This dialogue between cancer and evolution scientists marked an inflection point in the field, with far-reaching ramifications for physicians and patients as difficult questions have begun to be re-examined: Does the standard “maximum tolerable dose” of one single therapy, despite initial benefits, cause the disease to make a rapid evolutionary transition that inevitably does more long-term harm to patients as resistance evolves? Does the present treatment paradigm of not following up with secondary or tertiary therapies until after tumors reemerge demand reconsideration to extend more lives? What are the critical biomarkers for screening to identify tumors before they have evolved beyond treatable stages? Does this deeper understanding of these major evolutionary transitions in cancer offer new cell-level targets for treatment? Papers issued from the Cancer & Evolution Symposium will inform academic medical school, funding agency, diagnostic and biopharma company decision makers and society at large. Presenters hope to influence both early cancer management and applications of novel adaptive therapy strategies to significantly extend progression-free survivals. The 2020 Cancer & Evolution Symposium was organized by a committee including: Frank H. Laukien, Ph.D., Chairman and CEO of Bruker Corporation; James A. Shapiro, University of Chicago, Biochemistry and Molecular Biology; Henry H. Heng, Center for Molecular Medicine and Genetics, Wayne State University; Denis Noble, Oxford University Physiology, Anatomy and Genetics; and Perry Marshall, Founder, $10 M Evolution 2.0 Prize.
Among the notable advisors and presenters are:
Veracyte CEO, Bonnie Anderson; Anna Barker, Chief Strategy Officer, USC Institute for Transformative Medicine; Steven Carr, Broad Institute of Harvard and MIT; George Church, Genetics, Harvard and MIT; and Azra Raza, M.D. Columbia University and Author, *The First Cell: And the Human Costs of Pursuing Cancer to the Last*.
A detailed agenda, abstracts and links can be found at [www.cancerevolution.org](http://www.cancerevolution.org). Members of the press should contact Diane Ferrucci (diane.ferrucci@bruker.com) for more information. [Link to YouTube channel](https://www.youtube.com) for videos of the symposium and Q&A sessions. Cancer and Evolution Symposium is a 501(c)(3) non-profit organization administered by Evolution 2.0 (EIN 45-2295313).

To donate, contact us at [evolution@evo2.org](mailto:evolution@evo2.org)

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**Un- and Under-Acknowledged Pioneers**

- Richard Goldschmidt (1878 -1958) Evo-Devo, Macroevolution ≠ Microevolution
- Barbara McClintock (1902-1991), Chromosome restructuring and mobile DNA “controlling elements”
- Conrad Waddington (1905-1975), Epigenetic control of genome function
- Roy J. Britten (1919 -2012), repetitive DNA
- Carl Woese (1928-2012), discovery of Archaea, a third realm of life

All these have minimal or zero recognition in standard Evolutionary Biology textbooks
Uniformly sidelined for working outside The Modern Synthesis

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Familiar names appear in this slide from the James Shapiro & Denis Noble presentation, *The Post-Modern Synthesis Movements in Organismal Evolution* at the Cancer and Evolution Symposium.
[Here in New England the chloroplasts are converting to gerontoplasts and leaves are showing the colors of the preferential degradation of chlorophylls over carotenoids and the synthesis of red-colored pigments like anthocyanins. Autumn colors remind me that my mentor and friend Lynn Margulis, a Distinguished University Professor of Geosciences at the University of Massachusetts Amherst, died Nov. 22, 2011 at her home in Amherst. She was 73.]

Lynn Margulis (1938-2011)
Evolutionist

“Margulis was best known for her theory of symbiogenesis, which challenges central tenets of neo-Darwinism. She argued that inherited variation, significant in evolution, does not come mainly from random mutations. Rather, new tissues, organs, and even new species evolve primarily through the long-lasting intimacy of strangers. The fusion of genomes in symbioses followed by natural selection, she suggests, leads to increasingly complex levels of individuality. Margulis was also acknowledged for her contribution to James E. Lovelock's Gaia concept. Gaia theory posits that the Earth's surface interactions among living beings sediment, air, and water have created a vast self-regulating system.”

What Is Wrong with 68 Million Americans?

Gaian Systems Lynn Margulis, Neocybernetics, and the End of the Anthropocene

From Bruce Clarke: “Here is my Gaia book. Honest to god, my magnum opus. Meeting Lynn Margulis in 2005 was the start of it all. Then for three summers between 2007 and 2009, I was Lynn’s guest at a revived series of Lindisfarne Fellows meetings convened in Santa Fe, New Mexico, by Lindisfarne founder William Irwin Thompson.
In the fall of 2006 Lynn welcomed me to her Environmental Evolution lab for a two-week stay. I followed her entourage from a Gaia theory meeting in Arlington, VA, to her lab in Amherst, MA, to a Bioneers meeting on the Cape at UMass/Dartmouth, to see Lovelock at the Natural History Museum in New York City.

This period coincided with the Whole Earth symposium organized in 2006 by Doug Kahn and Simon Sadler at the University of California at Davis. Here I spoke on “The Flow of Energy through a System’: Getting Started with Systems in the Whole Earth Catalog.” Gaia was one of the system types I was getting started with—Gaia in the Whole Earth phase of the initial popularization of its hypothesis.

Lead-authored by Margulis, “The Atmosphere as Circulatory System of the Biosphere: The Gaia Hypothesis” appeared in a 1975 number of the Catalog’s periodical successor, CoEvolution Quarterly. The Whole Earth network of the 1970s formed the primary nexus of an intellectual gathering I call the systems counterculture. CQ delivered the first fruits of the neocybernetics seeded in the Catalog when Stewart Brand knit together Gregory Bateson with Heinz von Foerster and Francisco Varela. Steps to an Ecology of Mind arrived in 1972, just in front of second-order cybernetics and autopoietic systems theory, just as Gaia was taking discursive shape in the earliest Lovelock and Margulis papers. For me, Margulis and Lovelock were a part of the systems counterculture in light of their participation from afar in this California scene.

And for a long time, this book developed under the title Systems Countercultures. Gaia was to be a major chapter alongside the wider adventures of neocybernetics in and after von Foerster’s Biological Computer Laboratory, his seminal engagement with George Spencer-Brown’s primer for epistemological constructivism, Laws of Form, and his hosting of Varela’s intellectual debut as a whole-systems theorist. Lynn Margulis would come to pronounce Gaia theory in their second-order cybernetic idiom of self-reference and self-maintenance. Its first-order cybernetic description in Lovelock prepared for this autopoietic redescription in Margulis.

Between 2006 and 2019, I published talks, academic journal articles, and book chapters on the neocybernetics of Gaia. In 2011 Margulis gave me leave to take a copy of her Lovelock correspondence, about a linear foot in all. This book is built on those letters, their pairing with Lovelock’s Margulis papers, and a weave of prior essays and papers. Gaian Systems samples and remixes those discussions alongside considerable new writing.

For instance, portions of the introduction and chapter 1 are adapted from the book
chapter “Gaia Is Not an Organism’: The Early Scientific Collaboration of Lynn Margulis and James Lovelock,” an article worked up from a short talk at the Lynn Margulis Memorial meeting in Amherst, MA, in March 2012. Lynn’s fatal stroke in November 2011 was sudden and devastating but not entirely unexpected in her circle. Her personal and scientific passions were relentless.

From what I had a chance to see, Lynn’s mind was always on overdrive. A letter from her to Lovelock records her first diagnosis of hypertension in the early 1990s.

Similarly, portions of chapters 1 and 2 are adapted from “Rethinking Gaia: Stengers, Latour, Margulis,” published in Theory, Culture, and Society in 2017. A steady stream of Gaia writings in the last two decades, especially those by Donna Haraway, Isabelle Stengers, and Bruno Latour, convinced me that the thread of my own Gaia writings could go alongside theirs as a book in its own right. A chance to converse with Latour in Paris that same summer impressed on me the importance of the difference it made to have Margulis rather than Lovelock as my main focus. Lynn’s ecology is radically greener than Jim’s, deeper down into the sediments where bacterial nodules partner to fix nitrogen for plants and ectomycorrhizal symbioses connect forest roots to systems of biochemical transport and transmission. Margulis wrote in Symbiotic Planet, “The tendency of ‘independent’ life is to bind together and reemerge in a new wholeness at a higher, larger level of organization. . . . I suspect that the near future of Homo sapiens as a species requires our reorientation toward the fusions and mergers of the planetmates that have preceded us in the microcosm. . . . Now as throughout Earth’s history, living associations form and dissolve. Symbioses, both stable and ephemeral, prevail. Such evolutionary tales deserve broadcasting” Gaian Systems will have done its work if it assists any level of human behavioral assimilation to the evolutionary and autopoietic Gaian system broadcasting on Radio Margulis.”

Synchrony and symmetry-breaking in active flagellar coordination by Kirsty Y. Wan

Abstract  [Let’s replace “eukaryotic flagellum” with undulipodium.]

“Living creatures exhibit a remarkable diversity of locomotion mechanisms, evolving structures specialized for interacting with their environment. In the vast majority of cases, locomotor behaviours such as flying, crawling and running are orchestrated by nervous systems. Surprisingly, microorganisms can enact analogous movement gaits for swimming using multiple, fast-moving cellular protrusions called cilia and flagella. Here, I demonstrate intermittency, reversible rhythmogenesis and gait mechanosensitivity in algal flagella, to reveal the active nature of locomotor patterning. In addition to maintaining free-swimming gaits, I show that the algal flagellar apparatus functions as a central pattern generator that encodes the beating of each flagellum in a network in a distinguishable manner. The latter provides a novel symmetry-breaking mechanism for cell reorientation. These findings imply that the capacity to generate and coordinate complex locomotor patterns does not require neural circuitry but rather the minimal ingredients are present in simple unicellular organisms.”
Algae use flagella to trot, gallop and move with gaits all their own

(Algae with 2, 4, 8 and 16 flagella are shown with representative swimming gaits. These are characterized by specific phase relationships between the flagella (0 to 2π for a complete beat cycle). (Different species exhibit different gaits and swimming behaviours even for an identical arrangement of flagella.) Animal models with an equivalent number of locomotor appendages are shown for comparison. These are respectively, a human swimmer, a horse, a jellyfish ephyra (juvenile jellyfish) and the predatory sunflower sea star *Pycnopodia helianthoides* which walks with 16–24 limbs.)

With no brain or nervous system, one-celled algae can coordinate their sunbursts of threadlike flagella in graceful gaits.

“Moving diagonally opposite limbs, or flagella in this case, in unison — that’s a trot, Wan says. Her lab, at the University of Exeter …”
We and all animals are freeloaders. The biosphere has lasted well over three billion years. It absolutely does not need us. But we, “mammalian weeds,” as my mother said, cannot live without Earth’s living surface. We depend on the metabolic diversity of bacteria to recycle wastes into food, and on plants to produce food from water, air, and light. Gaia augurs a biological Copernican revolution in how we see ourselves. We are not alone, neither within our bodies nor as parts of ecosystems. ...”

James Shapiro corrects the slide above from MacAllister and Margulis keynote Fractality of Communities “... I would like to avoid the term ‘chaos’ ... Nonetheless I do admire Henry Heng’s 2019 ‘Genome Chaos’.”

Communities as dynamic complex systems
- exquisite sensitivity to initial conditions (cosmic, cyclical-temporal changes)
- feedback and interaction (epigenesis)
- self-similarity at varying scales
- understood holistically in time by performance (emergent properties)
- rugosity (fuzzy, inter-dimensional)
- separated by fuzzy borders (ecotones)
- non-linear (unpredictable in detail)
- may behave in regular, orderly, cyclical ways and display predictable succession until perturbed and then go chaotic (epigenesis) stressed, which perturbs cell division, lifts epigenetic controls on natural genetic engineering functions, and activates genome restructuring.”
Bacteria can survive for years in space
Microbes may be able to spread life via interplanetary travel
BY JONATHAN LAMBERT
“Outer space is not friendly to life. Extreme temperatures, low pressure and radiation can degrade cell membranes, destroy DNA and kill any life-forms that somehow find themselves in the void. But by banding together, some bacteria can withstand that harsh environment, shielded from the extremes of space by the group's outer layers. Microbes huddled at the heart of balls of bacteria as thin as five sheets of paper survived on the exterior of the Inter-national Space Station for three years, scientists report August 26 in Frontiers in Microbiology. Such microbial arks may be able to drift among planets and spread life, a concept known as panspermia. ...”

LYNN MARGULIS REMINDED HER AUDIENCES OF PROPAGULES.
Propagules are produced by plants (in the form of seeds, spores, gemmae, bulbils or turions), fungi (in the form of spores or gemmae), in amoebae (possibly as “chromidia”), in algae, liverworts and mosses (in the form of gemmae), in bacteria (for example endospores, microbial cysts, blebs, L-forms, or round bodies), and even in animals (for example the tun state of tardigrades, statoblasts, or dessication resistant eggs).
When it rains in Iran’s Dasht-e Lut desert, the ground comes alive with tiny, upside-down crustaceans.

By Sabrina Imbler

In springtime, when the rain gathers into pools in Iran’s Dasht-e Lut Desert, the sand comes alive. Tiny, desiccated eggs, buried among the ginger-colored granules, drink in the water and begin to hatch. Some may have been laid in the dunes decades ago. But when rains come, the eggs unfurl into small, feathery crustaceans called fairy shrimp, the freshwater cousins of brine shrimp. For a month or two, the fairy shrimp frolic, swimming upside-down in their ephemeral lakes and laying their eggs before they die or the pool dries up whichever comes first. Fairy shrimps live in brief spurts in seasonal ponds throughout the world, from steppes in Mongolia to woodlands in Long Island. But the Lut Desert, often called the hottest spot in the world, may be the last place one would think to find water, even seasonally. In 2005, NASA’s Aqua satellite recorded a ground temperature of 159.3 degrees Fahrenheit. So the presence of shrimp in the Lut, while striking, was not entirely out of character. ...

Life on Venus: Phosphine in clouds is a sign of possible life, research... 

By Marisa Iati and Joel Achenbach

“An international team of astronomers has detected a rare molecule in the atmosphere of Venus that could be produced by living organisms, according to a study published Monday. The discovery instantly puts the brightest planet in the night sky back into the conversation about where to search for extraterrestrial life. The researchers made clear this is not a direct detection of life on Venus. But the astronomical observations confirmed the highly intriguing presence of the chemical phosphine near the top of the acidic clouds that blanket the planet. Phosphine is a simple molecule produced on Earth by bacteria and through industrial processes. As a result, it is on the list of molecules — oxygen being another — considered by scientists to be potential ‘biosignatures’ of life on Earth sized planets whose atmospheres can be viewed through telescopes. ...”