**Hypotheses about the origins of life**

**(Khan academy)**

The Earth formed roughly **4.5 billion** years ago, and life probably began between **3.5 and 3.9** billion years ago.

***If there were other life out there in the universe, how similar would one think it would it be to life on Earth?*** We can only speculate about these as so far we have no evidence of life in outer space and heavenly bodies.

However using current day knowledge we can think in a more informed way about whether life might exist on other planets (and under what conditions) by considering how life may have arisen right here on our own planet. The **when** of life's origins (3.5 billion years ago or more) is well-supported by fossils and radiometric dating.

The fact that the Earth formed around 4.5 billion years ago comes from the measure of ages of rocks here using radiometric dating ( decay of radioactive isotopes in the rock sample). It is believed that the proto-earth was a cooling down molten mass of lava that was constantly bombarded by space debris of meteorites and asteroids. There may have been a period of eventless occasion when the molecules condensed with dipping temperatures and settling of dust leading to formation of liquid water.

**Evidence:** First solid evidence of life came from structures called **“STROMATOLITES”** formed by the growth of layer upon layer of single-celled microbes, such as cyanobacteria. (Stromatolites are also made by present-day microbes),

The earliest fossils of microbes themselves, rather than just their by-products, preserve the remains of what scientists think are sulfur-metabolizing bacteria but these life forms were already complex meaning life originated much earlier.

**How then did life arise on Earth?**

In the 1920s, Russian scientist Aleksandr Oparin and English scientist J.B.S. Haldane propounded separately and independently which is now referred to as the “Oparin-Haldane Hypothesis”.

The O-H Hypothesis:-

1. There could have been a sequential formation of life from non-living via gradual chemical evolution.
2. They deduced the reducing conditions on proto-earth due to poor Oxygen atmosphere and molecules donated electrons.
3. Under the prevailing conditions of temperature, pressure, light and molecular concentrations- Simple inorganic molecules could have reacted (with energy from lightning or the sun) to form building blocks like amino acids and Nucleotides and which accumulated in the oceanic sediments forming the “Primordial soup”
4. The building blocks could have combined in further reactions, forming larger and complex molecules and polymers that became the amino acids, nucleic acids, proteins we know today.
5. The polymers could have assembled into units or structures that were capable of sustaining and replicating themselves. Oparin thought, these might have been “colonies” of proteins clustered together to carry out metabolism, while Haldane suggested that macromolecules became enclosed in membranes to make celllike structures .

**From inorganic compounds to building blocks** :

To test Oparin and Haldane’s hypothesis Stanley Miller and Harold Urey did an

Experiment in 1953,

1. They found that organic molecules could be spontaneously produced under reducing conditions as believed to have existed on proto-earth.
2. Experiment: Miller and Urey built a closed system containing a heated pool of water and a mixture of gases that were thought to be abundant in the atmosphere of early earth ( H2O, NH4 CH4 and N2 ). To simulate the lightning that might have provided energy for chemical reactions in Earth’s early atmosphere, Miller and Urey sent an arching spark through electrodes in the system. The setup was allowed to run for a week and they were surprised to find molecules of amino acids, lipids and other organic molecules like DNA except proteins proving their hypothesis that these molecules could form spontaneously from simple compounds.

**From building blocks to polymers :-**

How could monomers (building blocks) like amino acids or nucleotides have assembled into polymers, or actual biological macromolecules, on early Earth?

Monomers may have been able to spontaneously form polymers under the conditions found on earth. Sidney Fox and colleagues found protein formation on heating amino acids in absence of water. Montmorillonite in particular has catalytic and organizing properties that may have been important in the origins of life , such as ability to catalyze formation of RNA polymers apart from micelle of cell like lipid vescicles.13

The question of how the polymers became self replicating or self perpetuating that is one of the characteristics of life lead to one possibility that the first life forms were self replicating nucleic acids, such as RNA and DNA and other metabolic networks got added to this basic system. This is called the “**Gene first Hypothesis**”14.

Many believe it is the RNA and not DNA for several reasons such as in addition to carrying information act as a catalyst and currently no known naturally occurring catalytic DNA molecules.

Another school of thought an alternative to **Gene First Hypothesis** suggesting **Metabolism First Hypothesis.** This propounded that self sustaining networks of metabolic reactions might have been the first simple life even predating nucleic acids.

Such network may have formed near undersea hydrothermal vents which continuously spewed chemical precursors that might have been self sustaining and persistent. Simple molecules formed may have acted a catalysts for the formation of complex molecules 18. Eventually under optimal temperatures and pressure the independent network of molecules may have built larger complex molecules such as proteins and nucleic acids and this could have later lead to enclosure of such interacting molecules into a polymeric membrane .14

The roles of lamina formed by polymers of lipids with their hydrophobic and hydrophilic properties appear to be apt candidates for a vesicle. Once enclosed within the membrane separates the environment to an inner and an outer one. The current evidence of the structure of cell membrane reflects this logic. Another possibility is the delivery of preformed Organic molecules from outer space brought by Meteorites e.g One meteorite, ALH84001 came from Mars and contained organic molecules with multiple ring structure while Murchison meteorite carried Nitrogenous bases as found in DNA and RNA and amino acids.

**Additional readings- Reference:**

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