients and exchange with environment.
   4. evolve a cytoskeleton... provided framework and allowed cells to grow larger, move, and permitted metabolism to evolve.
   5. evolve aerobic respiration... a more efficient energy transformation process than anaerobiosis.
   6. develop various organelles (maybe by endosymbiosis)... an organelle is a sub-cell part that catalyzes a specific metabolic function.
   7. development of sexual cell cycles (transposons - moveable genes)... a method to shuffle genes along chromosomes favored cellular evolution.
7. one member should define… metabolism and then another member should distinguish between an autotroph and a heterotroph?

   An autotroph is organism that obtains organic food molecules without eating other organisms or substances derived from other organisms. Autotrophs use energy from the sun or from the oxidation of inorganic substances to make organic molecules from inorganic ones. Some bacteria and green plants that photosynthesize are autotrophs.

   A heterotroph is an organism that obtains organic food molecules by eating other organisms or their by-products. The major heterotrophic metabolic pathways are glycolysis, Krebs cycle, and the electron transfer chain. Most animals are heterotrophic
8. Define, in relatively formal terms, what a cell is and then ask your group to add to it or change the definition presented. The short definition would include something as: the simplest collection of matter that can exhibit the properties of life.

   A more complete definition which I have complied would include... a living CELL is a...
   self contained,
   self assembling,
   self adjusting,
   self perpetuating,
   isothermal mix of biomolecules,
   held in a specific 3-D conformation by weak non-covalent forces,
   which can extract raw materials (precursors) & free energy from its surroundings,
   and can catalyze reactions with specific biocatalysts (enzymes), that it makes,
   which shows great efficiency & economy of metabolic regulation,
   and maintains a dynamic steady state far from equilibrium, and
   that can self-replicate, using the linear information molecule DNA.

   cm - 2017