Life

LIFE IS A WONDER of its own. It conceivably struck this planet at least some 3.8 billion years ago,[1] arguably the consequence of a phospholipidic layer-bound *quantum leap* in a soup of organic precursors.[2] From that singular moment on, little has been spared in guise of amazement.

[1] Mojzsis et al., 1996

[2] Miller and Urey, 1959

The first factual evidence of life on Earth appears inscribed in the fossil record some 3.5 billion years ago. It consists mainly of microfossils and ancient rock structures in Greenland and Australia called stromatolites,[3] the product of the metabolism of photosynthesizing cyanobacteria.

[3] Ohtomo et al., 2014; and Noffke et al., 2013

While the fine details of the abiogenic model[4] for the origin of life[5] remain to be chalked, its primed instances are often depicted as self-replicating units able to regulate their own chemical processes within the confinement of a cellular membrane. Such primeval unicellular organisms were most likely composed of some form of nucleic acid secluded from its external environment by a bilayer of phospholipids.

[4] From the Greek "spontaneous generation", this model posits that autocatalytic polymers able to function as simple molecular replicators are at the origin of life. Alternative models exist, most notably panspermia—the extraterrestrial origin of life.

[5] Much debate has been stirred around the definition of life itself, see for instance Benner, 2010.

Nucleic acids, RNA and DNA, are the sole organic molecules fit to direct their own replication and to act as genetic material. RNA was proposed as the original genetic system since it was shown to be able to catalize a variety of chemical reactions, notably the polymerization of nucleotides.[6] However, as the genetic load stored within cells increased, the lesser stability and reliability of RNA molecules rendered them unsuitable for the furtherance of genetic systems, a stage at which DNA eventually took over as universal hereditary material.

[6] Bass and Cech, 1984

These very simple and self-organized systems emerged in seas densely enriched in organic molecules and therefore didn't require sophisticated toolkits for intake of food or generation of energy. Only when systematic interactions between RNA and specific amino acids became enshrined in the genetic code[7] did evolution start to shape concerted molecular reactions between proteins that animated cells with metabolic activity.

[7] The central dogma of molecular biology, postulated by Francis Crick in 1958 and reasserted in 1970 (Crick, 1958, 1970), pertains to the rules that govern the sequential flow of genetic information between DNA, RNA and proteins. It can be summarized as "DNA makes RNA makes protein", which provides the template for the enactment of hereditary information for all living organisms and frames the scope of evolutionary forces on genetic systems.

Among the first tinkered metabolic pathways are likely to have been some simpler form of modern-day glycolysis, the anaerobic breakdown of glucose to lactic acid. Glycolysis is a fixture of all present-day cells and drives the generation of ATP molecules, their universal source of energy. This in turn enabled cellular life to fuel ever more complex metabolic reactions, prime among which was photosynthesis.

Photosynthesis is a metabolic reaction that gathers energy from sunlight to synthesize organic molecules, at the expense of carbon dioxide and water, and generating free oxygen as a by-product. The emergence of photosynthesis in cellular life had two major impacts in the course of evolution. Firstly, it liberated cells from the need to directly access preformed organic molecules to sustain their metabolism; and, secondly, it biologically enriched the content of

Earth's atmosphere in oxygen,[8] which is thought to have been a pre-condition for the thriving of eukariotyc life.

[8] This so called "Great Oxygenation Event", dated to 2.3 billion years ago, was arguably caused by photosynthesizing organisms whose presence was tracked long before it occurred (Flannery and Walter, 2012). The GOE likely had a catalytic effect in the evolution of life also through the oxidation of exposed rocks, liberating phosphorus and iron that flew into the oceans, there acting as fertilizer (Zimmer, 2013).

Up to that stage, all forms of life on Earth could still be modeled from the blueprint of modern Prokaria: a single-celled organism devoid of any membrane-bound organelles, capable of lateral DNA transfer and that usually reproduces itself through binary fission. This phylogenetic taxon accommodates both Archae (e.g., *Thermoplasma*-like organisms) and Eubacteria (e.g., *Spirochaeta*-like organisms), which fundamentally differ at the level of the chemical composition of their cell walls; the lipidic composition of their plasma membranes; and the number of subunits in their RNA polymerases. An hypothetical permanent whole-cell fusion between members of Archaea and Eubacteria has been proposed to be at the origin of the earliest anaerobic Eukarya.[9] A fossil record of highly organized and spatially discrete colonial living structures found in a formation of black shales in Gabon dating from 2.1 billion years ago could well be the oldest fossil evidence of such entities.[10]

[9] Margulis, 1996

[10] Albani et al., 2010

Eukaryotes are defined by the presence of specialized organelles enclosed within membranes, namely the presence of a discrete nucleus wherein all genetic material is confined. The endosymbiotic theory proposes that organelles, such like chloroplasts and mitochondria, evolved from certain types of bacteria that early eukaryotic cells engulfed through endophagocytosis and retained in a mutualistically beneficial relationship. The emergence eukaryotes marks compose a phylogenetic taxa characterized. Origin. Competitive advantage. Evolution of sex.

evolved from the first instances of unicellular organisms. These primeval self-replicating units able to regulate their own chemical processes within the confinement of a cellular membrane might well have of modern-day prokaryotes.

Such primeval cells might well resemble modern day prokaryotes, defined by their lack of membrane-bound organelles, most particularly a nuclear envelop secluding their genetic material. Whether representants of the Eubacteria phyla (defined by) or the Archea phyla (defined by), these first cells (metabolism). Change of atmospheric conditions. Evolution of Eukaryotic cells, definition, timing. Specific acquired features, metabolism, endosymbiotic model. Multicellular life, dramatic consequences for the establishment of genetic programs controlling differentiation and proliferation. Concept of embryogenesis. Cellular interdependence. Concept of totipotency. Concept of natural evolution as an over-reching common thread to interpret and understand the evolution of life. Darwin's quotation. Colonial organisms. Modularity in biology.

endosymbiosis

multicellularity

Life can be considered to have emerged when RNA chains began to express the basic conditions necessary for natural selection to operate as conceived by Darwin: heritability, variation of type, and differential transmission of genetic traits constrained by competition for limited resources.

> There is grandeur in this view of life, with its several powers, having been originally breathed into a few forms or into one; and that, whilst this planet has gone cycling on according to the fixed law of gravity, from so simple a beginning endless forms most beautiful and most wonderful have been, and are being, evolved.

How ironic that one of the best models to understand this order of things is actually one of its most harrowing violations: cancer.

Cancer

Cancer is a dysfunction of

Microarrays

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