Update to classic chemical evolution critique

The Mystery of Life's Origin: The continuing controversy

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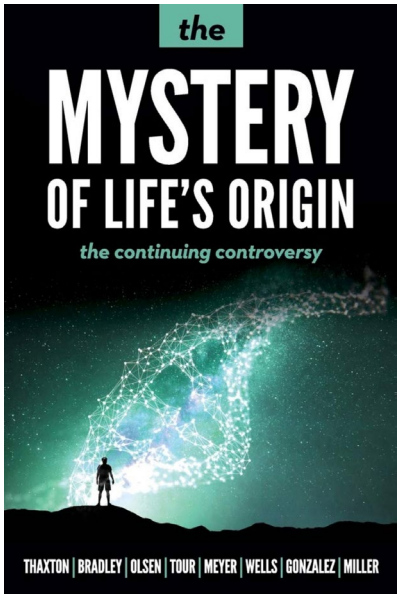
Discovery Institute, Seattle, WA, 2020



Jonathan Sarfati

Chemical evolution ('abiogenesis') is one of many intractable problems with evolution from goo to you via the zoo. How can non-living chemicals produce a living cell? In the 19th century, Joseph Jackson Lister (1786–1869)[1] improved light microscopes so much that biologists could see some of the complexity of a 'simple' cell. Charles Darwin (1809–1882) admitted, "our ignorance is as profound on the origin of life as on the origin of force or matter."[2] By the end of the 19th century, most cell organelles had been discovered.

Still, Darwin's followers were not deterred. They still had faith that undirected chemistry could generate life. In the 1920s, these ideas were cast in a basically modern form by Russian biochemist Alexander Oparin (1894–1980), who proposed that the earth's original atmosphere was reducing, i.e. rich in hydrogen compounds and lacking oxygen. Oparin proposed that simple building blocks of life could form from natural energy sources, and form living cells spontaneously. Independently, British biologist J.B.S. Haldane (1892–1964) proposed that organic molecules could form then accumulate in the oceans, forming what he called a 'hot dilute soup'.

These mostly theoretical ideas were supposedly validated by experiments in the 1950s by Stanley Miller (1930–2007). He was a graduate student of Harold Urey (1893–1981), winner of the 1934 Nobel Prize for Chemistry for discovering deuterium (heavy hydrogen). Together, they constructed a now-famous experiment using Oparin's gas recipe of methane, ammonia, and hydrogen, applying energy, and using a trap to collect products. After a while, the trap was found to contain small amounts of a few simple amino acids.[3]

After Miller died, his student Jeffrey Bada (b. 1942) re-analyzed some of Miller's old samples, including results of experiments that included hydrogen sulfide. Miller had not published on these, but Bada found a few more amino acids.[4]

The same year (1953) that Miller first published his experiment, the structure of DNA was unravelled. This added a new layer of complexity to the cell, already known to be far from simple. That is, DNA was clearly a carrier of digital information that coded for the complexity, which could be transmitted from generation to generation.

Early modern creationist critiques

However, these ideas were hardly unopposed. Informed critics of evolution pointed out huge flaws on both chemical and informational grounds. In the early days of the modern creationist movement, European triple-doctorate chemist/pharmacologist A.E. Wilder-Smith (1915–1995) wrote the influential book, *The Creation of Life: A cybernetic approach to evolution* (1970).

Leading chemical evolutionist Dean Kenyon (b. 1939) was given this book by a student around 1976. Kenyon admitted, "I found myself hard-pressed to come up with a counter-rebuttal."[5] He later became a creationist after studying other creationist works. Dr Wilder-Smith first raised the severe problem (for evolutionists) of the origin of new information. Bill Dembski (b. 1960), one of the leaders of the Intelligent Design Movement, credited Wilder-Smith as "particularly important … . Making rigorous his intuitive ideas about information has been the impetus for much of my research."[6] Wilder-Smith also pointed out the problem of homochirality,[7] a topic of one of his doctorates.

In the USA, Duane Gish gave up a promising career in protein synthesis to work at ICR. Leading chemical evolutionist Sydney Fox admitted that Gish was "co-author of a number of outstanding publications in peptide chemistry."[8] Not surprisingly, Gish over the years wrote devastating critiques of chemical evolution, and frequently debated leaders in that field on university campuses.[9]

The Mystery of Life's Origin

Meanwhile, outside the biblical ('young earth') creationist circles, physical chemist Charles Thaxton

(b. 1939), materials scientist Walter Bradley (p. 1943), and geochemist Roger Olsen wrote a ground-breaking book. *The Mystery of Life's Origin* was first published by Philosophical Library in 1984. Dean Kenyon wrote the foreword.

This book became the 'go-to' book for origin of life critiques, deeply penetrating the chemical weaknesses of chemical evolution, and putting the informational weaknesses on a firm foundation. Although the book is 36 years old at the time of writing, most of the arguments are still cogent. We published a review of the original edition in the last millennium.[10]

Chemical problems

While Haldane's 'primordial soup' has become part of common scientific 'knowledge', there is not the slightest evidence that one ever existed on Earth. Rather, any biological 'building blocks' would have been destroyed by UV, diluted, hydrolyzed, and cross-reacted destructively with each other. E.g. sugars and amino acids could not co-exist in a primordial soup because of reactions between the amino groups ($–NH_2$) of the amino acid and carbonyl groups (>C=O) in the sugars that would destroy both. These are *Maillard reactions,* known to food chemists as a source of flavouring and browning of heated foods. However, they are a serious problem for chemical evolution.

Even the right type of reaction can be in the wrong place, e.g. there are three possible binding spots on adenine and five on ribose, and three possibilities to attach the phosphate group. Of the 90 possibilities, only one is used in life. Vast eons of time are not the friend of chemical evolution, but the enemy. That's because there is more time to reach equilibrium, which is far away from life (chap. 4).

The Oparin–Haldane model required a reducing atmosphere, and this is what the Miller–Urey experiments used (figure 1). However, the geochemical evidence offers no support that such an atmosphere ever existed on Earth. So, the reducing atmosphere has largely been abandoned. There is even quite strong evidence that the earliest atmosphere contained oxygen. This would have been fatal for any primordial soup idea because it would prevent biomolecules from forming. Or if oxygen appeared later, it would destroy any biomolecules that had formed (chap. 5).

Are these simulations truly legitimate evidence for chemical evolution, with no intelligence allowed? They all required intelligent investigators to set them up and run. Some of the investigator input is not objectionable though. For instance, to test the Oparin claim about what would form in a mixture of reducing gases, it is fair to set up an experiment with those gases.

The products would probably end up in the oceans, so maybe it's OK to have a water trap for them. But then, not if the trap is unlike what could occur on the earth. The Miller experiments quickly blew the products away from the energy sources then trapped them safely. But on the primordial earth, the compounds would remain exposed to the energy sources that produced them. But the energy is far better at destroying than making them. Even in the ocean, these molecules would not be safe, because UV penetrates water (you can get sunburned while swimming). So traps are probably above the threshold for legitimacy of investigator interference.

Clearly above the threshold is the usual scenario: find a trace of compound X in a spark discharge experiment, claim 'see, X can be produced under realistic primitive-earth conditions'. Then they obtain pure, homochiral, concentrated X from an industrial synthetic chemicals company, react it to form traces of the more complex compound Y. Then this is touted as proof that Y could have formed in a

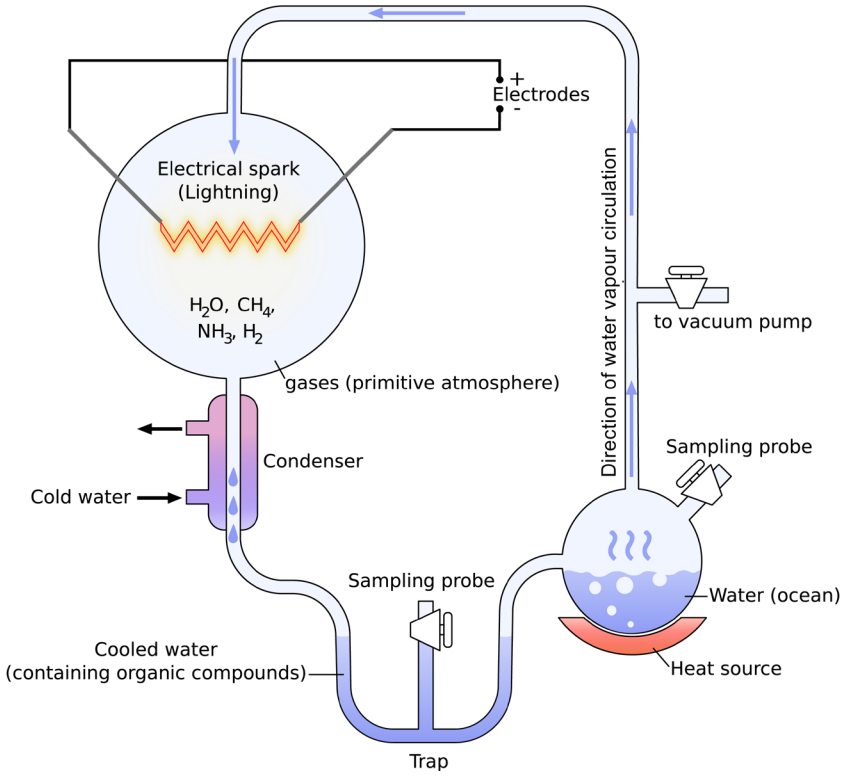


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Figure 1. The famous Miller–Urey experiment. The original used reducing gases that are no longer thought to have been in the earth's atmosphere. The experiment also moves newly formed products out of danger from being destroyed by the spark that formed them.

primordial soup. But in reality it would never have arisen without much intelligent investigator interference. Typically, the process is repeated to form traces of Z from purified Y, and so on.

Informational problems

This book was probably the first to present rigorous thermodynamic and informational arguments (chaps 7–9).[11] Both of these topics have been misunderstood by both evolutionists and creationists.

First, the issue is explaining what is unique about living creatures. The leading evolutionary origin-of-life researcher, Leslie Orgel, who had previously made very important contributions to transition metal complexes, outlined this:

> "Living things are distinguished by their specified complexity. Crystals such as granite fail to qualify as living because they lack complexity; mixtures of random polymers fail to qualify because they lack specificity."[12]

If we compare this to printed material, a random polymer is like a book of random letters, a crystal is like ABCD repeated, and a protein or DNA strand from a living creature is like a play of Shakespeare.

To elaborate, a *crystal* is a repetitive arrangement of atoms, so is *ordered*. Such ordered structures are usually in the configuration that has the lowest energy—so they will form spontaneously at low enough temperatures. And the information for making the crystals is already present in their building blocks (for example, directional forces between atoms). For example, a salt crystal has a very ordered cubic structure, but this is just the same arrangement repeated many times (figure 2). If you crush a large salt crystal into microscopic dust, the dust grains are just tiny crystals with the same arrangement, just repeated fewer times. There is no real difference between the large and small crystals apart from size.

But proteins and DNA, the most important large molecules of life, are not ordered (in the sense of repetitive) but have high *specified complexity*. If a DNA strand were broken, it would lose its information. A large DNA strand is different from lots of smaller ones. The same applies if a protein were broken.

There is nothing in the chemistry of the building blocks of proteins and DNA that would make them join up in predetermined ways, any more than the forces between ink molecules make them join up into letters and words. Michael Polanyi (1891–1976), a former chairman of physical chemistry at the University of Manchester (UK), confirmed this:

> "As the arrangement of a printed page is extraneous to the chemistry of the printed page, so is the base sequence in a DNA molecule extraneous to the chemical forces at work in the DNA molecule. It is this physical indeterminacy of the sequence that produces the improbability of any particular sequence and thereby enables it to have a meaning—a meaning that has a mathematically determinate information content."[13]

The mathematical determination comes from standard statistical thermodynamics:

$$S = k \ln\Omega$$

where S is the entropy of the system, k is Boltzmann's constant, and Ω corresponds to the number of ways the energy and mass in a system may be arranged.

The entropy can be subdivided into thermal entropy, S_{th}, the arrangement of energies, and configurational entropy, S_c, the arrangement of matter. In particular, for living systems, the relevant arrangements are amino acids in protein and nucleotides in DNA.

For random polypeptides and nucleic acid strands, there are astronomically many possible arrangements (Ω_{cr})—more than the number of atoms in the known universe. But there are very few arrangements that constitute meaningful DNA sequences, e.g. that code for functional proteins (Ω_{cm}). Going from random to meaningful polymer is thus a *reduction in configurational entropy.* This can be equated with an increase in *information*:

$$I = S_{cr} - S_{cm} = k \ln\Omega_{cr} - k \ln\Omega_{cm}$$

Tying this to standard classical thermodynamics, for a reaction to be spontaneous, the change in Gibbs free energy must be negative. This is provided by:

$$\Delta G = \Delta H - T\Delta S_{th} - T\Delta S_c$$

(Gibbs free energy) = (Chemical work) – (Thermal entropy work) – (Configurational entropy work)

Forming any sort of polymers is a huge problem, because of the chemical and thermal entropy work that must be done.[14] Attempts to form polymers using certain chemicals and energy flow under plausible prebiotic conditions have ended in failure. To form an informational polymer is much harder still because configurational entropy work is about 35% of the total for proteins, and 8.5% for DNA. And this doesn't include the work of selecting the right chemicals from the gunk produced by Miller-type experiments, in their right isomers, and combining them in the right way (figure 1).

A major problem for chemical evolution is that neither activated chemicals nor energy flow will do the necessary *configurational entropy* work. Compare this to building skyscrapers: a crane can provide the energy needed to lift heavy building blocks to a given height. But no matter how powerful the crane, by itself it will not place them in the right arrangements.

Philosophical

The authors argued that an intelligent designer was a legitimate explanation. This was before there was an official 'Intelligent Design' movement. One important point was the distinction between operational and origins/historical science. This has

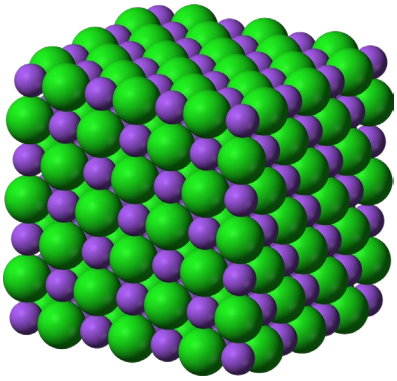

Figure 2. A sodium chloride crystal is just a repetition of the same thing, many times. A DNA strand in a living cell is very complex and non-repetitive.

been an important point that CMI writers and speakers make frequently.

Updated edition

The new edition first essentially reprints the original. The only updates are in the references, with online links to articles provided, because the internet was still in the future when the book was first released. The main updates comprise additional chapters by experts in different fields.

James Tour

Dr James Tour (b. 1959) of Rice University is one of the world's leading synthetic chemists—he made "the first reversible electronic switch out of molecules".[15] He is also vocally critical of chemical evolution papers. Tour points out that they gloss over too many of the needed steps of a real chemical synthesis, which require expensive and sophisticated laboratories.

He points out major hurdles, such as: selecting the compounds to go forward, purification, the right order of chemical reactions, controlling temperature and pH, and mass transfer (how do we get enough of the starting material to produce usable quantities of end product?). For living creatures, homochirality is a big problem that Tour raises, but which was only touched upon in the original book.

Stopping the reaction in the right place is important for chemical evolution. Evolutionists propose that sugars formed by the formose (or Butlerov) reaction that involves formaldehyde and alkali. But the very same alkaline conditions destroy aldose sugars (such as ribose and glucose) via the Cannizzaro reaction (this converts two molecules of aldehyde to an alcohol and an acid). Therefore, isolating the sugars requires an intelligent chemist to stop the reaction at the right time.

Indeed, Tour points out that the processes he supervises produce molecules far simpler than a living cell. So *a fortiori,* if undirected chemistry couldn't produce Tour's compounds, how could they produce life? In general, Tour's chapter is a worthy addition to the book.

Brian Miller

Dr Miller is a physicist. His chapter updates and reinforces the powerful arguments from thermodynamics and information. The fluctuation theorems formulated after the first edition provide no support for chemical evolution. RNA is too unstable for information storage—it is about 100 times less stable than DNA, and DNA is itself unstable over long periods of time. The 2015 Nobel Prize for Chemistry was awarded for this discovery and its implications:

> "In the early 1970s, scientists believed that DNA was an extremely stable molecule, but Tomas Lindahl demonstrated that DNA decays at a rate that ought to have made the development of life on Earth impossible. This insight led him to discover a molecular machinery, base excision repair, which constantly counteracts the collapse of our DNA."[16]

Miller also reinforces the homochirality problem, pointing out that homochiral solutions racemize over time.

Guillermo Gonzalez

Dr Gonzalez is famous for his work showing that the earth is a 'privileged planet'.[17] Here he applies this to the origin of life. There is limited usefulness, because he assumes the long ages and the general evolution of the solar system. But he shows that even given these assumptions, there is an extremely narrow window between the 'late heavy bombardment' and evidence of first life. Far from 'billions and billions' of years, there was at most 200 million years. Even most evolutionists would regard this as too short for chemical evolution.

Gonzalez also addresses the mutually incompatible scenarios required for production of different building blocks. For example, one scenario for producing building blocks of life is alkaline waters from hydrothermal vents. But hot alkaline solutions would destroy sugars and hydrolyze the amino acids serine, threonine, cystine, cysteine, and arginine. Also, hydrothermal vents are incompatible with other chemical evolutionary scenarios that require ultraviolet radiation to produce solvated electrons.

Jonathan Wells

For years, Dr Wells has been refuting 'icons of evolution' that appear in textbooks to indoctrinate students into evolution.[18] The Miller-type experiments are one infamous icon. Wells shows that the original experiment produced nothing that would itself go further. Attempts to salvage the experiment, with a neutral rather than reducing atmosphere, work even less well.

Wells reminds us of the problem of intelligent investigator interference, and he refers to the German organic chemist Clemens Richert:

> "We do our best to perform experiments that we believe re-enact possible steps of prebiotic evolution, but we know that we need to intervene manually to obtain meaningful results. Simply mixing chemicals and watching for a living system to appear from the broth seems unreasonable to me. This approach has never worked, and it is not expected

to work, at least not if one is limited to the lifetime of a human, let alone the duration of a funding period or a Ph.D. thesis. …

So, the periodic addition of a chemical condensing agent may be unavoidable to drive biochemical reactions that are endergonic, even in 'minimal intervention' experiments. Without the chemical activation, equilibrium (death) sets in. So, some level of human intervention may always be required for complex, multistep processes. After all, what the dominant activation agent was before enzymes began to use ATP will remain an enigma to many of us for the foreseeable future."[19]

Stephen Meyer

Dr Meyer is a leading light in the Intelligent Design movement. His chapter elaborates and updates the design and information arguments. Meyer cites the rigorous work by Douglas Axe that refines the informational argument. That is, are there many possible ways to make a functional protein? If there were, that would reduce the information content and thus the necessary reduction of configurational entropy.

For a protein to have enzyme activity, the bare minimum is functional folds. Dr Axe took a working enzyme beta-lactamase, which bacteria possess to destroy beta-lactam antibiotics such as penicillin. He took a functionally significant 150–amino-acid part of this enzyme, replaced side chains with random sequences, and tested them for stable folding. From this, he estimated the number of functional sequences compared with the number of possible sequences of 150 amino acids. He concluded:

"… the overall prevalence of sequences performing a specific function by any domain-sized fold may be as low as 1 in 10^{77}, adding to the body of evidence that functional folds require highly extraordinary sequences."[20]

Meyer critiques the popular RNA hypothesis, which was not so popular when the book was first published. He shows that even the building blocks are implausible, requiring extensive intelligent investigator interference. And the 'building blocks' don't *build* anything—they don't normally polymerize to any sequence, let alone functional ones. The self-copying ability is extremely limited to only about a tenth of its length.

Some claims of RNA copying itself have nothing to do with joining single building blocks on a template, as living things do. Rather, a single RNA strand catalyzed the formation of a single bond between two matching halves with predesigned complementary RNA sequences.

There is much talk of 'ribozymes', i.e. 'RNA enzymes' with catalytic activity. But while ribozymes can catalyze a limited number of energetically favourable reactions, they can't couple energetically favourable and unfavourable reactions as protein enzymes can.

Meyer rounds out the book by showing that the design hypothesis is good science, so we don't need the dogma of methodological naturalism to explain origins. It is *not* an argument from ignorance, or 'god of the gaps'. Rather, it is an *argument to the best explanation* based on what we *do* know about chemistry and information theory.

Conclusion

The book *The Mystery of Life's Origin* was a classic for its time, recommended for anyone with an interest in refuting chemical evolution. This updated edition with several new chapters is worthwhile for the current generation.

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