Article Tools:

Biosphere

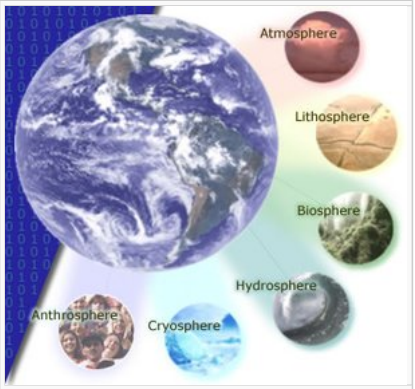
Lead Author: Erle Ellis (other articles)
Article Topic: Geography
This article has been reviewed and approved *by the following Topic Editor:* Leszek A. Bledzki (other articles)
Last Updated: January 8, 2009

Introduction

The **biosphere** is the biological component of earth systems, which also include the lithosphere, hydrosphere, atmosphere and other "spheres" (e.g. cryosphere, anthrosphere, etc.). The biosphere includes all living organisms on earth, together with the dead organic matter produced by them.

Table of Contents

The biosphere concept is common to many scientific disciplines including astronomy, geophysics, geology, hydrology, biogeography and evolution, and is a core concept in ecology, earth science and physical geography. A key component of earth systems, the biosphere interacts with and exchanges matter and energy with the other spheres, helping to drive the global biogeochemical cycling of carbon, nitrogen, phosphorus, sulfur and other elements. From an ecological point of view, the biosphere is the "global ecosystem", comprising the totality of biodiversity on earth and performing all manner of biological functions, including photosynthesis, respiration, decomposition, nitrogen fixation and denitrification.



The "spheres" of earth systems. (Source: Institute for Computational Earth System Science)

The biosphere is dynamic, undergoing strong seasonal cycles in primary productivity and the many biological processes driven by the energy captured by photosynthesis. Seasonal cycles in solar irradiation of the hemispheres is the main driver of this dynamic, especially by its strong effect on terrestrial primary productivity in the temperate and boreal biomes, which essentially cease productivity in the winter time.

The biosphere has evolved since the first single-celled organisms originated 3.5 billion years ago under atmospheric conditions resembling those of our neighboring planets Mars and Venus, which have atmospheres composed primarily of carbon dioxide. Billions of years of primary production by plants released oxygen from this carbon dioxide and deposited the carbon in sediments, eventually producing the oxygen-rich atmosphere we know today. Free oxygen, both for breathing (O_2, respiration) and in the stratospheric ozone (O_3) that protects us from harmful UV radiation, has made possible life as we know it while transforming the chemistry of earth systems forever.

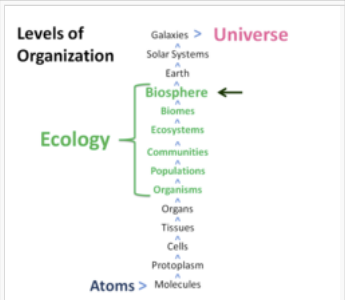
As a result of long-term interactions between the biosphere and the other earth systems, there is almost no part of the earth's surface that has not been profoundly altered by living organisms. The earth is a living planet, even in terms of its physics and chemistry. A concept related to, but different from, that of the biosphere, is the Gaia hypotheses, which posits that living organisms have and continue to transform earth systems for their own benefit.

History of the Biosphere Concept

The term "biosphere" originated with the geologist Eduard Suess in 1875, who defined it as "the place on earth's surface where life dwells". Vladimir I. Vernadsky first defined the biosphere in a form resembling its current ecological usage in his long-overlooked book of the same title, originally published in 1926. It is Vernadsky's work that redefined ecology as the science of the biosphere and placed the biosphere concept in its current central position in earth systems science.

The Biosphere in Education

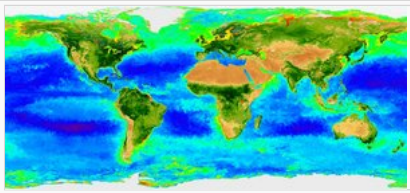
The biosphere is a core concept within Biology and Ecology, where it serves as the highest level of biological organization, which begins with parts of cells and proceed to populations, species, ecoregions, biomes and finally, the biosphere. Global patterns of biodiversity within the biosphere are described using biomes.



Levels of organization of Ecology, highlighting the Biosphere. (Credit: Erle Ellis)

In earth science, the biosphere represents the role of living organisms and their remains in controlling and interacting with the other spheres in the global biogeochemical cycles and energy budgets. The biosphere plays a central role in the biogeochemical processing of carbon, nitrogen, phosphorus, sulfur and other elements. As a result, biogeochemical processes such as photosynthesis and nitrogen fixation are critical to understanding the chemistry and physics of earth systems as a whole. The physical properties of the biosphere in terms of its surface reflectance (albedo) and exchange of heat and moisture with the atmosphere are also critical for understanding global circulation of heat and moisture and therefore climate. Alterations in both the physics (albedo, heat exchange) and chemistry (carbon dioxide, methane, etc.) of earth systems by the biosphere are fundamental in understanding anthropogenic global warming.

Biosphere Research


View of the biosphere from remote sensing (Source: NASA)

Researchers make direct observations on the biosphere using global remote sensing platforms. Beginning in the 1980s (AVHRR), this effort has evolved into advanced remote sensing systems that can scan the entire surface of the earth at least once each day (MODIS). These observations are now used to quantify the activities of the biosphere, primarily in terms of vegetation cover and function, using spectral indices such as NDVI. Future remote sensing efforts will directly observe global patterns of carbon dioxide exchange with the biosphere caused by photosynthesis, respiration and the combustion of biomass and fossil fuels (OCO).

To better understand the biogeochemical cycles of carbon and other elements, and the role of biospheric processes like photosynthesis, respiration and the storage of carbon in soils and vegetation, researchers have developed a variety of global biogeochemical models (e.g. CASA). There are also global models of vegetation patterns across the biosphere that are driven by climate (e.g. LPJ). Modeling plays an especially important role in understanding biospheric patterns and processes because there is only one earth: it is impossible to conduct global experiments on the entire biosphere or complete global processes (though some consider our current use of fossil fuels to be such an experiment). Understanding how humans are altering the biosphere and other earth systems has become a very active area of study, with concerted global efforts originating in the 1970s with the Man and the Biosphere Programme of UNESCO (MAB) , which also established a global system of biosphere reserves. Since the late 1980s, international scientific research on the biosphere has been coordinated by the International Geosphere-Biosphere Programme (IGBP) .

The Future of the Biosphere

The Biosphere II "experiments", which were conducted in the early 1990s in Arizona using private funding, enclosed a complex array of plants and animals together with humans in a sealed greenhouse complex which included a large "ocean". Within a short time, this "experimental biosphere" demonstrated how little we understand biosphere I (the biosphere of our planet): the project failed to replicate the basic biogeochemical functions that support life on Earth. Without resorting to drastic chemical interventions to inject oxygen and reduce toxic levels of carbon dioxide, it was impossible to support human life in the complex. Moreover, many keystone species, such as pollinators died off within a short time.

Many now see this as a good analogy for the current changes in atmospheric composition we are causing by rapidly burning off the fossil carbon captured by plants over millions of years, and by our conversion of forests to croplands. By releasing carbon stored by the biosphere over geologic time back to the atmosphere at unprecedented rates, humans are causing rapid global warming, and this warming is further altering global biogeochemical cycles and patterns of biodiversity across the biosphere. Anthropogenic climate change together with land use change and other anthropogenic alterations of the biosphere and other spheres have now reached such a high level that some earth scientist are now calling for the recognition that we have now entered a new, human-dominated, geologic era: the anthropocene.

Clearly, we are in need of greater understanding of how to better manage our one and only biosphere for the long-term benefit of ourselves and all other organisms.

More About the Biosphere

- Biomes
- Ecology
- Ecosystem
- Biogeochemical cycles
- Biodiversity
- International Geosphere-Biosphere Programme (IGBP)
- Remote sensing of the biosphere at NASA

- Biosphere II

Further Reading

- Vernadsky, V.I., 1998. Biosphere: Complete Annotated Edition. Copernicus Books (Springer Verlag), New York, NY. ISBN: 038798268X.
- Seuss, E., 1875. Die Entstehung Der Alpen [The Origin of the Alps]. Vienna: W. Braunmuller.

Citation

Erle Ellis (Lead Author); Leszek A. Bledzki (Topic Editor);. 2009. "Biosphere." In: Encyclopedia of Earth. Eds. Cutler J. Cleveland (Washington, D.C.: Environmental Information Coalition, National Council for Science and the Environment). [First published in the Encyclopedia of Earth June 21, 2008; Last revised January 8, 2009; Retrieved April 18, 2010]< http://www.eoearth.org/article/Biosphere>

Editing this Article

EoE Authors can click here to access this article within the editor wiki

If you are an expert, but not yet an Author, click here