

- **PRECURSORS OF LIFE** (Review)

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- Life is still an unsolved puzzle. Scientists found that life involves characteristic organic compounds such as proteins. Proteins consist of amino acids, which include nitrogen, in addition to carbon, oxygen, and hydrogen. The accepted assumption is that these compounds were formed before life. Therefore, these compounds are also called *precursors of life*. Also, nucleotides and nucleosides are considered as precursors of DNA and RNA. The unsolved problem of how life was formed was replaced with an easier

but still complicated problem: How were precursors of life formed?

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- Air contains nitrogen, but adding nitrogen to carbonaceous compounds does not occur easily. A few suggestions were made.
- One of them is lightning. Experiments with electric sparks in the assumed ancient atmosphere that included nitrogen produced amino acids. Stanley Miller (1953) tested this idea in an experiment and found that amino acids (the building blocks of proteins) were formed when an environment of methane, NH_3 , hydrogen, and water was subjected to electric sparks that simulated lightning.
- Another is micro-meteorites: Bar-Nun et al. (1970) made experiments in

which "a mixture of gases roughly simulating the primitive terrestrial atmosphere has been subjected to shock heating followed by a rapid thermal quench." The temperatures in their experiments ranged from 1000 to 3500 degrees K. They found that amino acids were formed. They interpreted this finding by assuming that thermal shocks in an atmospheric entry of cometary meteors and micrometeorites and from thunder may have been the principal energy sources for prebiological organic synthesis on the primitive Earth.

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- Carl Sagan produced amino acids from basic chemicals using radiation (1971).

- After sonochemistry experiments, Anbar (1968) suggested that the implosion of bubbles in sea waves (called cavitation) produces shocks of extreme heat and pressure and could form *precursors of life* as well. Ben-Amots and Anbar (2007) calculated the production of precursors of life by the implosion of bubbles in the present ocean and sea waves as approximately a thousand times larger than by lightning or micrometeorites. Consequently, Dharmarathne and Grieser (2016) confirmed this possibility by cavitation experiments. Using sonochemistry and various primordial materials, they formed amino acids. Their successful results drew attention among scientists.

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- Unfortunately, Michael Anbar passed away in 2014 before their confirmation. Stanley Miller, Carl Sagan, and Akiva Bar-Nun are also not among us anymore.
- Kalson et al. (2017) conducted exact computer simulations with higher values than were obtained by Ben-Amots and Anbar (2007), also confirming this possibility. Consequently, Patehebieke et al. (2021) conducted appropriate cavitation experiments using higher sonochemistry power, and formed purine nucleosides, the precursors of RNA, thus further confirming Anbar's (1968) predictions

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- The energy made available by *primordial* ocean tide waves was much higher than assumed in all the

previous research works mentioned above, because the primordial tide waves were then much higher than at the present time.

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- It was found that the Murchison meteorite contains amino acids ([9] (1970), [10] (1971), [11] (1998), [12] (2004), and others). This means that nature knows how to produce amino acids *out of* Earth. The Murchison meteorite is older than Earth, meaning that amino acids might have been in the materials from which the Earth was formed. However, the formation of Earth involved relatively high temperatures that decomposed the original amino acids. Therefore, amino acids were produced later on the surface of Earth after it had cooled sufficiently.

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- How precursors of life became life is still a subject of research. Various necessary stages are studied extensively. However, it is not yet clear what combination of the stage(s), feature(s), and processes is sufficient to make a living creature, or how, when, or where the first living creature was created. This article briefly reviewed the solution to the formation of *precursors of life* on the surface of Earth before life existed.

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Abiogenesis is the science of the origin and formation of life (Coyne, 2009; Wikipedia, 2020), although Carles (1964) mentioned that this word is misleading

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