Writing Gaia: The Scientific Correspondence of James Lovelock and Lynn Margulis

In 1972, James Lovelock and Lynn Margulis began collaborating on the Gaia hypothesis. They suggested that over geological time, life on Earth has had a major role in both producing and regulating its own environment. Gaia is now an ecological and environmental world view underpinning vital scientific and cultural debates over environmental issues. Their ideas have transformed the Earth and life sciences as well as contemporary conceptions of nature. Their correspondence describes these crucial developments from the inside, showing how their partnership proved decisive for the development of the Gaia hypothesis. Clarke and Dutreuil provide historical background and explain the concepts and references introduced throughout the Lovelock–Margulis correspondence, while highlighting the major landmarks of their collaboration within the sequence of almost 300 letters written between 1970 and 2007. This book will be of interest to researchers in ecology, history of science, environmental history and climate change, and literature and science studies.

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"Gaia – a hypothesis, a theory, a research program, a philosophy of nature. For the last half century, the astonishing work of James Lovelock and Lynn Margulis has cast and recast again a concept with implications for the atmosphere, Earth history, ecology, and exobiology. Both of them would have already stood as major figures in modern science; together, they gave us a concept that remains generative across fields. In this vital, remarkable volume of their letters, one can see the origin and development of Gaia, in the complementarity of their interventions, in their mutual support, in their occasional substantive disagreement. Bruce Clarke and Sébastien Dutreuil bring us a volume that will be read for decades across the very wide range of the environmental sciences."

Peter Galison, *Joseph Pellegrino University Professor, Harvard University, USA*

"Indeed, Lovelock and Margulis found that they 'had something to say' together, a question they ask in 1971 in a letter! What they had to say changed my life and the lives of many people. Gaia is a polymorphous concept, hypothesis, theory, material entity, planet, boundary object in conflict, and collaboration among scientists of different disciplines and persuasions, Earth systems' conceptual foundation, natural philosophy, popular passion, and much more. Gaia matters, and Lovelock and Margulis, separately and together, gave us this generative formulation of the living Earth as a complex dynamic, self-organizing system. This collection – with its sober, extensive, enticing scholarly apparatus – makes the hairs of my arms stand up with pleasure and excitement. Here the reader will find unadorned letters between two very different kinds of professional scientist over many years of a complex personal and intellectual relationship. These letters trace something bigger than an idea, something hard to pin down, something truly important. I am deeply grateful to the scholarship and passion of Bruce Clarke and Sébastien Dutreuil for this book."

Donna Haraway, *University of California at Santa Cruz, author of* Staying with the Trouble: Making Kin in the Chthulucene

"*Writing Gaia* offers a fascinating window on the meeting of two great minds. This insightful set of correspondence and commentaries provides an unprecedented resource on the history of the Gaia concept."

Michael R. Dietrich, *University of Pittsburgh, USA*

"*Writing Gaia* is a revealing and surprisingly entertaining record of the long intellectual and personal relationship between two idiosyncratic scientific geniuses and rebels from whose cerebral symbiosis and complex friendship was born the Gaia hypothesis, which profoundly changed how we think about Earth and life. The collected letters of Lovelock and Margulis, along with accompanying essays by some of their key collaborators, have been skillfully assembled with insightful commentary by Clarke and Dutreuil. The result is a riveting intellectual journey, spiced with gossip, intellectual feuds, and occasional moments of touching intimacy. This book will be required reading for students of Earth's biosphere and of modern history of science."

David Grinspoon, *Astrobiologist and author of* Earth in Human Hands

"It is not hyperbole to say that microbiologist and cell biologist Lynn Margulis and atmospheric chemist James Lovelock were two giants of twentieth-century science. Margulis's serial endosymbiosis theory resolved the riddle of the origin of the eukaryotic cell, forever changing biology. Lovelock developed the Gaia hypothesis, a radically synthetic vision of life on Earth, in which Margulis became his chief collaborator. Published here for the first time, their correspondence provides a fascinating window into the lively interaction of two extraordinary minds and personalities, while also showing the evolution of the Gaia idea and its cultural and scientific reception. This is captivating reading, and I could not put it down!"

James Strick, *Professor and Chair of Program in Science, Technology and Society, Franklin and Marshall College, Lancaster, USA*

Writing Gaia: The Scientific Correspondence of James Lovelock and Lynn Margulis

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. . . Infolded with innumerable distinctions,
Life gathers the species to itself,
like kneaded dough punched down
to let out the distending gas
and rise half-baked again.
From cell to plant to animal
To human and now God knows what.
Lynn says a planet of machines,
Jim says another age of ice,
And I believe them both. . .

William Irwin Thompson (1997)

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FOREWORD BY JAMES LOVELOCK

The first time the Earth was named Gaia in a scientific context was about 1967. It happened when my near neighbor, William Golding, and I were walking along the high street of Bowerchalke, a village in southern England. Bill Golding was interested in the search for life on other planets and at that time I was making frequent journeys to the Jet Propulsion Laboratory (JPL) in Southern California. It was here that NASA scientists were designing spacecraft that would travel to the Moon and Mars and seek the presence or absence of life on those planetary bodies. Although he was famous in a literary sense as a Nobel Prize-winning author, Golding had taken physics when an undergraduate at Oxford. He was interested, as a physicist, when I told him that I had recently read the book by Erwin Schrödinger with the title *What is Life?* (Schrödinger 1944). According to this book, life was a process that reduced the entropy of a system while excreting entropy to the environment.

Prior to this, when challenged by a senior engineer, Robert Meghreblian of JPL, to suggest from Schrödinger's definition a practical method for detecting life on Mars, I had suggested that it could be easily done by analyzing the chemical composition of a planet's atmosphere. The presence of entropy reduction would be indicated if the gases in the Mars atmosphere could still react with one another. This is true for the Earth, which has methane and oxygen simultaneously present. In contrast, the Mars atmosphere was soon found to be almost wholly carbon dioxide, that is, in a reduced state of high entropy, and therefore probably lifeless. When Golding and I had reached this point in our walk, he said: "If you intend to put forward an idea like that, you had better give the low-entropy system that is our planet a proper name, and I suggest the name Gaia." This was the name the ancient Greeks gave to the Earth. It is also the root of many Earth sciences, geology, geophysics, geography, and so on. I liked this suggestion that we name the live part of the Earth, Gaia. I found it attractive. Unfortunately, the Earth and life scientists of the universities did not. But I do not think that we should care too deeply about this disagreement; as Newton discovered long ago, speech and writing are not good languages for expressing dynamic concepts.

I first met Lynn Margulis at a meeting at Princeton in 1968, but there was no opportunity to discuss ideas. Sometime later, Lynn invited me to visit her laboratory at Boston University. This was the first time that we had a chance to discuss, in detail, the concept of a self-regulating Earth. It was a friendly and fruitful discussion and for the first time I found a biologist willing to discuss the concept of Gaia. Previously I had found American and English biologists united in their rejection of Gaia. They shared a unanimous opinion that it was an idea contrary to Darwin's theory of evolution. As one of them put it, "It would require an annual meeting of species representatives to choose the plan for next year's environment." At the end of our first meeting in Boston we realized that we shared a common view of the nature of the Earth system, but we had a battle on our hands. In 1974, I was invited to present a paper on the Earth as a self-regulating system. After the meeting, the chairman, the Swedish scientist Bert Bolin, invited me to publish my paper in the journal *Tellus*. This I did, but because we had by now started a collaborative research effort, I included Lynn as a co-author. Since our paper mainly expressed my views, which were amenable to physical scientists, Lynn also published a paper in *Icarus* in 1974 on a biologist's view of the self-regulating Earth.

Lynn Margulis and I had quite different ways of life and views of the world. I saw Lynn as a highly intelligent left-wing woman who had a true empathy with Darwin's science and his instinct about life. Perhaps, because both of us had been raised in tough city areas, Lynn in South Chicago and I in South London, we shared in common an attitude to life that would be foreign to middle-class academics. We were the best of colleagues but often quarreled over differences in opinion about our very different views on what constituted a self-regulating system. I thought that Lynn's statement about Gaia, "She is a tough bitch," says it all.[1] We continued to collaborate and support each other's ideas until Lynn's death in 2011.

Devon, England, June 2020

[1] Margulis 1995 – editors' note.

PREFACE

The English scientist and inventor James Lovelock (1919–) introduced Gaia into the professional literature in a brief letter to the editor of *Atmospheric Environment* with the title "Gaia as seen through the atmosphere" (Lovelock 1972). "Gaia" was the name he gave to a newly recognized entity, constituted at the planetary scale by the sum of living beings and the environments with which they interact. Earlier that same year, Lovelock and the American microbiologist and evolutionary theorist Lynn Margulis (1938–2011) had begun to develop an important series of papers on the Gaia hypothesis. They suggested, contrary to received ideas regarding life's passivity in the face of environmental change, that over geological time, life on Earth has had a major role in both producing and regulating its own environment. Spanning multiple disciplines, the innovative essays produced through their writing collaboration during the 1970s set the course for the gradual progress of Gaia from initial controversy to a broad reception in the Earth and environmental sciences. That collaboration also initiated a steady correspondence, along with a deep professional and personal relationship, that continued for the next four decades.

During that time, Gaia has grown into a theory, refined by Lovelock, Margulis, and a growing international cohort of scientific colleagues. By now, Gaia has inspired major scientific research programs, assisting in the constitution of Earth system science, and strongly affecting related disciplines such as geochemistry, Earth history, ecology, complexity sciences, and astrobiology. Moreover, the idea of Gaia itself has developed into an ecological and environmental world view, a broad philosophy of nature underpinning a number of significant contemporary representations of Earth and life in the scientific, political, and cultural debates over global climate change and broader environmental issues.

The last two decades have seen a strong renewal of interest in Gaia, with scientists opening new debates over the Gaia theory.[2] Scholars in the social sciences and humanities have been presenting challenging new perspectives on Gaia as they confront the emergencies brought on by climate change and

[2] For instance, Doolittle 2014, 2019; Lenton and Watson 2011; Lenton et al. 2018; McDonald-Gibson et al. 2008; Nicholson et al. 2018; Tyrrell 2013; and Williams and Lenton 2008.

the advent of the Anthropocene era.[3] Nevertheless, due to the overall scarcity of historical work on these topics, knowledgeable accounts of Gaia's backstory and, especially, of the scientific and personal relations of Lovelock and Margulis are much in need.[4] Gaining an historical perspective on Gaia is especially imperative in light of Bruno Latour's provocative comparison of the upheavals in scientific thought that Galileo introduced into Western modernity, by developing the Copernican conception of the cosmos, with the paradigm shifts that the concept of Gaia has brought about in our own time.

James Lovelock and Lynn Margulis are two of the most extraordinary scientific individuals of the last century. As a team they were equally formidable. Lovelock quit his professional position as a salaried researcher at the UK's National Institute for Medical Research in 1964 and, after remarkable contributions in analytical chemistry, gas chromatography, cryobiology, cell biochemistry, and other fields, established himself as a scientific entrepreneur, consulting for private corporations such as Shell and Hewlett Packard, and scientific institutions such as NASA's Jet Propulsion Laboratory and the US National Oceanic and Atmospheric Administration. Thanks to one of his inventions, the electron capture detector (ECD), he made the first measurements of the chlorofluorocarbons (CFCs) later determined to be responsible for the depletion of ozone in the stratosphere. Had he not become known for the Gaia hypothesis, Lovelock still would have been recognized in the history of science for the invention of the ECD. Similarly, had Margulis not become famous for her contributions to and support of Gaian science, she still would have been renowned in her own right as a passionate and prescient advocate for the central importance of symbiosis for the biosphere altogether. Her leading role in the renewal and development within evolutionary biology of the theory regarding the endosymbiotic origin of the eukaryotic cell, eventually confirmed by molecular evidence, would still be an exemplary accomplishment. And her strong personality would still be legendary.

[3] See Clarke 2020 and Latour 2017a.

[4] Exceptions in the scholarly literature include Aronowsky 2018, 2021; Bryant 2006; Clarke 2015, 2020; Dutreuil 2016, 2018a; Gribbin and Gribbin 2009; Grinevald 1996; Latour 2014, 2017a; Latour and Lenton 2019; Rispoli 2020; Ruse 2013. Caitlin Kossmann is developing a PhD thesis in the history of science on planetary ecology as understood through the Gaia hypothesis. See also various contributions in Latour and Weibel 2020.

The literature on Gaia contains a lengthy discussion about its status. Is it to be considered a hypothetical entity or a confirmed scientific fact, a conceptual fiction or a mythic reimagining? The scientific community has pursued an equally long debate over what counts as evidence or proof for Gaia. The Lovelock–Margulis correspondence allows one to follow the progress of these authors' internal discussions from the beginnings of Gaia's elaboration and to specify and examine the elements that Lovelock and Margulis counted as most important to the exploration of Gaia. It also reveals how they negotiated these ideas with their own colleagues and how they saw their own progress. However, for Lovelock and for Margulis, Gaia was not only a scientific hypothesis awaiting testing and potential confirmation, but also a world view, a philosophy of nature comprising an ontology, an epistemology, and and a politics. Their correspondence provides crucial insights on these matters, as well as on the dissemination and reception of Gaia beyond scientific spheres, be it in the American counterculture, in English political ecology, or in other environmentalist circles.

The Gaia concept and the research programs to which it has given rise are intrinsically interdisciplinary. Gaia's diverse scientific reception in various disciplines is a case study for how differently a given scientific proposition may be received in different disciplinary contexts. The letters shed light on these issues by showing how Lovelock and Margulis explicitly worked to reframe the discussion of Gaia according to their audience. Given the differences between their own disciplinary backgrounds, at times they even struggled to understand each other. The Lovelock–Margulis correspondence also contains valuable documentation that makes explicit the material and practical dimensions of a scientific collaboration by two researchers living on different continents. Questions to which answers may be found include: how often, and where and when, did Lovelock and Margulis meet? As they worked up their own scientific articles and presentations, what kinds of information, artifacts, and other professional materials did they exchange through their letters?

Gaia is sometimes presented, even by Margulis, as having been elaborated largely by Lovelock himself. Others consider that the developed state of Gaia should be understood as the product of their close collaboration, especially in its first decade. The correspondence provides a range of evidence critical for the determination of this issue. It brings forward decisive elements for understanding their respective roles in the history of Gaia as a scientific idea. It highlights how their individual backgrounds and training, social and cultural commitments, intellectual temperaments, and geographical and

institutional spaces, were complementary for the elaboration, dissemination, and reception of Gaia, but also, occasionally, in conflict. Indeed, their disciplinary and stylistic differences, as well as the divergence between their overarching motivations, also led to disagreements and tensions, and ultimately to a gradual subsiding of their writing collaboration by the 1980s. Still, the correspondence we have been able to recover shows that their conversation and parallel efforts on Gaia's behalf continued and remained vibrant and revelatory until within a few years of Margulis's untimely death in 2011.

The correspondence between James Lovelock and Lynn Margulis tells the story of these developments from the inside. Likely due to Margulis having consistent secretarial support from academic departments, more of Lovelock's letters to her survive than of hers to him. All the same, we have been able to establish a record of their correspondence giving a well-balanced portrait of the beginnings and the progress of their scientific and personal association. The correspondence shows from moment to moment how their partnership proves decisive for the effective development and dissemination of the Gaia hypothesis. Taken singly and together, their ideas have transformed significant parts of the Earth and life sciences as well as contemporary conceptions of nature and the Earth at large.

The international meeting held at the University of Exeter for Lovelock's centenary in 2019 provided one more testimony to the diversity of current scholarly interest in Gaia. Attendees included natural scientists – climatologists, biologists, oceanographers, astrophysicists, astrobiologists, and ecologists – as well as science writers, journalists, historians, literary scholars, sociologists, economists, and philosophers. This volume is addressed most directly to academic workers and their advanced students and other professional observers who have taken up the Gaia debate. We hope that it will also be of interest to historians, philosophers, and sociologists of science and to scholars of literature and science and cultural studies, as well as to adventurous members of the wider public who may have followed several decades of books and articles by Lovelock or Margulis and who are interested in a more detailed knowledge of their scientific lives and contributions.

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Writing Gaia presents a full and annotated collection of the Lovelock and Margulis correspondence. The idea for this volume originated in May 2011, when Bruce Clarke visited Margulis's lab, only to find that she was to be delayed for a few days in returning from a trip to Europe. "That's OK," she emailed back, or words to that effect: "you can use my office in the

meantime, and you're welcome to look at anything in there." Before long, he came across filing cabinets full of professional correspondence and, within one of them, several folders of Lovelock's letters, which he summarily marched to the photocopier. The idea of joining both sides of the correspondence soon presented itself, but Lovelock's papers turned out to be in flux at that moment. However, by 2017 his library and lab had been acquired by the Science Museum, headquartered in South Kensington, London. Around this time, Clarke got word through Bruno Latour about Sébastien Dutreuil's work on Lovelock's archives at the Science Museum for his doctoral thesis on the history of Gaia. That is how our own collaboration began and, in the summer of 2018, we met in London to begin piecing the Lovelock–Margulis correspondence together. Our particular fields of expertise have been complementary for the production of this volume: Bruce Clarke is a senior professor in literature and science and a specialist in the writings of Margulis; Sébastien Dutreuil is a historian and philosopher of the Earth and environmental sciences, specializing in Lovelock's work. We have now assembled a roughly complete record, totaling 286 discrete items dating from 1970 to 2007. This invaluable register of their relationship shows them both in an instructive light, doing the work of doing science together. The texts presented in this volume have been transcribed from copies of the original documents – hand- and type-written letters sent by international post, then faxes, and, eventually, email print-outs. Scholars and other interested readers of this volume will be able to study the final record of a lifelong exchange of correspondence between major researchers who also happened to be two of the greatest scientists of the modern era.

The primary documents transcribed or otherwise cited in *Writing Gaia* are housed in both public and private repositories. We took images of James Lovelock's letters and other scientific papers at the Dana Research Centre and Library at the Science Museum in South Kensington, London, where visitation is available through regular academic arrangements. Lynn Margulis's personal library and correspondence remain in the possession of the Lynn Margulis estate, administered by her daughter, Jennifer Margulis. In May 2011, while Margulis's papers were still housed in her lab at the University of Massachusetts, Amherst, Bruce Clarke made xerox copies from these files – letters and other documents from Lovelock and other correspondents, including the original prospectus for *The Ages of Gaia* (Lovelock 1988), titled "The Colligative Properties of Life: A New Look at Gaia." He checked these holdings against the original documents during a visit to Jennifer Margulis in Ashland, Oregon, in June 2021. Our volume also

incorporates materials drawn from the G. Evelyn Hutchinson Papers, housed at the Manuscripts and Archives collection of the Yale University Library.

We have arranged the letters chronologically and divided them into four parts. Footnoted annotations clarify matters of information that would otherwise remain obscure. When the letters refer to journals and books, we have added italic emphasis. Occasional introductory sections guide the reader toward the major landmarks of Lovelock's and Margulis's collaboration as these arrive within the sequence of the correspondence, while additional commentaries provide information regarding the significance of key individuals and topics of discussion. At the end of the volume, a glossary of names, a glossary of terms, and a bibliography provide further annotations and scholarly references. We have also reproduced a number of the tables and figures they published, mostly from their co-authored papers, especially when we could determine that they matched the content of a particular item of correspondence. Our introduction offers an original discussion of the emergence of Gaia, informed by the extant literature while centered on the letters exchanged in their working relationship, drawing new connections and insights from these previously unpublished materials. It highlights a range of themes that animate their conversations and the history of Gaia as a scientific and philosophical idea.

The record of their correspondence is succeeded by a set of short commentaries on Lovelock and Margulis as individuals and on pertinent aspects of the Lovelock–Margulis collaboration. The contributors to this volume form a select group of colleagues, all of whom have personal connections with one or both of our primary figures. Many have also played significant roles in Gaia's development as a scientific idea. Molecular biologist W. Ford Doolittle was a friend of Margulis who published a widely noted review of Lovelock's first book with the first significant critique of Gaia from the viewpoint of evolutionary biology. Biologist Betsey Dexter Dyer did her doctoral studies under Margulis during Gaia's emergence onto the scientific stage in the 1970s and 1980s, affording her an intimate view of Margulis's academic style. Oxford-trained ecologist Stephan Harding collaborated with Lovelock in the 1990s on the refinement of the Daisyworld model and then established Gaia as a centerpiece of the curriculum at Schumacher College in Devon, England. Bruno Latour is a world-famous philosopher and sociologist whose interest in Gaia, coalescing in the new millennium, has markedly advanced its profile in the humanities and social sciences. In recent years, Latour has also published collaborative articles with Tim Lenton, who did

his doctoral work with Lovelock and Andrew Watson in the 1990s. Lenton is now considered to be the preeminent proponent of Gaia in the contemporary scientific academy.

Contributor Chris Rapley is an Earth scientist and communicator who, while holding a series of distinguished academic and science leadership positions, has been instrumental in bringing Gaian ideas into the discourse of Earth system science. As Director of the London Science Museum, Rapley encouraged and approved a Lovelock exhibition and the establishment of the Lovelock archive. Biologist John F. Stolz also did his doctoral studies with Margulis, participating with her as well as Dyer in the 1980s in Margulis's famous NASA-sponsored summer programs in planetary biology. Earth scientist and biologist Tyler Volk fell in with the science of Gaia while attending the legendary first American Geophysical Union Chapman Conference on the Gaia hypothesis in 1988, leading to several decades of significant academic and general Gaia publications. Marine and atmospheric scientist Andrew Watson sought Lovelock out to direct his dissertation in the 1970s and then joined with his mentor to develop the first computer programs running the Daisyworld model of planetary homeostasis. And finally, an early proponent of Gaia as a new paradigm for the Earth sciences, the Dutch geologist Peter Westbroek worked closely with Lovelock and Margulis, authoring *Life as a Geological Force* (Westbroek 1991) as well as subsequent volumes developing a planetary outlook on human civilization.

Bruce Clarke and Sébastien Dutreuil

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We must also thank the great scholar Bruno Latour for making the two of us aware of the other's interest in Gaia. In 2017, upon learning about Sébastien Dutreuil's outstanding dissertation on James Lovelock, Bruce Clarke initiated an email exchange that led in 2018 to a rendezvous in South Kensington, London, to explore the possibility of bringing Lovelock's and Margulis's letters together in a chronological sequence. Our success in this effort has been aided by the kind assistance in 2011 of Celeste Asikainen and the Lynn Margulis lab at the University of Massachusetts at Amherst and of the curators of the Science Museum in London: Beata Bradford, Katherine Ford, Katie Lissamore, Alexandra Rose, Prabha Shah, Cate Watson, and Nick Wyatt.

A crucial stage in the planning for *Writing Gaia* coincided with the Lovelock centenary meeting held at the University of Exeter in August 2019. At that point we had already assembled the bulk of the Lovelock–Margulis correspondence. Now we met in Exeter to attend the conference on "The Future of Global Systems Thinking," celebrating Lovelock's 100th birthday, and to draft a prospectus for our volume. We had the good fortune to discuss our project there with numerous centenary participants. We showed our work to another Exeter attendee in particular, philosopher of science Rasmus Grønfeldt Winther. We owe Rasmus a great debt of gratitude for his helpful insights and comments and for directing us toward Cambridge University Press as the ideal outlet and Dr. Katrina Halliday as a prospective editor, at that time Cambridge University Press's Executive Publisher for the Life Sciences. Katrina's steady guidance and enthusiasm for the project were crucial in successfully negotiating the complex legal matters involved in getting the press, the estates, and the editors all on the same contractual page. It was a pleasure to work with Katrina, and we greatly appreciate the continued and dedicated support of editorial assistant Aleksandra Serocka and our current editor, Dr. Susan Francis, Executive

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