

Sustaining Life

How Human Health Depends on Biodiversity

FOREWORD BY EDWARD O. WILSON



Edited by Eric Chivian and Aaron Bernstein

Forthcoming from Oxford

“*Sustaining Life* is the most complete and powerful argument I have seen for the importance of preserving biodiversity” —Al Gore

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How Human Health Depends on Biodiversity

Edited by ERIC CHIVIAN and AARON BERNSTEIN

The Earth’s biodiversity—the rich variety of life on our planet—is disappearing at an alarming rate. And while many books have focused on the expected ecological consequences, or on the aesthetic, ethical, sociological, or economic dimensions of this loss, *Sustaining Life* is the first to examine the full range of potential threats that diminishing biodiversity poses to human health.

Edited and written by Harvard Medical School physicians Eric Chivian and Aaron Bernstein, along with contributions by over 100 leading scientists, *Sustaining Life* presents a comprehensive—and sobering—view of how human medicines, biomedical research, the emergence and spread of infectious diseases, and the production of food, both on land and in the oceans, depend on biodiversity. The book’s ten chapters cover everything from what biodiversity is and how human activity threatens it to how we as individuals can help conserve the world’s richly varied biota. Seven groups of organisms, some of the most endangered on Earth, provide detailed case studies to illustrate the contributions they have already made to human medicine, and those they are expected to make if we do not drive them to extinction. Drawing on the latest research, but written in language a general reader can easily follow, *Sustaining Life* argues that we can no longer see ourselves as separate from the natural world, nor assume that we will be unharmed by its alteration. Our health, as the authors so vividly detail, depends on the health of other species and on the vitality of natural ecosystems.

With a foreword by E.O. Wilson and a prologue by Kofi Annan, and more than 200 poignant color illustrations, *Sustaining Life* contributes essential perspective to the debate over how humans affect biodiversity and a compelling demonstration of the human health costs.

Eric Chivian, M.D., is the Director of the Center for Health and the Global Environment at Harvard Medical School. He shared the 1985 Nobel Peace Prize. He is the lead editor and author of *Critical Condition: Human Health and the Environment* and *Last Aid: The Medical Dimensions of Nuclear War*.

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Edited by

ERIC CHIVIAN, M.D., AND AARON BERNSTEIN, M.D.



CENTER FOR HEALTH AND THE GLOBAL ENVIRONMENT
HARVARD MEDICAL SCHOOL

Foreword by Edward O. Wilson

Prologue by Kofi Annan



SECRETARIAT OF THE
CONVENTION ON BIOLOGICAL
DIVERSITY



UNITED NATIONS
DEVELOPMENT PROGRAMME



UNITED NATIONS
ENVIRONMENT PROGRAMME



THE WORLD
CONSERVATION UNION

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We dedicate this book to the millions of plant, animal, and microbial species we share this small planet with, and to our own species, Homo sapiens, who first walked on Earth some 195,000 years ago and struggled to survive over the millennia to become the magnificent and extraordinarily powerful beings we are today.

May we have the wisdom, and the love for our children and all children to come, to use that power to save the indescribably beautiful and precious gift we have been given.

PREFACE

Edward O. Wilson once said about ants, “We need them to survive, but they don’t need us at all.” The same, in fact, could be said about countless other insects, bacteria, fungi, plankton, plants, and other organisms. This fundamental truth, however, is largely lost to many of us. Rather, we humans generally act as if we were totally independent of Nature, as if we could do without most of its creatures and the life-giving services they provide, as if the natural world were designed to be an infinite source of products and services for our use alone and an infinite sink for our wastes.

During the past fifty years or so, for example, our actions have resulted in the loss of roughly one-fifth of Earth’s topsoil, one-fifth of its land suitable for agriculture, almost 90 percent of its large commercial marine fisheries, and one-third of its forests, while we now need these resources more than ever, as our population has almost tripled during this period of time, increasing from 2.5 to more than 6.5 billion. We have dumped millions of tons of chemicals onto soils and into fresh water, the oceans, and the air, while knowing very little about the effects these chemicals have on other species or, in fact, on ourselves. We have changed the composition of the atmosphere, thinning the ozone layer that filters out harmful ultraviolet radiation, toxic to all living things on land and in surface waters, and increasing the concentration of atmospheric carbon dioxide to levels not present on Earth for more than 600,000 years. These carbon dioxide emissions, caused mainly by our burning fossil fuels, are unleashing a warming of Earth’s surface and of the oceans and a change in the climate that will increasingly threaten our health and the survival of other species worldwide. And we are now consuming or wasting or diverting almost half of all the net biological production on land, which ultimately derives from photosynthesis, and more than half of the planet’s renewable fresh water.

We are so damaging the habitats in which other species live that we are driving them to extinction, the only truly irreversible consequence of our environmental assaults, at a rate that is hundreds to even thousands of times greater than natural background levels. As a result, some biologists have concluded that we have entered what they are calling “the sixth great extinction event,” the fifth having occurred sixty-five million years ago when dinosaurs and many other organisms were wiped out. That event was most likely the result of a giant asteroid striking Earth; this one we are causing.

Most disturbing of all, as a result of all of these actions taken together, we are disrupting what are called “ecosystem services,” that is, the various ways that organisms, and the sum total of their interactions with each other and with the environments in which they live, function to keep all life on this planet, including human life, alive.

We have done all these things—our species, *Homo sapiens*, one species out of perhaps ten million on Earth, and maybe even many times more than that, behaving as if these alterations were happening someplace other than where we live, as if they had no effect on us whatsoever.

This heedless degradation of the planet is driven by many factors, not the least of which is our inability to take seriously the implications of our rapidly growing populations and of our unsustainable consumption of its resources, largely by people in industrialized countries, but increasingly by those in the developing world. Ultimately, our behavior is the result of a basic failure to recognize that human beings are an inseparable part of Nature and that we cannot damage it severely without severely damaging ourselves.

This book was first conceived in 1992 at the Earth Summit in Rio de Janeiro, when the largest collection of world leaders ever assembled until that time, along with tens of thousands of concerned policy makers, scientists, environmentalists, and others, gathered to set ambitious goals for controlling global climate change and for conserving the world's biological diversity. What we recognized then, and what is even more widely apparent now, is that, in contrast to the issue of global climate change, which has seen significant attention paid to the potential consequences for human health, with chapters devoted to this topic in all the major international reports, the same has not been true for the issues of species loss and ecosystem disruption.

This general neglect of the relationship between biodiversity and human health, we believe, is a very serious problem, for not only are the full human dimensions of biodiversity loss failing to inform policy decisions, but the general public, lacking an understanding of the health risks involved, is not grasping the magnitude of the biodiversity crisis and not developing a sense of urgency to address it. Tragically, aesthetic, ethical, religious, even economic arguments have not been enough to convince them.

To address this need, the Center for Health and the Global Environment at Harvard Medical School proposed that it coordinate an international scientific effort to compile what was known about how other species contribute to human health, under the auspices of the United Nations, and to produce a comprehensive report on the subject. Happily, the U.N. Environment Programme, the U.N. Development Programme, and the Secretariat of the Convention on Biological Diversity agreed to co-sponsor this project, and at a later time, the International Union for the Conservation of Nature and Natural Resources joined them. The result is this book, *Sustaining Life: How Human Health Depends on Biodiversity*.

We have focused much attention in *Sustaining Life* on seven groups of organisms in order to illustrate what their loss and, by extension, the loss of countless other organisms mean for human health. We have focused particular attention on amphibians, which are among the most threatened of any group of organisms on the planet, with almost one-third of some 6,000 known species in danger of extinction, and more than 120 believed to have already gone extinct in the past few decades. There is no evidence in the fossil record that such a high rate of extinction among amphibians, which have been on Earth for more than 350 million years, has occurred in the past, so it is believed that this loss is a new, and human-caused, phenomenon.

We have given many examples in the book of how amphibians contribute to human medicine—from the vitally important chemicals they contain that may lead to new pain killers and drugs to treat high blood pressure, to the central roles



Southern Gastric Brooding Frog (*Rheobatrachus silus*). Tadpole being delivered from mother's stomach. (© Michael J. Tyler.)

they have played, and continue to play, in biomedical research. Amphibians may, for example, help us figure out ways to prevent bacteria from developing resistance to our antibiotic treatments, a rapidly escalating phenomenon that is causing great alarm among physicians as they struggle to keep one step ahead of their patients' infections. We provide here yet another example to help the reader understand the magnitude of our loss with a loss of amphibians:

Gastric brooding frogs (*Rheobatrachus vitellinus* and *R. silus*), the only amphibians known to raise their young in their stomachs, were discovered in the 1980s in undisturbed rainforests in Australia. The female swallows her fertilized eggs, which then hatch in her stomach.

When the hatchlings become fully developed tadpoles, they are "delivered" to the outside world, propelled by their mother's vomiting, where they continue their development into adult frogs.

The stomachs of all vertebrate species, including frogs, contain cells that secrete acid and enzymes such as pepsin to begin the process of digesting food. There are also compounds that stimulate emptying of the stomach so that its contents can be moved along into the small intestine where further digestion takes place. The ingestion of food triggers the release of these compounds. Preliminary studies with gastric brooding frog tadpoles demonstrated that they secrete a substance, or substances, that both inhibits acid and pepsin secretions and prevents stomach emptying so that they do not end up being digested by their mother. But these studies, which might have led to important new insights for treating human peptic ulcers, a disease that affects more than twenty-five million people in the United States, could not be continued because both species of *Rheobatrachus* became extinct.

Scientists with expertise in a wide range of disciplines, from industrialized and developing countries alike, have been involved in putting this book together. We have done so because we are convinced that it can help people understand that human beings are an integral part of Nature, and that our health depends ultimately on the health of its species and on the natural functioning of its ecosystems. We have done so because all of us hope that our efforts will help guide policy makers in developing innovative and equitable policies based on sound science that will effectively preserve biodiversity and promote human health for generations to come. And we have done so, finally, because we all believe that life on Earth is sacred and that we must never give up in trying to preserve it, and because we all share the conviction that once people recognize how much is at stake with their health and lives, and with the health and lives of their children, they will do everything in their power to protect the global environment.

Eric Chivian, M.D.
Aaron Bernstein, M.D.

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This is the token of the covenant which I make between Me and you and every living creature that is with you, for perpetual generations . . . and the bow [rainbow] shall be in the cloud; and I will look upon it, that I may remember the everlasting covenant between God and every living creature of all flesh that is upon the earth.

—GENESIS 9:16

There is not an animal on the earth nor a being that flies on its wings, but [forms part of] communities like you.

—KORAN (QUR'AN) 6:38

All this world is strung on me like jewels on a string. I am the taste in the waters, the radiance in the sun and moon, the sacred syllable Om that reverberates in space, the manliness in men. I am the pleasant fragrance in earth, the glowing brightness in fire, the life in all beings.

—BHAGAVAD GITA VII:7–9

My love to the footless, my love to the two-footed, my love to the four-footed, my love to the many-footed . . . All sentient beings, all breathing things, creatures without exception, let them all see good things, may no evil befall them.

—“GRADUAL SAYINGS” OF THE BUDDHA



1 LOXOPEZA HÖGEI
 2 " URANIA.
 3 " CYANE.
 4 " TRANSLUCENS
 5 " EXARATA
 6 " EBURATA.
 7 LEBIA QUADRICOLOR.
 8 " BRACHINOIDES.

9 LEBIA CHARILLA.
 10 " IGNITA.
 11 " CELINA.
 12 " CONIESSA.
 13 " GROCEICOLLIS.
 14 " FIMBRIOLATA.
 15 " RETUSA
 16 " PŒCLURA
 17 " CALLIZONA.

18 LEBIA CHARINA.
 19 " CLIO
 20 " ANCHORA
 21 " SCALPTA
 22 " NEANTHE.
 23 " CALLIOPE.
 24 " RHODOPE.
 25 " RUFILIA.



FIGURE 73. *ANOPHELES FREEBORNI* MOSQUITO. This female *Anopheles freeborni*, known as the Western Malaria Mosquito, is having a blood meal. The malarial parasite must mature in the mosquito's gut for more than a week before the disease can be transmitted to another person via the mosquito's saliva. (Photo by James Gathany, Centers for Disease Control and Prevention.)