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Origins of Life - A Biochemical Perspective

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Abstract: ***The origin of life has been speculated for centuries with multiple different theories having shown up. From the theory of special creation to the Oparin-Haldane hypothesis, our understanding of the origin of life has evolved. Biochemistry and its subdisciplines have been a major factor in giving scientific proof to these theories. This article provides an overview of the major theories for how life originated, and the biochemical methods and reactions used to substantiate them.***

Keywords: Biochemistry, Geochemistry, Molecular Biology, Evolutionary Biology, Biology

1. Introduction

1) The origins of the Origin of Life

The discussion on the possible origins of life has been a raging topic amongst scientists and academicians for centuries. Multiple theories have come up over the years trying to prove a single source for the origin of life forms. The theory of special creation, given by Father Suarez talks about how all organisms arose from the acts of a pre-existing being by means of special methods that are not operable in current times (Gish, 1973). However, most scientists believe that this theory should be excluded from all scientific discussions since it does not stand scientific argument.

Another theory that gained importance in the 15th Century was the Theory of Spontaneous Generation. In historic Greek antiquity, the existence of every species of animal the sex history of which was not known was accounted for by spontaneous generation or some kindred notion (McCartney, 1920).Most of this theory accounted for the general observations made by the public and then was accepted by scholars. Historical narratives of the theory's downfall generally give a three-stage account which begins in the seventeenth century with Francesco Redi and ends in the nineteenth with Louis Pasteur (Parke, 2014). He placed samples of organic matter in jars, left some uncovered and sealed others with paper and twine, and reported that by preventing insects from gaining access to the latter jars' contents, no larvae would appear therein. His subjects were primarily flies and their maggots, and he used hundreds of different kinds of plant and animal matter to demonstrate his point, including flowers, grasses, and an impressive array of animal and fish corpses ranging from dog and eel to lion and water buffalo. Redi concludes from these experiments that rotting organic matter does not generate insects; it serves only as a potential nest for the development of eggs into eventual flies (Parke, 2014).

2) The modern view on the Origin of Life

With the rise of Darwinism, multiple different hypotheses arose to explain the origin of life. In the 19th Century, two approaches towards understanding life came up which differ drastically in their assumptions towards the nature of life. One approach assumed that life is an aspiring property of nature, that life is a product of lifeless matter that evolved in the course of the history of the universe. The second assumed that life is a fundamental property of the cosmos and living beings always have existed somewhere in the universe (Kamminga, 1991). The second approach, as it is, did not stand scientific scrutiny, but it gave rise to the panspermia hypothesis.

The 'modern' theory, with the inclusion of the possible development of life first in an extra-terrestrial place followed by subsequent migration to the Earth, had been proposed in 1865 by the German physician Hermann E. Richter (Raulin-Cerceau, 1998). Multiple different hypotheses like this were proposed in the coming years which all suggested that life is eternal, and the sowing of planets is a continuous process hence, life on earth has extra-terrestrial origins. At that time, none of the scientific hypotheses related to the origins of life on Earth was yet born, even if the experiments undertaken by L. Pasteur in 1860 showed that life was not a spontaneous process (Maurel, 1995). The Russian biochemist A. I. Oparin (1894–1980), one of the pioneers of biochemistry in the Soviet Union, was the first in 1924 to propose a well-argued scientific scenario leading to bioorganic molecules on primitive Earth (Oparin A. I., 1965). Oparin did not reject Panspermia, but he agreed with others that such a theory only pushed the question of origins to some other planet (Dick, 1996). Oparin was particularly interested in the basic question of whether there is a fundamental difference between living and dead things, and he felt that to discover the conditions under which the properties of life were conjoined, would be to explain the origin of life (Dick, 1996).

It is impossible at present to detect under natural conditions a primary form of life because the evolution of carbonaceous forms was an irreversible one-way process (Oparin A. I., 1965).However, it is important to understand the prebiotic conditions that were in place for the origin of life. Hydrogen is the most abundant element in the universe and carbon does not require any exceptional processes to be formed. Hence, it can be expected that hydrocarbons might have been abundantly formed in the universe. The formation of hydrogen compounds of carbon at lower temperatures and pressure conditions is also confirmed by data on the chemical composition of comets (Whipple, 1961).

The Oparin-Haldane hypothesis talks about how the primaeval climate supported the origin of life. Monomers like monosaccharides, amino acids and proteins were generated in the primordial ocean due to the climatic conditions. They reasoned that present-day conditions on early earth do not allow for the spontaneous synthesis of organic compounds simply because now the atmosphere is

rich in oxygen which tends to disrupt chemical bonds (Reece, 2014). However, it was assumed that the atmosphere must have been reducing in nature before early photosynthetic organisms released oxygen in the atmosphere (Reece, 2014). The energy for this abiotic synthesis could have come up from lightning or UV radiation (Reece, 2014). A classic experiment conducted by Stanley Miller under the guidance of Professor Harold Urey was seen as the de facto proof for this hypothesis. Ammonia, methane, and hydrogen were mixed in a sealed glass container with boiling water, and the entire mixture was exposed to electrical discharges which was said to imitate an energy source such as lightning (McNichol, 2008). After 1 week of treatment, Miller was able to detect 'building blocks' of life produced in relatively high yield, including simple amino acids such as alanine and glycine (Shapiro, Origins, A Skeptic's Guide to the Creation of Life on Earth , 1986). Adenine synthesis was the final step in confirming this hypothesis (Shapiro, The prebiotic role of adenine: a critical analysis, 1995).

Both Oparin and Haldane believed that the first life forms appeared in the warm, primitive ocean and were heterotrophic (obtaining preformed nutrients from the compounds in existence on early Earth) rather than autotrophic (generating food and nutrients from sunlight or inorganic materials) (Rogers, 2022). Oparin believed that life developed from coacervates, microscopic spontaneously formedspherical aggregates of lipid molecules held together by electrostatic forces and may have been cell precursors (Rogers, 2022).Oparin borrowed the concept of coacervates to describe protocells that may have been present on early Earth (Oparin A. I., 1957). On the other hand, Fox claims that the origin of the cell is a microsphere or protocell. Microspheres are made from the addition of water or salt solution to the appropriate proteinoids. To prepare microspheres, Fox added 10 mL of boiling salt solution to the hot proteinoids and stirred carefully. Then, he boiled the solution for thirty seconds, removed the solution from its vessel, and poured it into a cool vessel. When the solution was cooled, he observed the results under a microscope. One gram of protein polymer yields up to one billion microspheres with about ten billion molecules of proteinoid in each sphere. Fox says that the assembly of microspheres takes about twenty minutes and is more immediate and produces better microspheres if the water (or salt solution) is heated prior to mixing (Fox & Dose, 1977). Microspheres have multiple properties that are like those of cells. The microspheres produced were mostly uniformly spherical and Fox believed that the shape and uniformity mimic that of coccoid bacteria. He also believed that uniformity meant that there was a sophisticated system that kept the microspheres at equilibrium. The microspheres were able to asexually divide via binary fission, could form junctions with other microspheres, and developed a double membrane corresponding to that of a cell (Fox & Dose, 1977).

3) The RNA World Hypothesis

The RNA world hypothesis was first put forth by Walter Gilbert in 1986(Gilbert, 1986). Even though this is just a hypothesis, it has brought forth multiple biogenesis models that have been verified by the means of successful experiments.

The matrix properties of RNA make the self-replication process easier(H., 2008). It might be imagined that all RNA components were available in some prebiotic pool and that these components were assembled into replicating, evolving polynucleotides without any evolved macromolecules. It is fruitful to consider the alternative possibility that RNA was preceded by some other replicating, evolving molecule, just as DNA and proteins were preceded by RNA

All RNA World hypotheses include these three key pointers - at some time in the evolution of life, genetic continuity was assured by the replication of RNA. Watson-Crick base-pairing was the key to replication. Genetically encoded proteins were not involved as catalysts(Joyce, Appendix 3: reactions catalyzed by RNA and DNA enzymes, 1999). In this article, we aim to see how RNA would have been synthesized from its constituent molecules in a world where enzymes did not exist.

a) Abiotic Nucleoside Synthesis

Considering that RNA was the preceding polymer responsible for the propagation of life, we need to consider how it came to be. Since RNA preceded DNA and proteins, the polynucleotides responsible for the formation of RNA need to be synthesized abiotically to synthesise RNA effectively. We are considering the synthesis of oligonucleotides from ß-D-nucleoside 5' -phosphates.

Since nucleoside formation would have had to occur non-enzymatically, the reaction is not easy. There have been multiple different hypotheses that try to explain how these reactions would have occurred. In one instance, small amounts of adenosine (0.01%) were detected when a 10^{-3} M solution of adenine, ribose and phosphate was irradiated with UV light(Ponnamperuma, 1963). In other experiments, a low yield of nucleosides was obtained by heating a mixture of purines (adenine, hypoxanthine, and guanine) with ribose and Mg salts; however, similar experiments using pyrimidines were unsuccessful(Fuller, 1972). Perhaps, the method used might be like what we see in living cells. Nature uses 5- phosphoribosyl-1-pyrophosphate (PRPP), i.e., ribose which is activated prior to the coupling with the base(Zubay G. L., 2000).

b) Abiotic Nucleotide synthesis

The actual building blocks for synthesis of RNA are nucleotides, formed by the esterification reaction between nucleosides and phosphates. For nucleotide synthesis, certain conditions must have been met in the prebiotic times. A readily available source for phosphate and an activation mechanism which permits the phosphate residue to form a phosphate ester ensures efficient nucleotide synthesis (H., 2008). Fluoroapatite, Schreibersite, and Alkyl phosphonic acids could have been possible phosphate sources in primitive times (Havin, 1998).

There is experimental proof of one method of synthesis of phosphorylated nucleosides. This method supports the hypothesis that life began in water. Phosphorylation of ADP to ATP in an aqueous solution with the help of cyanate as the condensation agent in the presence of calcium phosphate showed successful results (Yamagata, 2000). Cyanate might have been present in primitive earth. HCN could have also

been a possible prebiotic ingredient for the nitrogenous bases (Zubay G. &., 2001).

c) Oligonucleotide synthesis

For the synthesis of oligonucleotides, first, the nucleotide must be converted to an activated derivative. The 3' -hydroxyl group of a nucleotide or oligonucleotide molecule must be made to react with the activated phosphate group of the monomer. Nucleoside 5'-polyphosphates are obvious candidates for the activated forms of nucleotides. Although nucleoside 5' -triphosphates are not formed readily, the synthesis of nucleoside 5' -tetraphosphates from nucleotides and inorganic trimetaphosphate provides a reasonably plausible prebiotic route to activated nucleotides (Lohrmann, 1975). Nucleoside 5' -polyphosphates are high-energy phosphate esters but are relatively unreactive in aqueous solutions. This causes issues when it comes to non-enzymatic polymerisation (Robertson M., 2012). Using condensing agents like carbodiimide can help avoid isolating activated intermediates (Moffatt, 1961). However, this might not be entirely applicable in prebiotic chemistry since molecules like cyanamide and cyanoacetylene activate nucleotides in an aqueous solution (Verlander, 1973).

Nucleotides contain three principal nucleophilic groups: the 5'-phosphate, the 2'-hydroxyl, and the 3'-hydroxyl group, in order of decreasing reactivity. The reaction of a nucleotide or oligonucleotide with an activated nucleotide, therefore, normally yields 5',5'-pyrophosphate-, 2',5' -phosphodiester-, and 3',5' -phosphodiester-linked adducts, in order of decreasing abundance (Sulston, 1968). Thus, the condensation of several monomers would likely yield an oligomer containing one pyrophosphate and a preponderance of 2',5' -phosphodiester linkages. There is little chance of producing entirely 3',5' -linked oligomers from activated nucleotides unless a catalyst can be found that increases the proportion of 3',5' -phosphodiester linkages (Robertson M., 2012). A metal ion or simple acid-base catalyst would provide sufficient regiospecificity. Adsorption to a specific surface of a mineral might orient activated nucleotides rigidly and thus catalyse a highly regiospecific reaction.

d) Nonenzymatic Replication of RNA

If a mechanism existed on the primitive Earth for the polymerization of activated nucleotides, it would have generated a complex mixture of product oligonucleotides that differed in both length and sequence (Robertson M., 2012). For the replication of nucleic acid, a template-directed synthesis under the direction of a pre-existing oligonucleotide is employed. Most activated nucleotides do not undergo efficient, regiospecific, template-directed reactions in the presence of an RNA or DNA template. Usually, only a small proportion of template molecules succeed in directing the synthesis of a complete complement, and the complement usually contains a mixture of 2',5' - and 3',5' -phosphodiester linkages.

Hence, it was important to look for a set of nucleotides that can achieve an efficient and highly regiospecific template directed reaction. Working with guanosine 5'-phospho-2-methyl imidazoline (2-MeImpG), it was shown that poly(C) can direct the synthesis of long oligo(G)s in a reaction that is highly efficient and highly regiospecific (Inoue, Substituent control of the poly (C)-directed oligomerization of guanosine 5'-phosphoroimidazolide, 1981). If poly(C) is incubated with an equimolar mixture of the four 2-MeImpNs (N = G, A, C, or U), less than 1% of the product consists of noncomplementary nucleotides (Inoue, Oligomerization of (guanosine 5′-phosphor)-2-methylimidazolide on poly (C): an RNA polymerase model, 1982). Subsequent experiments suggested that this and the related reactions discussed later occur preferentially within the context of double helices that have a structure resembling the A form of RNA (Gelfand, 1999). The reaction with a poly (C, G) template is especially interesting because the products, like the template, are composed entirely of C and G residues. If these products in turn could be used as templates, it might allow the emergence of a self-replicating sequence (Robertson M., 2012). Self-replication, however, is unlikely, mainly because poly (C, G) molecules that do not contain an excess of C residues tend to form stable self-structures that prevent them from acting as templates (Joyce, Non-enzymic template-directed synthesis on RNA random copolymers: poly (C, G) templates, 1986**).** Due to this, any C-rich oligonucleotide will give rise to a self-structure locked G-rich product. Hence, conditions favouring binding of mononucleotides to allow template directed synthesis to occur but suppress the formation of long duplex chains locking out the activated monomer is required (Robertson M., 2012).
Successful templates typically contain an excess of C residues, with A and U residues isolated from each other by at least three C residues. Runs of G residues are copied into runs of C residues, so long as the formation of self-structures by G residues can be avoided (Wu, 1992). Some of the obstacles to self-replication may be attributable to the choice of reagents and reaction conditions, but others seem to be intrinsic to the template-directed condensation of activated mononucleotides (Robertson M., 2012).

Another related non-enzymatic replication scheme involves synthesis by ligation of the short 3',5'-linked oligomers (James, 1999). The possibility of this mechanism to have existed is high considering that there exist analogous ribozyme-catalysed reactions (Bartel, 1993) but it faces two major drawbacks. Obtaining the substrates in the prebiotic era must have been next to impossible. Secondly, maintaining fidelity under any plausible temperature range must be difficult, considering hybridization of the oligomers with even a single base mismatch is a possibility except when the temperatures are close to the melting point.

e) RNA Replicase Formation

The RNA World Hypothesis places an important emphasis on the notion that there existed an RNA molecule that could catalyse its own replication – an RNA-dependent RNA polymerase or a primitive RNA replicase. Such a molecule must act on itself to produce complementary RNA and act on those RNA strands as well to produce additional copies. The efficiency and fidelity of this process must be viable enough to produce those copies.

Hence, the concept of an error threshold, an upper limit to the frequency of copying errors, was first introduced in Eigen's model (Eigen M. , 1971). The model states that the rate of synthesis of new copies of RNA is proportional to its concentration, resulting in autocatalytic growth. For an

advantageous RNA to outgrow its competitors, its net rate of production must exceed the mean rate of production of all the RNAs in the population (Robertson M., 2012). The net rate of production refers to the difference between the rate of formation of error-free copies and the rate of decomposition of existing copies of the RNA. The relative advantage enjoyed by the advantageous individual compared with the rest of the population (often referred to as the "superiority" of the advantageous individual) must exceed the probability of producing an error copy of that advantageous individual(Robertson M., 2012). The proportion of copies of an RNA that are error-free is determined by the fidelity of the component condensation reactions that are required to produce a complete copy. By calculating the error threshold of the maximum possible condensation reactions required to form a self-replicating RNA, a total of 2n – 2 condensation reactions will be required to produce a complete copy (Robertson M., 2012). Without any effective replicators, a primitive self-replicating RNA operating with low fidelity gets a head start by taking advantage of a less stringent error threshold. When self-replication was first established, fidelity must have been poor. Hence, there was a strong selection pressure favouring the improvement of fidelity. As fidelity improves, a larger genome can be maintained. Once the evolving population has achieved a fidelity of about 99%, a genome length of about 100 nucleotides can be maintained, even for modest superiority values(Robertson M., 2012). This would let an RNA-based life be established successfully.

During the initial period, a successful clone would have expanded in the absence of competition. As competition for substrates intensified there would have followed a succession of increasingly more advantageous individuals, each replicating within its error threshold. After a period of intensifying competition, the single most advantageous species would have been replaced by a "quasispecies," that is, a mixture of the most advantageous individual and substantial amounts of closely related individuals that replicate almost as fast and almost as faithfully as the most advantageous one (Eigen M. &., A principle of natural self-organization, 1977). Once this quasispecies arises, the RNA World is off to a strong start with an unlikely chance to lose the ability to maintain genetic information over time. Until the advent of a general-purpose RNA polymerase ribozyme, the system of cross-replicating ligases offers the best platform to study the biochemical properties and evolutionary behaviour of an all-RNA replicative system(Robertson M., 2012).

f) Biotic Nucleotide Synthesis

To maintain the continuous formation of RNA, a continuous supply of nucleotides is of paramount importance. A method for the biotic synthesis of nucleotides is required. RNA can perform the relevant chemistry with substantial catalytic rate enhancement(H., 2008)**.** These sets of RNAs can catalyse reactions performed on other RNAs without getting depleted and hence, were labelled as ribozymes. There were multiple attempts to study RNA-catalysed reactions, but none had precisely the right format for the corresponding reaction in a hypothetical nucleotide biosynthesis pathway in the RNA World(Robertson M., 2012).

4) Eigen's Biogenesis Theory

Manfred Eigen presented this theory assuming that biogenesis went through all the phases of the formation of small molecules in prebiotic environments, the self-organisation of those molecules into macromolecules, the formation of self-reproducing units, the formation of cell structures and biological evolution of multicellularity (H., 2008). Eigen's theory is the complete opposite to what Oparin proposed;however, it can be supported experimentally. Eigen's theory describes the self-organisation of biological macromolecules based on kinetic considerations and mathematical formulations, which are in turn based on the thermodynamics of irreversible systems (H., 2008). The theory banks on the concept of a quasispecies (discussed in section 2.5) and the hypercycle model.

The hypercycle model relies on the presence of such RNA quasispecies that can amalgamate with certain proteins to favour the formation of some other RNA quasi-species. However, there is a possibility that the system may get stuck in equilibrium, causing a replication error. M. Eigen describes this process roughly as follows: let us consider a self-replicating system which is characterized by a quantity of information equal to N bits. The probability that a bit is incorrectly copied is w, and the selection reacts to errors by means of a selection factor S. In other words: an error-free system has a selection advantage S over a system with an error. The survival criterion is then: $N.w < \log S$(H., 2008). If the above condition is fulfilled, the selection advantage of the error-free system is so large that several errors in the total population can be tolerated. If it is not fulfilled, the error catastrophe occurs. On the left-hand side of the equation is the number of bits of information which the system loses if the errors are copied in each new generation. The right-hand side corresponds to the number of bits which are caused by selection (H., 2008). Hence, if more information is lost than can be additionally delivered, the system is threatened. If the above condition is to be fulfilled, the error rate cannot be larger than $\frac{1}{N}$. This condition can hardly be fulfilled by today's organisms, as they have values of N of around 10^8 and of w of around 10^{-8}(Dyson F. J., Origins of life, 1985).

To reduce the amount of error, complex error correction methods would be required which were not available in the prebiotic environment. Hence, these systems would require surviving with error rates of over 1:100 reducing the genome size to around 100 bp (H., 2008). This was proven by an experiment conducted by Saul Spiegelmann in 1967. He studied the bacteriophage Q-ß. He showed that the replicases (RNA-dependent RNA polymerases) induced by two unrelated bacteriophages (MS-2 and Q-ß) have been isolated and shown to require their intact homologous RNA as template (Mills, 1967). They were able to demonstrate that these RNA molecules synthesised could serve as templates for further synthesis and were fully competent to program the synthesis of complete virus particles in protoplasts (Mills, 1967). Finally, when Q-ß-replicase is presented with

either of two genetically distinct Q-ß-RNA molecules, the RNA synthesized is identical to the initiating template (Mills, 1967). This specific response of the same enzyme preparation to the template added proved that the RNA is the instructive agent in the replicative process and hence satisfies the operational definition of a self-duplicating entity (Mills, 1967).However, the RNA products that were formed had a considerably short length and was finally only around 17% of its original length (H., 2008). If a triple codon genetic code system existed in those conditions, from a 100 base pair long RNA molecule, only a 33 amino acid long polypeptide chain can be generated. It is doubtful whether this length would have sufficed for an active replication system (H., 2008). Longer RNA chains would have had so many errors that would deem them to be useless for replication purposes. To prevent that, catalysis would have been required. More complex catalysts would have required more complex matrices, but we do not know how these matrix molecules arose. This dilemma can be overcome by the hypercycle model.

Hypercycles are concepts that can be observed in daily life. As an example, a second order catalysis was explained using RNA transferred from viruses to host cells (Eigen M. &., Stages of emerging life—five principles of early organization, 1982). RNA transfer from the virus to the host cell transfers information from the virus to the cell, which can carry out synthesis of a new virus RNA. This synthesis is supported by the conditions in the host cell, forming an RNA minus strand. Replication of this strand yields an RNA plus strand. The process corresponds to a double feedback loop and involves the enzyme coded by the RNA matrix and the information present in the matrix in the form of a nucleotide sequence. Both factors contribute to the replication of the matrix (H., 2008). Since both protein enzymes and nucleic acids contribute to hypercycles, the latter could only have come into operation at a later stage of the (hypothetical) RNA world. It seems possible that the protein enzymes on the primeval Earth could have been replaced by ribozymes (H., 2008). Eigen formulated more complex hypercycle models. Considering a self-reproducing, catalytic hypercycle of the second order, a polynucleotide chain contained information for not only its own replication but also for the formation of an enzyme. The hypercycle closed only when the cycle catalyses the formation of the original polynucleotide (H., 2008). However, it is unclear as to how the first hypercycle emerged. Along with that, there were other doubts regarding this model that surfaced. There were three possible catastrophes that could be expected from this model – if, due to mutation, an RNA molecule replicates faster, ignoring its catalytic duties, if the cycle short circuits due to a mutated RNA molecule catalysing a reaction much further in the cycle, and if due to variations, an important part of the cycle dies off (Bresch, 1980).

5) Kuhn's Biogenesis Model

Kuhn's model has a different approach to provide an explanation to the evolution of replication. He developed a model which shows how it is possible to proceed in small, clear, calculable steps from one development phase to the next. Starting from certain situations or states of the system, possible conditions for moving to the next steps are estimated (H., 2008). The starting conditions are assessed and depending upon them, the steps further are estimated. Suitable test functions were generated which provided approximate solutions for the wavefunctions to explain the chemical bonding phenomenon better (H., 2008). Kuhn described a model in which he assumed that RNA replication with a certain error rate could have occurred without the participation of enzymes (H., 2008). An important factor in this model are natural phenomena with cyclic behaviour. It can be assumed that the cyclic variations involved reactions in which monomers were linked to form polymers (H., 2008).

His initial model refers to a divergent phase where many molecular species survived with similar probabilities resulting in a diverse population and a convergent phase as a highly selective phase wherein those mutants that best served the new purpose survived. A phase reversal occurs at a turning point which is usually very unlikely to be reached. However, it may become necessary if the population becomes larger (H., 2008).

An extended model was presented in the 1980s which also described the evolution of replication systems as a series of single reaction steps, important preconditions for which are periodic temperature changes and a structured environment (H., 2008). However, a new mechanism for the way in which RNA strands can take upstructures in the form of hairpin strands involving Watson-Crick pairing was proposed (H., 2008). The assumption was that, at a later phase of development, amino acids would attach themselves to the RNA structures, which would reach the approximate length of today's tRNA molecules. The structures could be stabilized, for example, by Ca^{2+} ions in the space between the strands (with their negatively charged phosphate groups) (H., 2008).

Kuhn's model treats the question of the origin of life primarily as a logistical problem, and only secondarily as a physicochemical one. The question then arises as to how the logistical requirements of biogenesis can be dealt with by physicochemical models (Kuhn H. &., 1983).
Computer simulations were able to confirm certain critical phases of this model (Kuhn C. , 2001). Each generation consists of three steps: (1) construction of devices (entities exposed to selection) presently available; (2) selection; and (3) multiplication of the isolated strands (R oligomers) by complementary copying with occasional variation by copying mismatch (Kuhn C. , 2001). With a particular seed given to the random number generator, the computer simulation presents devices entering the scene in order of increasing complexity and with different seeds given to the random number generator for each run, it is shown that evolution frequently became stuck at an early stage because of the emergence of an ambiguous reading frame or at the later stage of a binary code because of an incomplete incorporation of the additional monomers within the 5,000 generations given (Kuhn C. , 2001). There was an enormous selection of regions with different properties and states on the young Earth which acted as stimuli for the increasing complexity of the evolving systems (H., 2008).

Dyson's view on origins of life

The salient feature of Dyson's theory, proposed in 1985, used the term "origins" instead of focusing on just one origin. According to Dyson, there are two logical possibilities for the origin of life. If life had just one origin, then the two properties – replication and metabolism – must have been present at the same time (Dyson F. J., Origins of life, 1985). If life began twice in two different systems, one being capable of metabolism only and one only capable of replication (Dyson F. J., Origins of life, 1985). If life began twice—and that is the central premise in Dyson's thinking—the process must have had its origin in proteins and not in nucleic acids or their precursors (H., 2008). Dyson considers Eigen, Orgel and Kuhn's models to fit into the second condition. Eigen's detailed theory Eigen's detailed theory, according to Dyson, talks about the theory of the origin of replication.

His model focuses on metabolism firstand tries using mathematical models to quantify the processes of development from metabolism to life. However, this poses some difficulty since metabolism as a concept is not well defined. He solves this issue in two stages. He describes molecular populations mathematically in the way physicists calculate classical dynamic systems. Very exact dynamic equations are devised, while the laws of interaction are left very general. This leads to a general theory of molecular systems, which makes it possible to define what is understood by the origin of metabolism (Dyson F. , 1999) (Dyson F. J., Origins of life, 1985). The general theory is now reduced to a "toy model", using the following assumption: there are simple, arbitrary rules for the probability of a molecular interaction. The complex network of biochemical reaction chains is expressed by one single formula (H., 2008).

The model is defined using certain assumptions. One assumption is that first, there were cells, then enzymes and then genes came much later (H., 2008). Another assumption is that cells are sluggish drops with a population of polymeric molecules that do not leave the cell (H., 2008). The reason for success of this model is solely due to it being able to tolerate high error rates and hence it can avoid an error catastrophe by not replicating (H., 2008).

A Geochemical approach towards origin of life

The discovery of hydrothermal vents in the 70s proved useful to biologists to solve the problem of the origin of life. Hydrothermal vents occur along the mid-ocean ridges, where sea floor spreading allows magma to rise from the Earth's mantle and form a new sea floor (H., 2008). At higher pressures and higher temperatures, this superheated water dissolves minerals and precipitates to form chimney like structures. The hot deep-sea vents sustain rich ecosystems; large colonies of clams, 25–30 cm in diameter, live alongside long tube worms (*Vestimentiferan pogonophorans*) and white crabs on the basalt sea floor (H., 2008). The food chain in these remarkable ecosystems is based on bacteria which metabolize sulphides, hydrogen sulphide and CO_2 in the hydrothermal solutions (Macdonald, 1981).The simplest known organisms are thermophilic archaebacteria which supports the assumption that biogenesis may have occurred at thermal sources (H., 2008).

2. Conclusion

Throughout history, the origins of life have been explained by means and methods available to scientists at their time. With time, we started gaining a stronger understanding of biochemical processes occurring in nature and how these processes shaped life. The answer to the question of how life originated is still a mystery, however, as we discover the intricacies of prebiotic processes and discover more evidence (such as biochemical reactions supporting the RNA world hypothesis), we will reach closer and closer to the actual answer.

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