

## *Darwinism and the Origin of Life*

### **Seven Pines Symposium on the Origin of Life**

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Origin-of-life research is still struggling with an enormous number of unsolved problems. **Yet, it is clear that the question will eventually be solved within the general framework of the Darwinian worldview.**

**Darwin's impact on the study of the origin of life was both philosophical and scientific.** Establishing the natural **evolution** of life on Earth suggested also a natural **origin** of life. The mechanism of natural selection - Darwin's major answer to the evolution of biological complex organization - proved essential also in dealing with the **origin** of such organization.

In order to illustrate how the rise of Darwin's evolutionary theory and its elaboration in the 20<sup>th</sup> century, indeed changed entirely our understanding of the origin-of-life problem I will refer to a few relevant historical episodes, unfortunately only very few and

very briefly. I will also not be able to discuss important recent developments in the field demonstrating Darwinism's more current impact, a subject that will probably be explored by other speakers.

**Curiously, for most of human history, people were not perplexed over the question of the origin of life. The answer was provided by a varying combination of the beliefs in spontaneous generation and in the divine creation of life.** Based on their everyday experience, people did not doubt that many living beings were spontaneously generated repeatedly from various inorganic and organic materials, under the influence of moisture and heat. As to generation from parents, since the rise of monotheistic religions, the general belief was that God originally created the "founding fathers" of the major types of living beings that kept perpetuating their fixed kind generation after generation.

**Accepted as self-evident by both naturalists and laypersons, the belief in spontaneous generation was justified by changing, often contradictory, philosophical and religious assumptions (Farley 1977, Fry 2000).** For example, the Greek atomists in the first centuries BC explained spontaneous generation materialistically. Then, for hundreds of years, it was the religious explanation of Saint Augustine that reigned unchallenged. According to Augustine, God originally implanted the "seed principles" (rationes seminales) of living species in the earth and organic matter and decreed organisms to be produced repeatedly in the future. From the 17<sup>th</sup> century onward, mechanistic explanations of spontaneous generation were raised, for example by Descartes, and by the 18<sup>th</sup> century this belief was already fought by the Church as a dangerous doctrine.

This was the background on which the drama over spontaneous generation between **Louis Pasteur and Felix Pouchet** was played out in France in the 1860s.

Pasteur's decisive experiments showed that no microbes were generated in various organic solutions under strict sterilization. **However, his devout Catholicism led him to interpret his results as evidence that life could come out only from life and not from matter and that on the primordial Earth life was created by God (Geison 1995).**

Rejection of the possibility of the generation of life from matter **in the ancient past** was intertwined in France with the rejection of Darwin's theory of evolution. **The connection between the issues of spontaneous generation and evolution goes back to the beginning of the 19<sup>th</sup> century when Jean-Baptiste Lamarck** published his theory of the transformation of species. As part of his theory, Lamarck assumed repeated events of spontaneous generation of the simplest life forms through a materialistic process.

Unlike Darwin's later hypothesis of a single origin of the evolutionary tree, Lamarck believed that these

repeatedly formed primordial systems evolved along several evolutionary scales into all the complex forms of life known to us (Lamarck 1984 [1809]). Lamarck's materialistic ideas were attacked not only in France but also in England during the first half of the 19<sup>th</sup> century, famously by [Charles Lyell](#), who later became Darwin's close friend (Desmond and Moore 1991).

**What about Darwin's own ideas on the origin of life (Pereto et al 2009, Strick 2009)?** [mention paper by [Julie Pereto, Antonio Lazcano and Jeffrey Bada](#), OLEB 2009] It is well known that Darwin's *Origin* book hardly touches upon the origin of what Darwin called the "primordial form" (Darwin 1859, 484) at the root of the tree of life. Moreover, at the end of the 2<sup>nd</sup> edition of his book, Darwin referred to the Creator breathing life powers into the primordial forms (Darwin 1860, 484). However, in a letter to his friend [Joseph Hooker](#), Darwin later regretted his **“trucking to public opinion”** and using this biblical expression (Darwin 1863). Darwin's famous hypothesis, included as well in

a letter to Hooker, on the development from "**all sort of ammonia and phosphoric salts**" of "**a protein compound ready to undergo still more complex changes**" on the ancient Earth in a "**warm little pond**" is also well known (Darwin 1887, 3:168-169).

**It is important to point out that Darwin's reluctance to discuss the origin of life in the *Origin* can be attributed to his caution on sensitive religious issues.**

It is noteworthy that already in one of his private notebooks from 1838, where he discussed his materialistic ideas about evolution and his awareness of their danger, Darwin wrote: "**In my speculation must not go back to first stock of all animals.**" [Darwin wrote this comment after he had the famous conversation with his father about Emma's religiosity.] Obviously, at this stage and on this issue, Darwin chose silence as a safe strategy (Kohn 1989, p. 225, p. 224).

**Toward the end of the 19<sup>th</sup> century, Darwin's supporters were convinced that a natural emergence of life was a necessary requirement of a general**

**evolutionary worldview.** Unlike Darwin's awareness of the complexity of the problem and its intractability to contemporary science, many Darwinians ([Ernst Haeckel](#), [T. H. Huxley](#)) suggested a simple passage between non-life to life, emphasizing the similarities between physical and biological systems (Haeckel 1902[1899]). This position was losing ground at the turn of the century: Based on new [cytological studies](#), [on the advance of biochemistry and genetics](#) and the [realization of the extreme complexity even of the simplest cells](#), many researchers **despaired of solving the problem of the origin of life and preferred "to let the riddle rest"** (Henderson, 1970[1913]). Several scientists, mainly physicists, raised the hypothesis of the eternal existence of life in the universe, side by side with matter, and its [delivery to Earth on comets, meteorites, or on cosmic dust particles](#). By assuming that life and matter were separate entities these so called [panspermia](#) [Latin; seeds of life everywhere] theories,

tried to explain away the question of the origin of life (Kamminga 1982).

This **impasse and confusion** was challenged by the Russian biochemist **Alexander Oparin** who in a booklet published in 1924 in the Soviet Union offered a detailed scenario for the emergence of life and specified a set of conditions on the ancient Earth that could have enabled such a scenario (Oparin 1967 [1924]). Elements common to Oparin's scenario and to an independent theory published by the British biochemist and geneticist **J. B. S. Haldane** in 1929 (Haldane 1967 [1929]) became later known as **the Oparin-Haldane Hypothesis**. These breakthrough ideas were based on developments in **geochemistry and astronomy**. Furthermore, **Oparin was especially inspired by the progress in the study of metabolizing enzymes and in the field of colloidal chemistry**, and Haldane by the new science of **genetics and the discovery of viruses**.



Most important, **the philosophical significance of the Hypothesis was its insistence on the evolutionary nature of the origin-of-life process.** Oparin and Haldane emphasized both **continuity and novelty.** They referred to the continuous, gradual development from the component of the primordial atmosphere, via organic chemical building blocks to primitive organized systems. They also called attention to the new, unique features of these systems. This philosophical message was embodied in their empirical scenarios. Oparin envisaged **intermediate links in the form of metabolic colloidal systems made of protoenzymes** and Haldane spoke **of virus-like self-reproducing organic polymers.** They contemplated how these intermediate structures could have undergone evolution through a primitive process of **natural selection** (Fry 2006).

The Oparin-Haldane hypothesis and particularly Oparin's ideas triggered in the 1950s the establishment of an experimental field of research on the emergence of life on Earth. Oparin's metabolic and Haldane's

genetic theories became the two leading [research traditions in the field](#) (Fry 2000). As I said earlier, I will not be able to dwell here on the strong ongoing impact of Darwinism on the field. I will just say that in my view, a crucial challenge facing researchers today is **whether a gene-like molecule or a primitive metabolic system could have arisen on the ancient Earth by regular physical and chemical means and could have later evolved via natural selection (Fry 2011).**

[In my cursory historical survey I emphasized the role of philosophical assumptions in the observation and study of the origin of life.](#) At the end, I would like to comment very briefly on the question **of the nature of science** from the perspective of **the study of the origin of life**. So far, there is no agreed upon solution to the problem and no complete scientific scenario was experimentally demonstrated. As a consequence, **the origin-of-life question is often regarded even by advocates of science as the "soft underbelly of**

**evolutionary biology"** (Scott 1996). Some scientists and philosophers of biology prefer at the moment **not to make the natural emergence of life "an issue" in debating religious believers** (De Duve 2002; Ruse 2001).

Indeed, it is the aim of scientists to corroborate hypotheses and where possible to gather supporting empirical evidence. **Thus, the presence or absence of empirical validation is a crucial issue. But this methodical distinction of science does not fully describe its unique nature. Natural science today is characterized by the interaction between specific empirical claims within specific theories and a broader evolutionary worldview. I wish to emphasize, first, that both the empirical and the philosophical elements are crucial to science. Second, these two elements are of different epistemological status.** Philosophical conceptions or what I called here worldviews, unlike empirical claims, cannot be refuted or confirmed. However, based to a large extent on the

empirical achievements of the natural sciences during the last few hundred years, the evolutionary naturalistic worldview is by now strongly substantiated (Fry 2009).

**Though the *general, or philosophical question* whether life emerged naturally from chemical compounds cannot in principle be validated in the laboratory it is by now long considered settled by the majority of scientists. You might notice that the philosophical element which I see as an essential part of science can be also described as a “scientific belief”. Yet, because it can and is substantiated by the empirical element of science, this belief differs from a dogmatic belief or faith. [Due to the constraints of time I presented here a very concise version of a most complicated argument. I would be glad to elaborate on this argument during the discussion.]**

*In summary*, it is the philosophical and empirical strength of the Darwinian revolution that underlies the *confidence* shared by researchers that sooner or later the

origin of life on Earth will be scientifically accounted for.

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**A comment for the discussion:**

The belief in spontaneous generation, its common acceptance during most of history and its eventual demise is a good case in point in discussing the nature of science. What are the distinctions between "spontaneous generation" and "the emergence of life on Earth"?

## Spontaneous generation

1. Complete organisms can be generated from inorganic material (abiogenesis) or (only) from organic material (heterogenesis).
2. Generation occurs repeatedly when conditions are favorable.
3. Generation was explained alternatively as a materialistic process (Greek Atomists, 17th century mechanists, e.g. Descartes and Francis Bacon, in the 18<sup>th</sup> century, Epigenesis, e.g., Buffon, Maupertuis; French Materialists during the Enlightenment, e.g., Diderot, La Metrie, Holbach, Lamarck – probably deistic position) or on religious grounds (Fathers of the Church, Saint Augustine in the 4-5<sup>th</sup> centuries, Aquinas in the 13<sup>th</sup> century), Combination of religious and mechanistic conception in the 17<sup>th</sup> century, preformation and pre-existence of the germs)
4. Experiments for and against spontaneous generation interpreted on the basis of philosophical

and religious assumptions, Francesco Redi (preformation), Spalanzani and Needham, Pasteur, Pouchet and Bastian.

### Emergence of life on Earth

1. A gradual process of emergence
2. Most researchers who believe that the emergence process was heterothropic see the synthesis of organic compounds or their delivery to Earth a necessary precondition.
3. Most researchers (see, Darwin, Oparin, Haldane) believe that life emerged once on the primordial Earth, (but see the ideas of Wachtershauser)
4. The emergence of life was a natural process.
- 5.

**Comment for Seven Pines:** If I discuss **Darwin's attitude to the origin of life**, I could add a comment I found in David Kohn's paper on Darwin's Ambiguity 1989, p. 225.

Kohn quotes from Darwin's Notebook D started in July 15 1838, while on a geological trip to Scotland. On his

way back to London, he was visiting Emma Wedgwood's house in Maer toward the end of July and wrote in notebook D: **In my speculation Must not go back to first stock of all animals...**for if so, it will be necessary to show how the first eye is formed. – how one nerve becomes sensitive to light.

And Kohn adds: This is a piece of metaphysical strategic advice. Darwin is saying, do not write about the specific 'origins' of things (note 49: It is an advice Darwin takes to heart. **It has been often observed that for a book called the Origin, there is conspicuous avoidance of some kinds of origins. Here we see that avoidance is ancient and self-conscious.**) Kohn continues: The reason for Darwin's caution is that origins imply creation. To discuss them, Darwin the materialist would have to posit physical mechanisms 'how one nerve becomes sensitive to light'. That would be both speculative and materialistic; hence controversial and revealing.

Kohn comments that during the same days Darwin wrote in Notebook M (on Man, metaphysics, and morals): To avoid stating how far I believe in Materialism, say only that emotions, instincts...

On p. 224, Kohn comments on Darwin's "silence" strategy in the context of his secularization of biology.

### **Another comment on Darwin and the Origin of life:**

John Hedley Brooke, in his paper on The Origin and the question of religion, included in Cambridge Companion to the Origin (2008), writes on p. 264 that at the end of the Origin Darwin uses the term "**was created**" when referring to the progenitor of all creatures. **Only in the 5<sup>th</sup> edition of the book did Darwin change this term into "appeared on the stage"**. Brooke believes that this change either expresses Darwin's agnosticism or his wish to avoid using a misleading language.

[In Darwin's letter to Hooker in 1863 where he regrets the biblical expression, he says that all he meant was that life **appeared** in a wholly unknown process.]