Deep-sea hydrothermal vents may have provided the conditions for the origins of life.

ORIGIN OF LIFE

The first spark

David Deamer welcomes a synthesis of what we know about the origins of life, as told by a master in the field.

Franklin Harold's *In Search of Cell History* is a wonderful book. Harold has for 60 years been an intelligent and clear-minded researcher and observer in the fields of cell and molecular biology. His book is a loving distillation of connections within the incredible diversity of life in the biosphere, framing one of biology's most important remaining questions: how did life begin?

This is also a personal account. Here is Harold musing after washing the dishes: "I look upon my work and see that it is good,

and I have no doubt that the same need to find order in the universe motivates much of science." Using this deceptively casual approach, he cleans up the vast untidy mess of biology and stacks the fundamental concepts in an orderly and creative way for readers to enjoy.

The content of each chapter can be found in any good undergraduate biology text, but Harold fits the information into a larger context, often in unexpected ways. For instance, he discusses geochemist Michael Russell's idea that physical processes in hydrothermal vents could produce proton gradients,

in which one side of a barrier membrane is acidic, the other alkaline. The movement of protons across these gradients supplies energy to all life now, and perhaps did so even in the first primitive life. Harold also reveals how much biologists can learn from geologists about the history of life on Earth. For instance, liquid water appeared on Earth more than 4 billion years ago; half a billion years later, the first known microbes (now fossilized in Australian rock) appeared.

I do have a quibble. Harold argues that, notwithstanding the vast literature, progress has gone little beyond the findings of Soviet biochemist Alexander Oparin and British polymath J. B. S. Haldane more than 80 years ago, when they independently argued that Louis Pasteur's dictum 'All life from life' was wrong. Oparin and Haldane theorized that life may have emerged on a sterile prebiotic Earth through a series of chemical and physical processes.

I confess to being more optimistic than Harold. There has been extraordinary progress in understanding the principles by which life works at the molecular level, and that can be applied to the question of how life begins. Over the past eight decades, it has become clear that the basic molecules of life can be synthesized through well-understood chemical reactions. The Strecker synthesis, for instance, produced amino acids from methane, ammonia, hydrogen and water vapour in Stanley Miller's famous 1950s experiment testing the Oparin–Haldane hypothesis. Furthermore, amino acids, nucleobases and lipid-like molecules — the building blocks of life — are present in carbon-containing meteorites. That makes it entirely plausible that similar organic compounds were available on the prebiotic Earth, waiting to be caught up in whatever process led to life's beginning.

There is more. In the 1960s, biophysicist Alec Bangham discovered that phospholipids assemble into cell-sized compartments (liposomes), and chemist Leslie Orgel found that chemically activated nucleotides — the organic molecular subunits of nucleic acids — spontaneously combine, or polymerize,

into short strands of RNA. We now understand how light energy is captured by green plants, that the molecule adenosine triphosphate (ATP) is the energy currency of all life and that enzymes such as polymerases use that energy to catalyse the polymerization of amino acids into proteins, and of nucleotides into nucleic

In Search of Cell History: The Evolution of Life's Building Blocks
FRANKLIN M. HAROLD
University of Chicago Press: 2014.

acids. The molecular foundation of evolution became clear when DNA's structure and function were established by Francis Crick and James Watson in the 1950s and 1960s. Finally, we know how to encapsulate all those reactions in lipid compartments that mimic cell membranes, and several pioneering laboratories are taking the first steps towards fabricating microscopic systems of molecules that display the fundamental properties of life.

Harold writes about these topics, so it seems that we have made considerable progress after all. If we use a jigsaw puzzle as a metaphor, more than 80 years ago we opened the box and found hundreds of loose pieces; today, some of them have been correctly placed around the edges of the puzzle. We still cannot see the picture in the centre, but I am satisfied that we have the framework.

Thousands of young biologists work mostly on the narrowly defined problems that are the crux of successful grantsmanship. Harold's book is like a balloon that will let them rise above the trees for a while and look down to better understand the scope and shape of the forest — and perhaps then descend to pluck some low-hanging

A depiction of an animal cell.

fruit. Senior scientists like myself will take pleasure in comparing perspectives with Harold's. This is, after all, a story to conjure with — that of how life began and evolved into eukaryotic cells, a hundred trillion of which compose the human body. No one can yet tell this story in its entirety, but Harold's book is a good place to start. ■

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Books in brief

Life's Blueprint: The Science and Art of Embryo Creation

Benny Shilo YALE UNIVERSITY PRESS (2014)

The extraordinary 'shape-shifting' of the developing embryo marks embryology as one of the most visually arresting studies in science. Fittingly, evocative images pack geneticist and photographer Benny Shilo's concise tour of the field's evolution over the past 30 years. Shilo juxtaposes scientific photographs with his own stunning shots, chosen to elucidate the findings metaphorically. So a spiral staircase and its shadow against the sunlit side of a building echo the complementarity of DNA structure, while a relief carving in stone illustrates how cells are selectively killed to shape digits.

How We Got to Now: Six Innovations that Made the Modern World

Steven Johnson RIVERHEAD (2014)

In this nimble history of invention, science writer Steven Johnson reframes ubiquity by focusing on six unglamorous innovations that triggered vast social transformation — from water purification to electric lighting. He uses a "long zoom" approach to history, tracing change on scales from the atomic to the planetary, to reveal how the impacts of innovation can be unexpected, for good or ill. From the sanitation engineering that literally raised nineteenth-century Chicago to the 23 men who partially invented the light bulb before Thomas Edison, this is a many-layered delight.

Dr. Mutter's Marvels: A True Tale of Intrigue and Innovation at the Dawn of Modern Medicine

Cristin O'Keefe Aptowicz GOTHAM (2014)

Fused skeletons, grossly enlarged colons and other pathological curiosities crowd the Mutter Museum in Philadelphia, Pennsylvania. But it is the collector — nineteenth-century surgeon Thomas Mutter — who stars in this beautifully detailed biography by writer Cristin O'Keefe Aptowicz. Mutter started out as a foppish medical student in Paris, but ended a hero tending to the injured poor of Chicago. What emerges here is a dual portrait of the driven doctor and a medical field transformed by scientific, if sometimes eccentric, pioneers.

Claxton: Field Notes from a Small Planet

Mark Cocker JONATHAN CAPE (2014)

Naturalist Mark Cocker last astonished us with a global survey of avian and human interaction, *Birds and People* (Jonathan Cape, 2013; see *Nature* 500, 25; 2013). Now he homes in on the local for this lovingly edited assemblage of 140 previously published pieces chronicling a 'year in the (wild) life' of Claxton in East Anglia, UK. Cocker is a quietly eloquent guide to this landscape teeming with species from mouse moth to wych elm — describing, for instance, how wigeons "peel off the water as a continuous blanket that instantly atomises and falls back to earth amid a downpour of contact notes".

Molecules: The Elements and the Architecture of Everything

Theodore Gray BLACK DOG AND LEVENTHAL (2014)

This big, lush chemical romance of a coffee-table book showcases photographs of compounds and materials as if they were Bulgari jewels on black velvet. Theodore Gray, whose 2009 book and app *The Elements* (Black Dog and Leventhal) remains a huge best-seller, here canters through atomic and molecular structure and bonds; organic and inorganic chemicals; and materials. Gray's wit and scientific nous blaze as he unpacks the mechanics of soap, the sulphur compounds in essence of skunk and more. [Barbara Kiser](#)