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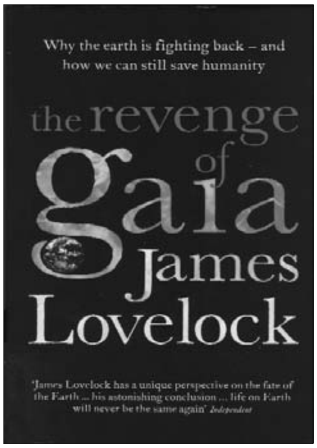

The Revenge of Gaia. Why the Earth is fighting back – and how we can still save humanity

JAMES LOVELOCK

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It is the autumn of 1964. In a NASA office in Pasadena California, scientist-inventor James Lovelock is talking with his colleague, the philosopher Diane Hitchcock, about a newly minted data set that has just arrived on his desk. The data reveal a significant fact: the atmosphere of Mars consists mostly of carbon dioxide and is thus at or near chemical equilibrium. How different, muses Lovelock, to the Earth's far-from-equilibrium atmosphere, in which highly reactive biogenic gasses, such as oxygen and methane, rapidly react together in the presence of sunlight to form carbon dioxide and water. Charged by NASA to develop a life-detection experiment for the agency's mission to the Red Planet, he ponders this contrast, and as he does so a startling idea flashes into his mind like a bolt of lightening—an idea that will propel him into a courageous quest to establish a new way of thinking within science and that will trigger a more meaningful way of relating to the Earth within society as a whole. The idea, stated in its contemporary scientific form, is that the Earth displays a stunning capacity for emergent self-regulation arising out of the tightly coupled feedbacks between the sum total of all the planet's living beings and the atmosphere, rocks and water that they have so intimately interacted with over the course of geological time. Furthermore, the system has a goal: to regulate the surface conditions of the planet within the narrow bounds that living beings can tolerate. Lovelock named his theory of a self-regulating Earth after Gaia, the ancient Greek divinity of the Earth—a move that angered many of his scientific colleagues but which activated a dormant thought within the collective unconscious of our culture: that, far from being a dead 'machine' governed solely by the laws of geology, our Earth is in some sense alive, in no small measure because of the important contributions made by the biological realm to the surface characteristics of our planet.

Since 1972, when he wrote his first scientific paper with Gaia in the title, Lovelock has tirelessly campaigned to have his idea of self-regulation taken seriously within the scientific mainstream. When major journals refused to publish some of his key work, including Daisyworld, his brilliant mathematical exploration of planetary self-regulation, he outlined his ideas in his classic book, *The Ages of Gaia*. By 2001, Lovelock could count on considerable success. In the Amsterdam Declaration, a group of eminent scientists recognized that the Earth is indeed a self-regulating system in which life plays a key role, an idea now enshrined within the latest generation of complex super-computer simulations used in the study of climate change by leading institutes such as the UK's Hadley Centre. 'Gaia theory', however, is still not a respectable name for such an enterprise; scientists prefer the more poetically neutral epithet 'Earth System Science'.

In the *Revenge of Gaia* Lovelock gives us his latest thinking about the state of Gaia and what we must do if we are to live sustainably within her ancient dappled surface. The first chapter makes for chilling reading—through the burning of fossil fuels and the destruction of wild habitats we have waged an unwitting war against Gaia that we cannot possibly win, a war that is poised to demolish our civilization with the lethal weapons of climate change as severe weather events, sea-level rise and intolerable global heating take their toll on our burgeoning and overly consumptive populations. Far from changing gradually and predictably, our climate seems set to plunge over a series of dramatic 'tipping points' beyond which there will be no return to the equable conditions that have made our complex civilization possible.

Sustainable development—the idea that we can have economic growth without destabilizing the climate and the great wild biodiversity on which climate depends—is for Lovelock the ultimate oxymoron, a fallacy so dangerous that he recommends its immediate rejection. Instead, he proposes the notion of 'sustainable retreat'—a withdrawal from our inappropriate role as the major disturber of the Earth's biodiversity and of her great biogeochemical cycles. To do this we must understand Gaia, but this escapes us because of the overly reductionist attitudes of mainstream science, which believes that it is possible to understand the workings of any phenomenon by splitting it apart into its constituent parts. Valuable as this approach is, it makes us blind to the often unexpected emergent properties that characterize whole systems such as Gaia. A holist by nature and a highly intuitive scientist to boot, Lovelock is perhaps better placed than anyone else to understand our impact on Gaia as an emergent whole, and what he sees should deeply trouble all of us. His solution is essentially two-fold: (i) an immediate and massive reduction in our burning of fossil fuels and a rapid adoption, at least in the UK, of nuclear power, and (ii) a widespread abandonment of farming in favour of chemical, synthesized food production.

In the second chapter Lovelock gives us a succinct overview of what Gaia is. She is 'the largest living thing in the solar system', and is '… a physiological system that unconsciously regulates climate and chemistry at a state fit for life.' He makes the following statement, which for me is perhaps the most important message in the book: '*Unless we see the Earth as a planet that behaves as if it were alive, at least to the extent of regulating its climate and chemistry, we will lack the will to change our way of life and to understand that we have made it our greatest enemy*'. In other words, we need to experience ourselves as living not just *on* the Earth, but *in* the Earth as fully interactive members of the great planetary community of air, rocks, water and life. A key idea, he says, for understanding Gaia and our place within her is that all living beings operate within bounds or constraints. Any creatures that push the environment towards the limits of their own tolerance will experience limiting feedbacks from the system as a whole—a rule to which we humans have no exemption.

In Chap. 3, Lovelock gives us a brief history of Gaia, which helps us to better understand exactly what kind of being it is that we live within and that gave us birth. Here the importance of the microbial realm comes to the fore. We explore the prediction from Gaia theory that the Archean atmosphere was dominated by methane produced by methanogenic bacteria in the sediments as they digested the dead bodies of their carbon-fixing photosynthetic cousins sinking down from the sunlit ocean surface. Lovelock points out that microbes have been key players right form the very start—they are Gaia's 'natural proletariat' that keep her healthy, an idea that he has explored for many years with Lynn Margulis, the eminent American microbiologist and a co-developer with Lovelock of the Gaia theory. In this chapter, we encounter the idea that our sun has increased its output of energy by about 25% since the early Archean, and that this has been one of the major forcings to which Gaia has had to adapt over geological time—at first by generating a warming atmosphere full of greenhouse gasses like methane. Now, under an intensely energetic sun, her forests and marine algae seed vast banks of cooling clouds, and she deposits carbon from the atmosphere in the flesh of her photosynthetic beings and in the chalky calcium carbonate structures of her marine creatures. So bright is the modern sun that the high latitudes have been sacrificed to a cooling blanket of reflective ice and snow.

In Chap. 4, we return, in more detail, to the dire climate forecasts for this century. Once again we encounter the notion of abrupt climate change and explore what would happen if (or when) we cross certain irreversible tipping points, including changes to the global oceanic circulation; the collapse of tropical forests; the rapid disappearance in a warming ocean of the climatically vital communities of oceanic algae; the rapid melting of glaciers and the polar ice caps; and the removal of our sulphur emissions, which, by seeding the production of cooling clouds and hazes, counteract the warming effects of our greenhouse gasses. In effect, without major changes to our lifestyles, we are likely to cross these tipping points in the next few decades, after which we will live in a torrid, largely uninhabitable world in which sea-level rise will have decimated the coastal cities where most of us live.

In Chap. 5, Lovelock focuses specifically on sources of energy. He dismisses renewables and hydrogen because, elegant as they are, there is no time to bring them to technological maturity. His controversial proposal is that nuclear power is the stopgap measure that we must adopt if we are to keep the lights of civilization burning through the dark ages to come. He suggests that we must overcome our unfounded fear of nuclear power. It does induce cancers, he says, but to nowhere near the extent we have been lead to believe by the scare-mongering media. His is a severe prognosis. In the maw of the climate holocaust, each nation will have to look after itself, for there will be no international trade, and we will have to learn to live without the comforts of today's highly consumptive lifestyles. National self-sufficiency will become the order of the day. In Chap. 6, Lovelock's laments the fact that the Greens have expended so much effort on persuading us of the evils of pesticides, inorganic fertilizers, and acid rain, whereas, to him at least, if wisely used, each of these supposed miscreants can make a great contribution to a way of life in tune with Gaia. In the next chapter, he focuses on technological solutions for 'sustainable retreat'. Here we learn about 'geoengineering'—the placing of sunlight-reflecting mirrors in space, the artificial seeding of cooling clouds and the extraction of atmospheric carbon dioxide by sequestering it in underground reservoirs or by fixing it by in various chemical and biological forms.

In Chap. 8, Lovelock give us his personal view of environmentalism. For him to think that humans are the masters or even stewards of nature is akin to contemplating the nightmare scenario of trying to consciously control every aspect of our own physiologies. Instead, he urges us to use the science of Gaia for developing our intuitive, instinctive sense of Gaia as a living system, for he points out that we will never be able to fully comprehend Gaia with our conscious minds. We need 'a new sermon on the mount' for living with Gaia, and it must be preached quickly and effectively to everyone who has the capacity to understand it and put it into action. In the last chapter, Lovelock declares his aversion to economic growth, which '… is as addictive to the body politic as is heroin to one of us.' We need to 'make a just peace with Gaia whilst we are strong enough to negotiate and not a defeated, broken rabble on the way to extinction.' This will require us to radically change our lifestyles, and, as in time of war, to accept rationing and constraints imposed from above.

Lovelock's predictions about the impending dangers of climate change are well-researched and represent what is now rapidly becoming mainstream opinion within science, but his solutions have generated huge controversy. Is it true that nuclear power is the only way, for the UK at least, to power itself during the drastic times ahead? What would it do to us psychologically if we no longer lived off the land but from synthesized food instead? Are large-scale, centralized technological solutions really necessary to help us solve the crisis? Have we really focused too much on the scare of cancer and not enough on our cancerous destruction of the living world? Whatever your position on these matters, Lovelock's book has given us all at least one great gift. It is a wake-up call from a giant of science, from a great thinker who was the first to clearly articulate the fact that we exist on a self-regulating, living planet. It is a wake-up call that we ignore at our peril.

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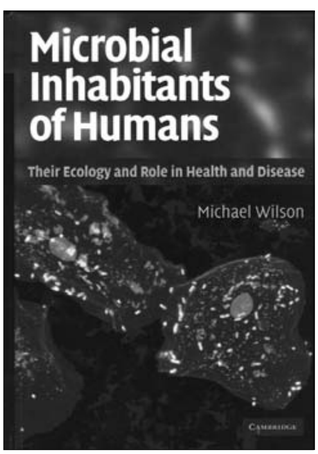

Microbial inhabitants of humans

MICHAEL WILSON

2005. Cambridge Univ. Press, NY, USA
455 pp, 18 × 26 cm
Price: US$ 65.00
ISBN 0-521-84158-5

Everywhere life is found, microbes are present. We are becoming increasingly aware that microorganisms form the basis of the functioning of both the biosphere and the human body. The fame of microbes as agents of disease has tended to overshadow their vital role in nature. For all the threat represented by pathogens, humans and other forms of life have nonetheless learned to coexist with microbes. *Microbial inhabitants of humans* provides a unique insight into the microbial communities inhabiting the human body whose more representative interactions are not pathological but symbiotic.

The firsts 9 months of our existence—the time we spend in the womb—is the only period of our life during which we are free of microbes. The microbial component of the average human being weighs approximately 1.25 kg; in terms of cell numbers, microbes outnumber mammalian cells by a factor of 10 (10^{14} versus 10^{13}). Over 700 taxa can be found at a single site in the body, the oral cavity, and the structures of "human" microbial communities vary tremendously. Normal indigenous microbiota colonize those regions of the human body that are exposed to the external environment, such as the skin, eyes, oral cavity, and the respiratory, urinary, reproductive and gastrointestinal tracts. Despite the fact that we are exposed to a wide variety of microbes, only certain populations are able to permanently inhabit those body sites that are available. In order for an organism to become established as part of a community colonizing a particular site on a human being, the environment of that site must satisfy the organism's nutritional and physicochemical requirements, and the microbe must be able to withstand any adverse features present at the site, including the innate and acquired immune systems, various mechanical removing systems, and the resident microbial community. At present, little is known about the mechanisms that enable the survival and long-term tolerance of indigenous microbial communities or why these microorganisms do not elicit a damaging chronic inflammatory response. *Microbial inhabitants of humans* adopts an ecological approach to try to understand how members of the microbiota manage to colonize, survive, and persist in and on our body.

The book covers the detailed relevant anatomy and local defenses for each colonized site. Also, for each anatomical site (skin, eyes, the respiratory, urinary, reproductive and gastrointestinal tracts, and oral cavity), there is a list of the resident bacteria and a discussion of how these populations are sustained in healthy humans. In addition, each chapter includes a description of diseases that are caused by those microbes that are normal inhabitants. There is also a discussion of advances in medicine and surgery, which have resulted in the increasing use of various devices and immunosuppressive therapies and thus in providing opportunities for many indigenous microbes to cause a variety of infections.

Chapter 2 focuses on *The skin and its indigenous microbiota*. Skin is one of the largest organs of the body in terms of its surface area (ca. 1.75 m^2) and weight (ca. 5 kg). It has a variety of functions, such as protecting underlying tissues from microbes. It is important to point out that the structure of the skin is not uniform over the entire surface of the body. These differences determine specific colonization by several types of microorganisms. In general, the skin is a relatively inhospitable environment for microbial growth because of the dry conditions, low pH, high osmolality, and exposure to the external environment, resulting in fluctuations in temperature, radiation, and mechanical stress. The composition and population density of the skin microbiota vary dramatically between different anatomical sites, and in the case of a particular site, between individuals. A new idea is introduced in this chapter: skin hygiene (skin cleansing) does not prevent disease transmission; rather, it changes the composition of the cutaneous microbiota.

Chapter 3, *The eye and its indigenous microbiota*, discusses the fact that most of the accessory structures of the eye (i.e., eyebrows, eyelids, and eyelashes) are colonized by microbes. The environmental factors and microbiota of these sites are similar to those of the skin. The most highly colonized structure of the eye is the conjunctiva, and the tear fluid is the main source of host-derived nutrients for the resident microbes. The nature of the ocular microbiota of neonates is profoundly affected by their mode of delivery. In neonates delivered vaginally, the first colonizers of the conjunctiva are predominantly members of the genital microbiota of the mother. In contrast, those delivered by caesarean section have sparser conjunctival microbiota and the organisms present are cutaneous species. However, if the genital tract of the mother is colonized by *Chlamydia trachomatis* or *Neisseria gonorrhoeae*, vaginal delivery increases colonization of the neonatal conjunctiva with those pathogens, which can cause blindness. The administration of silver nitrate to the conjunctive of neonates has been effective in preventing these infections since 1881.

As discussed in Chapter 4, *The respiratory system and its indigenous microbiota*, the respiratory tract is predominantly an oxic environment. Nevertheless, obligate anaerobes can be isolated from some regions. Anoxic microhabitats can originate as a result of oxygen utilization by aerobes and facultative species, and the number of such sites can be increased by local anatomical features. The lower respiratory tract (trachea, bronchi, bronchioles, and alveoli) of healthy individuals is not usually colonized by microbes, and the presence of bacteria is the result of aspiration of bacteria-laden secretions from the upper respiratory tract. Although microorganisms colonizing the respiratory tract are disseminated as airborne particles, their ability to survive in the droplets varies depending on the species. *Neisseria meningitidis* does not survive well in air or in the environment, and droplets that have travelled more than 1 m from an infected individual generally do not contain viable organisms. Therefore, bacteria of this species can be transferred to other individuals only by direct contact or between individuals who are in close proximity.

To consider the microbiota of the urinary system, it is convenient to study the male and female urinary system separately, as is done in *The urinary system and its indigenous microbiota* (Chap. 5). The reasons for this approach include the fact that the anatomy of the urinary tract differs significantly between males and females. In males, the terminal portion of the urinary tract (urethra) also constitutes part of the reproductive system, resulting in important functional differences with the urethra of females. The urethral opening in females is closer to the anus than in males and is also close to the vaginal introitus, and these heavily colonized sites provide important additional sources of potential microbial colonizers. Also, unlike the long urethra of males, in which only the distal portion is colonized by microbes, bacteria have been detected along the entire length of the short female urethra. These factors combine to generate significant differences not only in the type of microbes that colonize the urinary system in males and females, but also in the relative susceptibility to infection, both of the urethra and of the bladder.

Since only the terminal region of the male reproductive system (urethra) is colonized by microorganism, Chapter 6, *The reproductive system and its indigenous microbiota*, limits its discussion to the female reproductive system. Differences in vaginal microbiota have been detected between premenarchal, post-menarchal/pre-menopausal, and post-menopausal women, but the environmental determinants responsible for inducing such changes have not been elucidated.

Chapter 7, *The gastrointestinal tract and its indigenous microbiota*, focuses on the main regions of the gastrointestinal tract (GIT): the oral cavity, oropharynx, laryngopharynx (which are also part of the respiratory tract), the esophagus, stomach, small intestine, and large intestine. Each section of the GIT provides a different set of environmental conditions, and each is colonized by distinctive microbiota. The oral cavity has a complex anatomy that leads to a great variety of habitats; in contrast, the other regions of the GIT have a "simpler" structure, one that is basically tubular. The microbiota of the oral cavity is described in Chap. 8. The distal human intestine represents an anoxic bioreactor with an enormous population of bacteria, dominated by relatively few divisions that are highly diverse at the strain level. Only eight of the 55 known bacterial divisions have been identified to date; of these, five are rare. The divisions that dominate are the *Cytophaga-Flavobacterium-Bacteroides* (CFB) and the Firmicutes. Proteobacteria are common but usually not dominant, as it is the case of *Escherichia coli*, a γ-proteobacteria.

Chapter 9, *Role of the indigenous microbiota in maintaining human health*, reminds us that microorganisms protect us against exogenous pathogens. They regulate the development of our immune system and mucosa, provide us with nutrients and vitamins, and detoxify harmful dietary constituents.

Chapter 10, *Manipulation of the indigenous microbiota*, begins with a historical discussion. The use of "harmless" bacteria to combat "dangerous" bacteria dates back to the nineteenth century, when it was realized that some bacterial species were able to produce substances that inhibited or killed other species of bacteria. At the turn of the nineteenth century, Metchnikoff attributed the beneficial effects of fermented dairy products to changes in the microbial balance of the gut. From this observation emerged the concept of probiotics, which can be defined as a live microbial food-supplement that beneficially affects the host. Mainly, lactobacilli, bifidobacteria, and streptococci are used to prevent or treat gastrointestinal infections. However, there is also interest in the use of these microorganisms for the maintenance of vaginal health. Another strategy is the use of prebiotics, which are non-digestible food ingredients that beneficially affect the host by selectively stimulating the growth and/or activity of a limited number of indigenous bacteria. It has been suggested that a combination of probiotics and prebiotics may be beneficial to human health.

A central idea in *Microbial inhabitants of humans* is that microbe–host interactions are mutually beneficial and seldom dangerous. So, do not be afraid of your microbes, and take good care of them!

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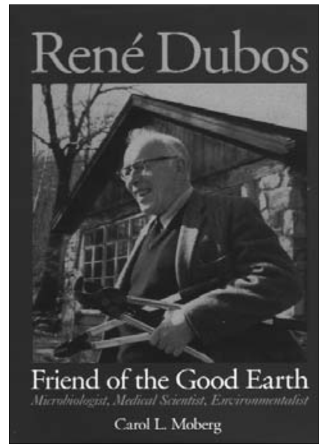

René Dubos, friend of the good Earth: microbiologist, medical scientist, environmentalist

CAROL L. MOBERG

2005. ASM Press, Washington, D.C., USA
292 pp.16 × 23.5 cm
US$ 29.95
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If you asked young microbiologists—let alone students of microbiology—who René Dubos was and what were his major achievements, it is unlikely that you would get an answer. If you asked them—or even lay people—which was the first antibiotic clinically tested and who discovered it, "penicillin" and "Fleming" would surely be the most frequent answers, if not the only ones. If you asked young environmentalists—even those not so young—who coined the worldwide popular motto "think globally, act locally", you would surely get many answers, most of them wrong. The French-born American microbiologist René Dubos was a pioneer in the search for antibiotics; he discovered and isolated gramicidin, the first antibiotic to be clinically tested and released into the market. Regarding the widely known environmentalist slogan, it was also Dubos that originated it. Although "think globally, act locally" first appeared in print as the title of an interview with Dubos in 1978, the idea behind this sentence originated in 1972, when he served as adviser to the United Nations Conference on the Human Environment.

René Dubos, friend of the good Earth is a biography of a scientist who moved from soil microbiology to medical microbiology and then to ecology. However, Dubos was an ecologist from the very beginning. In fact, his research focused consecutively on soil ecology, medical microbial ecology, human ecology, and, eventually, global ecology. He was thus a pioneer in microbial ecology; his ecological approach pervaded his medical microbiology career and led him to isolate the first antibiotic. Carol L. Moberg, a Senior Research Associate at The Rockefeller University, is probably the most qualified person to write Dubos' biography. Although not a scientist, she has worked for years with scientists, focusing on biomedical sciences in the twentieth-century. Moberg completed her doctorate in comparative literature at Columbia University and worked with René Dubos when he wrote his major works on environemtal issues. She became acquainted with his work and got to know him well, even though Moberg states that Dubos always “remained a private person”.

Some of the issues that would cause great concern to humans at the end of the twentieth century, including the danger of antibiotic resistance by bacteria, hidden exposure to toxins, and the emerging of new diseases, had already been addressed by Dubos. He and his second wife were critical of twentieth-century medicine, which delayed health by the use of vaccines, surgery, and drugs instead of searching for other ways of protecting the body against infections. They believed that disease eradication programmes should be based on encouraging lifestyles that make people resistant and on creating social environments that protect populations against disease. Dubos’ critical opinions about those issues remain controversial, and some of them are shared by certain segments of the population, such as parents who reject vaccination of their children.

Gramicidin (literally, killer of gram[-positive] bacteria) and tyrocidine were two crystalline polypeptides that Dubos detected in the antibiotic substance that he isolated from *Bacillus brevis*. The extract containing the antibiotics was named tyrothricin. The name came from *Tyrothrix scaber* (*Tyrothrix* was a genus name formerly given to various bacteria, including *Bacillus brevis*), a bacterium that, at the time, was the subject of research by F. Duran Reynals (1899–1958) and J.J. Bronfenbrenner, two colleagues of Dubos at the Rockefeller Institute for Medical Research (currently The Rockefeller University), where they had moved from the Pasteur Institute in Paris. Duran Reynals had observed the ability of *T. scaber* to produce substances that destroyed intestinal bacteria, and Bronfenbrenner compared the behaviour of *Tyrothrix* to that of bacteriophages. Whereas the phages caused the bacteria on which they preyed to swell and eventually burst, *Tyrothrix* attacked the bacterial cell membrane such that the bacteria shrunk and eventually disintegrated.

Since the beginning of his career in medical microbiology, Dubos focused his research with an ecological approach. When he joined Oswald T. Avery’s team as a postdoctoral fellow, he started studying pneumococcus (*Streptococcus pneumoniae*), the main causal agent of pneumonia. (Before antibiotics to fight pneumococcus were discovered, this bacterium killed more human beings than cancer and heart disease together [5].) Avery was convinced that the pathogenicity of pneumococcus lay in its polysaccharide’s capsule and asked Dubos to find a substance capable of degrading that polysaccharide. Dubos was familiar with the degradation of cellulose in soils, as it has been the subject of his doctoral thesis—under the direction of Selman Waksman—at Rutgers University. He had recognized the role of microorganisms in the recycling of organic matter and was certain that there must be an organism capable of degrading the polysaccharide that surrounded pneumoccus. However, looking for it was like looking for a needle in a haystack. One thing Dubos had learned from Avery from the very beginning was to consider all possibilities before drawing a conclusion and taking any decision. The capsular polysaccharide of pneumococcus did not differ very much from other polysaccharides found in soils, which could be degraded by bacteria [3]. So, it seemed reasonable to think that some bacterium or fungus from soil could degrade pneumococcal polysaccharide. And Dubos found it! The article describing that finding was published in the August 30, 1930 issue of *Science* [1].

Next came the work that led Dubos to the discovery of tyrothricin. Of the two components of this antibiotic substance, tyrocidine turned out to be useless; it reacted with many proteins, could be inhibited by many tissue components, and was toxic to many cells. Although the other component, gramicidin, destroyed red blood cells and damaged the kidney, it was very effective for external use and it is still used in this way, mainly in veterinary medicine. Nevertheless, the triumph of penicillin cast a shadow over Dubos’ discovery. In 1944, two years after the death of his first wife from tuberculosis, he focused his research on several aspects of that disease, especially on the ecological aspects of infection, including environmental factors involved in human resistance or sensitivity to the pathogen. From the ecology of tuberculosis, Dubos moved to study the influence of the environment on other infectious and noninfectious diseases. In 1961, he changed the name of his laboratory from “Bacteriology and Pathology” to “Environmental Medicine”. Rachel Carson acknowledged Dubos’ ecological view of disease and referred to him as “a wise physician” [2].

Throughout the last decades of his life, Dubos remained actively involved in the environmental movement and in trying to find solutions to social problems; he wrote many articles and several books, and spoke at many places. In addition to providing environmentalism with its best slogans, including the above-mentioned “think globally, act locally”, he also provided it with a human perspective. He claimed that the human presence in or influence of almost all ecosystems had made necessary the five e’s of environmental management—ecology, economics, energetics, esthetics and ethics. To reach a decision regarding the suitability of an artificial ecosystem or the use of land for growing crops, those five factors had to be considered and a balance among them reached. For Dubos, the most difficult environmental problems to solve were not related to ecology but to ethics and to the rights and obligations that humans have towards the Earth. Everybody has the same rights, but they can only be exerted to the extent that they do not damage the health of the planet.

René Dubos. Friend of the good Earth is an account of Dubos' life in both the biological, medical, and social context of the twentieth century, a century that witnessed the most dramatic changes in human history. The book is the work of a scholar who clearly spent much time gathering information, consulting archives, and talking to people that knew Dubos—it includes more than fifty pages of notes consisting of references to many sources and comments by the author. The book will interest general readers as well as biologists, physicians, and other scientists familiar with the issues dealt with in the text.

In 1990, a book was published, edited by Gerard Piel (1915–2004) and Osborn Segerberg, that contained a selection of Dubos' essays. At the very beginning, there are a few sentences by Dubos that are, or at least used to be, engraved in an inscription at the entrance to "The Land" pavilion at the Epcot Center in Orlando, Florida: "Symbiotic relationships mean creative partnerships. The earth is to be seen neither as an ecosytem to be preserved unchanged, nor as quarry to be exploited for selfish and short-range economic reasons, but as a garden to be cultivated for the development of its own potentialities of the human adventure. The goal of this relationship is not the maintenance of the status quo, but the emergence of new phenomena and new values." This is a quote from the last paragraph of an article published by Dubos in *Science* and reproduced in the above-mentioned anthology [6]. The last sentence of the *Science* article—immediately following the quote at Epcot Center—says: "Millennia of experience show that by entering into a symbiotic relationship with nature, humankind can invent and generate futures not predictable from the deterministic order of things, and thus can engage in a continuous process of creation." [4] Humankind might now be reaching a turning point in its relationship with nature. Let us hope that politicians are sensible enough to understand the need to maintain such a symbiotic relationship.

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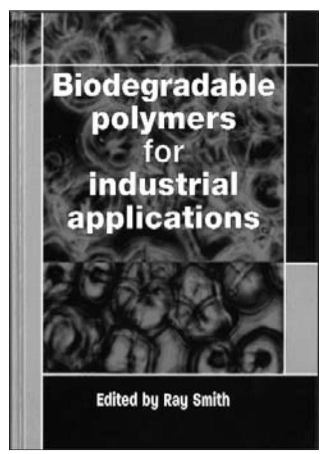

Biodegradable polymers for industrial applications

RAY SMITH (ED)

2005. Woodhead Publishing, Cambridge, UK
351 pp, 16 × 24 cm
Price: $ 239.95
ISBN 1- 85573-934-8

One of the fields in which microbiology can play an important part is polymer science and technology. A few decades ago, the discovery of new polymers synthesized by microorganisms launched a new scientific approach to studying the production, properties, applications, and, of course, the role of microbes in their manufacture. The main property of polymers from microorganism is biodegradability. This characteristic is desirable because it avoids contaminant processes when organic materials are converted into waste either by incineration or burial in landfills. In addition, the use of natural polymers reduces the environmental impact since their contribution of carbon dioxide emissions into the atmosphere is zero. Biodegradable polymers also have excellent properties with respect to medical applications, as most of them are converted to innocuous metabolites and they are substituted by natural body tissues.

In spite of difficulties in commercializing biodegradable polymers, their industrial applications have increased during the last few years. It is interesting to note that microorganisms produce biodegradable polymers such as polyhydroxyalkanoates (PHA), polysaccharides, lignin, and nylon-like proteins. *Biodegradable polymers for industrial applications* is a new book that covers many aspects of these compounds from a practical viewpoint. Importantly, it must be emphasized that this is not a microbiology book; rather, it is a polymer book with several sections in each chapter devoted to the relationship between microorganisms and polymers, including topics such as biosynthesis, biodegradation, and bioerosion. The book is aimed at chemists, engineers, material scientists, biochemists, researchers in the pharmaceutical industry, and environmental specialists who want to expand their knowledge of biodegradable polymers. Nonetheless, it is also of interest to microbiologists because of the important role of microbes in the production and degradation of polymers.

Biodegradable polymers for industrial applications is edited by Ray Smith, who is a senior lecturer at the University of London (Department of Materials) with extensive experience in the characterization of biodegradable polymers. The book is organized into nineteen chapters comprising four parts. Part I (Classification and development) describes some of the most important biodegradable polymers, such as polyhydroxyalkanoates (Chap. 2), oxo-biodegradable polyolefins (Chap. 3), aliphatic polyesters (Chap. 4), polyesteramides (Chap. 5), and starch-derived plastics (Chap. 6). Every chapter includes a discussion of polymer synthesis or biosynthesis, degradation or biodegradation under a variety of conditions as well as of some of the interesting characteristics of every material (processability, composting, etc.). Part II (Materials for production of biodegradable polymers) consists of Chaps. 7–11. Chapter 7 explains how to obtain special polysaccharides from monomeric carbohydrates. Chapter 8 describes the properties of new composites made from natural fibers, PHA, and other polymers. Lignocellulosic compounds and methods to obtain polyhydroxyalkanoates from renewable substrates are the subjects of Chap. 9. In Chap. 10 lactic-acid-based bioplastics, from synthesis to biodegradation, are introduced. Finally, Chap. 11 tackles the very interesting field of nanocomposites derived from protein materials. Part III, comprising Chaps. 12–15, covers the properties and mechanisms of biodegradation, ranging from standards for biodegradable plastics to chemical and biological mechanisms, including the catalytic effects of different enzymes. Chapter 14 is particularly interesting as it covers microbiological treatment of polymer biodegradation. Part IV is perhaps the most fascinating section of the book. It discusses industrial applications of biodegradable polymers, for example, in packaging or agriculture. Several economic aspects are also considered. For example, the production of biodegradable polymers, mostly obtained from renewable resources such as microorganisms, will multiply ten-fold between 2000 and 2007.

Every chapter is written by an expert (or experts) from different countries, which ensures a wide variety of opinions. *Biodegradable polymers* will be of value to every scientist or technician working in polymer chemistry, materials engineering, or applied biology. The book can also be recommended to postgraduate students who seek an introduction to biodegradable polymers. As noted above, the book is not aimed at microbiologists, as it covers only basic aspects of biodegradation and biosynthesis. However, as biotechnology becomes increasingly attractive to industry, the importance of microorganisms in the production and processing of innovative materials will continue to expand.

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