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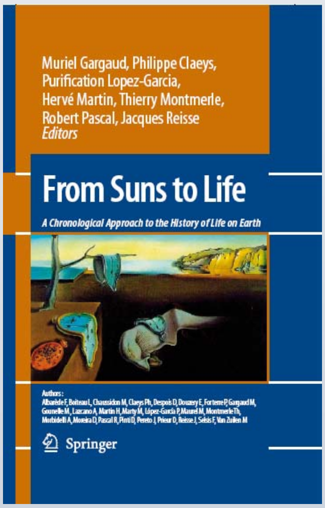
# The Odyssey of life

## Sources

From Suns to Life : a chronological approach to the history of life on Earth ,

Muriel Gargaud, Philippe Claeys, Purification Lopez-Garcia, Hervé Martin, Thierry Montmerle, Robert Pascal, Jacques Reisse

Springer, reprint from *Earth, Moon and Planets Journal*, Vol. 98/1-4, november 2006




The Sun and its procession of planets are relatively simple objects to define. Their formation and evolution follow physical laws which can be modelled and compared with astronomers' observations. Life appears to be something obvious but, thus far, has only been found on our planet. However, no single, thorough definition of life has been unanimously accepted. In spite of knowledge gathered by the many disciplines which now go by the name of 'life sciences', the stages leading from primitive chemistry to metabolism remain unknown.

The origin of life of Earth depended on the first stages in the evolution of the solar system and the chronology of the formation of the Earth, which are now better understood as covering a period of about 100 billion years. Hypotheses about prebiotic chemistry and the emergence of life are more and more precise but have to be set into their environmental context. The most ancient traces of life, according to the authors, go back some 3.8 or 3.4 million years, i.e. about one billion years after the Sun was formed, to a time when the Earth was very different to what it was for the last 800 or 900 million years. In an attempt to synthesise the achievements of astronomy, geology, biology and chemistry, the authors of the publication have gathered all of the knowledge acquired as well as data which remains controversial, in articles published in the *'Earth, Moon and Planets journal'* and quoted again in their book.

Each discipline has its own 'timepieces' which it uses to establish a 'chronology', based on observations combined with physical models or laboratory experiments. Astronomers thus use sophisticated theoretical models based on the law of gravitation and hypotheses about sources of energy to estimate the age and mass of stars on the basis of their surface temperature and apparent brightness. Geologists use the radioactive disintegration of some elements founds in rocks or meteorites as their tool. The accuracy of geological dating depends on the elements found and the sensitivity of analytical methods. Chemical reactions, on the other hand, do not keep any traces of the moment at which they occurred. It is only possible to obtain some chronological indications by considering the degradation of molecules or their epimerization and these are not applicable to investigations of the prebiotic chemistry.

Using these different chronometers, astronomers and geologists are able to describe with increasing accuracy the successive stages during which the Solar system and Earth were formed. The terrestrial atmosphere formed in several steps. Hydrogen, the lightest gas, escaped leaving carbonic gas and water vapour.

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## Notes

**Prebiotic chemistry:**
Chemistry centred around carbon and water which preceded the emergence of life.

**Element :**
Almost all natural heavy elements, i.e. heavier than helium, were form by successive generations of stars in the galaxy. All of those known to us, with a few very rare exceptions, were already in the cloud of dust and molecules from which the Sun and the planets were formed. It is this characteristic which enables us to date very old objects by means of radioactivity and isotopes.

**Epimerization:**
Because of constraints imposed by carbon atoms, some organic bodies may have two different configurations called epimers. Epimerization is the property of a molecule which enables it to spontaneously change its configuration.

**Bar:**
A unit of pressure corresponding to $10^5$ Pascals. Standard atmospheric pressure is about 1 bar.

**Exoplanet:**
A planet revolving around a star other than the Sun. Sometimes also called an extra-solar planet. By the beginning of 2007, 200 exoplanets had been listed .

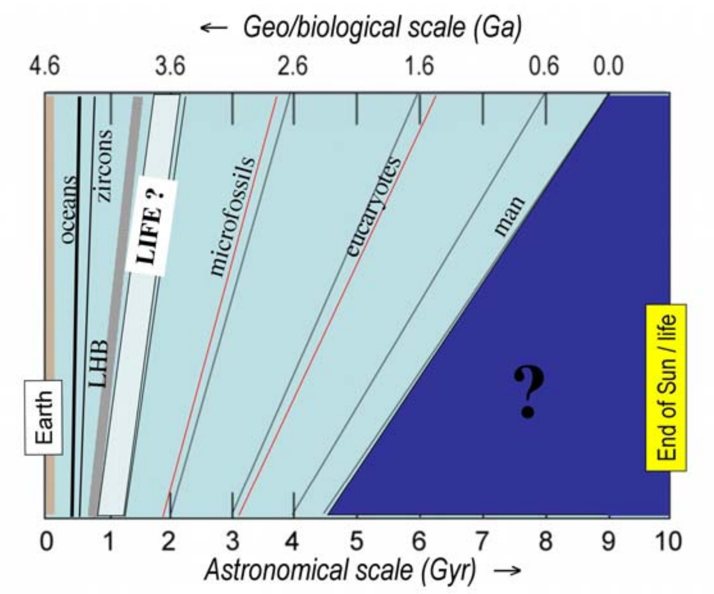


Fig. 1: Astronomy, biology and geology of the solar system use linear scales. Astronomy expresses increasing ages with respect to the date of formation of the solar system, by convention equal to that of the oldest meteorites (unit: Gyr). Geology and biology express ages in a decreasing way with respect to a zero time, by convention, the year 1950 (unit: GA).

1 Giga-year (Gyr) = 1 Giga-annum (GA) = 1 billion years.

The oceans were formed, the carbonic gas was partially dissolved and trapped in the form of carbonates before being recycled by plate tectonics. Pressure and temperature evolved over several hundred millions of years from a few hundred bars to only a few bars[v] and from 200°C to a few tens of degrees. The first oceans probably formed and became inhabitable after about 165 million years.

There are many hypotheses as to the origin of life, which give no information on how long the various stages took or the moment at which life began. The oceans were inhabitable very early on but nothing lived in them. The oldest sedimentary rocks found were formed about 3.865 billion years ago. Microfossil traces have proved that there was microbial life at the time; however, while these have been identified by scientists, they are still controversial. Traces of previous events such as the transition from the first chemical elements to the formation of polymers and then to the emergence of organisms, separated from the surrounding environment by a membrane, were wiped out by plate tectonics. Another approach consists in deducing the characteristics of primitive organisms from our knowledge of existing organisms.

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## Life : *bis repetita placent* ?

This multidisciplinary book ends by summing up the major astronomy, geology and chemical stages which may have led to the beginnings of life on Earth or on other planets in the Solar system. Large ground-based telescopes and the Corot satellite, launched by France on 27 December 2006 are continuing to look for exoplanets. The search for the origins of life will no doubt prove useful when it becomes possible to study the atmosphere of 'inhabitable' exoplanets using next Space generation instruments such as NASA's Terrestrial Planet Finder (TPF) or ESA's Darwin telescope.

The three main categories of life:
Living organisms are classified into three major categories. The **Archeabacteria** and the **Eubacteria** consist of a membrane and a wall separating their interior (cytoplasm) from the exterior. The genetic material, generally represented by a single chromosome, is not isolated from the cytoplasm. The **Eukaryotes** have a true nucleus which isolates the genetic material (the chromosomes) from the cytoplasm. They also have small specialised compartments, also separated from the cytoplasm by a membrane (mitochondrites, chloroplasts, endoplasmic reticula, etc.). These three categories of living matter have the same genetic code and probably came from a population of a single ancestral organism.

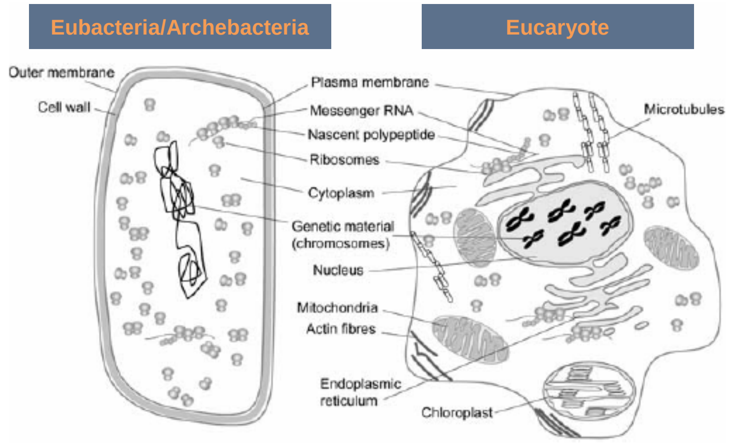


Fig. 2 : Schematic organisation of Eubacteria/Archebacteria and Eucaryotic cells.

## Contact

Muriel Gargaud
Observatoire Aquitain des Sciences de l'Univers
Université Bordeaux1
Bordeaux

gargaud@obs.u-bordeaux1.fr

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