Biosphere 2 - A Laboratory for the Study of Global Ecology
Scientific and Engineering Accomplishments 1991-1993

Overall
The Biosphere 2 (two year closed system experiment (September 26, 1991 to September 26, 1993) sustained 8 humans and some 3,800 species of plants and other animals in seven biomes with no major operational setbacks.

Longest human life support mission ever conducted
The crew - 4 men and 4 women - set a record for living in a closed system by surpassing the previous record (6 months) held by Russian researchers in the Bios-3 experiment. Still to this date, no other closed system human experiment has surpassed this length of time.

Human health
The 8-person crew did not get sick. Even when colleagues on the outside were ill with the common cold or flu, the crew remained healthy because they were sealed off in an entirely different atmosphere. During the course of the 2-year closure, blood pressure and heart rates for all 8 persons declined indicating an overall increase in well-being.

Human psychology
Although there were challenges amongst the crew, as is normal for all small groups in isolated confinement, all remained healthy and most importantly all 8 people rose above personal difficulties by working together to care for the biosphere. Our motto was “if the biosphere is healthy, then we are healthy.” It was our love for the biosphere that taught us how to live and work together regardless of any hardship, an important lesson for all of us “biospherians” on Earth.

Concept of stewardship
Every action had a noticeable effect which underscored the importance of individual accountability. We learned that we could enhance our environment or degrade it and thus our role as humans in our earth’s biosphere is that of a steward.

Most sealed system ever engineered
Biosphere 2’s annual air-leak rate of less than 10 percent is the lowest leak rate of any such structure ever built. (NASA's closed-system facility at Kennedy Space Center leaks 10 percent a day). This seal gave us the ability to track ppb and ppm molecules and learn about the cycles of gases. For example, we would not have ever detected the decline in Oxygen or the dramatic cycles of CO2 if the system had not been so sealed.

Carbon dioxide
CO2 would rise and fall diurnally as much as 1,000ppm. Over the two years, CO2 rose to 4,500 ppm during winter months. The correlation between CO2 and sunlight was exact.

Oxygen decline
The tight seal enabled the detection of an oxygen decline, which led to significant research about

oxygen cycles. Oxygen was being sequestered into the cement via the absorption of CO2. This fact is evidence that technology can and is altering our environment in dramatic ways.

Soil and the atmosphere
The Biosphere 2 system included tons of soil because of the necessity to have a source of carbon for the trees and biosphere growth over a long-term period of time. What we learned, however, is that soil respires CO2 and that soil composition is interactive with the atmosphere.

Biospheric respiration: To reduce the rise of CO2 and the respiration of the overall biosphere (soils, plants and animals all respire), we lowered the temperature to slow down metabolism and curb respiration. We also adopted the following procedures to reduce CO2:

- only the top soil of the agriculture fields were tilled in order to reduce the disturbance of soil respiration,
- biomass and compost were sources of high respiration and were thus dried, and
- we grew plants everywhere possible to capture all available sunlight so they could turn CO2 into O2.

Ecology is a synergetic system
Repeatedly we experienced the fact that ecology does not operate in a simple linear pathway. Life aims to thrive and will fill all available niches needed to help maintain a healthy biosphere.

Ocean
The one million gallon coral reef adapted to the temperate light regime of Arizona and its location in the foothills with an elevation at 3,500 ft. The reef was self-sustaining and there were no catastrophic losses. At the end of the two years there were 986 colonies thriving: 863 living stony coral colonies (of which 87 were judged to be recruits) and 123 colonies of living soft corals.

During these years, we learned that the coral was the indicator for the health of ocean and thus the overall health of Biosphere 2 and ourselves. Its large size and biodiverse ecosystems helped maintain its resiliency to the high levels of CO2 in the atmosphere as well as to ocean acidification.

Greatest record for agriculture productivity
Despite two winters of record high rainfall and cloudy weather (*El Nino* years) the agriculture area (½ acre of land) produced 80% of all the food for 8 people and their farm animals. The remaining approximately 20% was provided from seed stock and from crops grown and stored in Biosphere 2 prior to closure. The crops were produced without the use of toxic pesticides or chemical fertilizers.

Agriculture soil-based systems
Soil is critical for a sustainable agriculture system because of the necessity to recycle and all nutrients.

Organic agriculture
As the agriculture system matured, it was more capable of growing 100% of all food required for

8 people. This productivity along with the system that recycled all waste promise for reducing ground water pollution from agricultural chemicals, production of pesticide-free foods and more efficient food production on earth.

Human diet
The low-calorie, nutrient-dense diet dramatically lowered the biospherians' cholesterol levels. The diet had been studied in animals, but this was the first long-term study in humans.

Ecotechnics
Technology was used to maintain and enhance biodiverse ecosystems to support all life – including humans.

Recycling systems
One of the most striking accomplishments was its massive recycling systems for air, water and wastewater.

Biosphere 2 was not large enough for weather processes to occur entirely naturally. Mechanical systems assisted the heating, cooling, and air / water circulation. Water evaporation from the ocean was condensed for human drinking water and for return to the stream and rainforest. Human and animal wastes were treated in a combination microbial and intensive wetlands ecology. (Water effluent was tested before returning to the irrigation system.)

Development of new environmental technologies
Biosphere 2 pioneered new environmental technologies in wastewater management, air purification, and water recycling, etc.

For example, please learn more about the work we have since done at Biosphere Foundation with Wastewater Gardens® and the Coral Reef Satellite Mission.

Wastewater Gardens® is an example of a such a technology that has been further developed by Biosphere Foundation for use in tropical countries. Another example of a planetary monitoring program that we developed called the Coral Reef Satellite Mission.

https://biospherefoundation.org/project/the-coral-reef-satellite-mission/
https://biospherefoundation.org/project/wastewater-gardens/

Ecological restoration
The making of Biosphere 2 was the most significant undertaking on the planet in ecological restoration and drives much of the practice today at Biosphere Foundation.

Biosphere 2, a unique laboratory for the study of global ecology
"The achievements of the biospherians go beyond the application of state-of-the-art methods of sustainable agriculture. Biosphere 2 recreates in miniature the flows and balances that occur on Earth, but it moves through these cycles on 'fast forward'. Carbon dioxide turnover on Earth takes about three years: in Biosphere 2 it takes about three days. On Earth it takes years or decades to see how changes in the rainforest affect the growth of sorghum or sweet potatoes in

another part of the world; in Biosphere 2 the impact may be seen in a matter of weeks. In Biosphere 2 agricultural materials such as crop nutrients and animal wastes recycle through the water and air systems in days as opposed to weeks or years on Earth. It is, in this sense, an ecological laboratory of incalculable value—the world's largest test-tube." - *Dr. Richard Harwood, C. S. Mott Foundation Chair of Sustainable Agriculture Department of Crop & Soil Sciences at Michigan State University*

Papers relating to Biosphere 2 and the study of Biospherics
https://biospherefoundation.org/project/mars-on-earth/