Biosphere 2 Scientific and Engineering Accomplishments

Overall:
The 1991 to 1993 Biosphere 2 experiment sustained eight 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 to have been completed:
The four men and four women of the Biosphere 2 crew set a new record for living in a closed system by surpassing the previous record (six 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 humans did not get sick. Even when colleagues on the outside were ill with the common cold or flu, the 8 people remained healthy. Blood pressure and heart rates for all 8 declined and all were considered more healthy for having remained inside Biosphere 2 at the end of the two years.

Human Factors: all 8 people remained isolated and confined within the boundaries of Biosphere for 2 years (with the exception of Jane Poynter's brief visit to the hospital that was under 4 hours).

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 Planet Earth.

Concept of stewardship: Each action made by a Biospherian had an immediate effect on this mini-world, which dramatically demonstrated the importance of individual accountability for the larger closed system, Earth, in which we live. We lived this concept as our reality each day for two years and is, again, an extremely important concept for "biospherians" of Planet Earth.

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: C02 would rise and fall diurnally as much as 1,000ppm. Over the two years, C02 rose up to 4,500 ppm. The correlation between C02 and sunlight was exact.

Oxygen decline: The tight seal enabled the detection of an oxygen decline which has led to significant research about oxygen cycles. Oxygen was being sequestered into the cement. This is direct evidence that technology can and is altering our environment in dramatic ways.

Soil and the atmosphere: Knowledge about soil was learned during the first years of Biosphere 2. Prior to this experiment, it was not understand how active soil is with the atmosphere. The initial design 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 was that the soil respired daily and it was the carbon in the soil that became the immediate concern re the atmospheric carbon dioxide.

Biospheric respiration: To slow down the CO2 respiration of the overall biosphere (soils, plants and animals!), we kept the temperature of the biosphere down to slow down metabolism and curb respiration.

Ecology as a synergistic system: Repeatedly we experienced the fact that ecology does not operate in a simple linear pathway. Life aims to thrive and will fill niches needed to help maintain a healthy biosphere. Examples, ocean pH, CO2 management, the function of bacteria, insect pollination by ants and cockroaches, intelligent (as opposed to ignorant) stewardship by humans, etc.

Coral reef: The coral reef adapted to high carbon dioxide, an elevation above sea level and a temperate as opposed to tropical light regime. There were no catastrophic losses of corals which had been predicted even though the coral reef was self-sustaining during the two years without any addition of outside sea water. At the end of the two years there were 986 colonies: 863 living stony coral colonies of which 87 were judged to be recruits and 123 colonies of living soft corals.

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 percent 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 ability to compost and recycle all materials.

Organic agriculture: Application on Earth of similar systems show promise for reducing ground water pollution from agricultural chemicals, production of pesticide-free foods and more efficient food production.

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: Biosphere 2 pioneered the idea critically important in our world today that technology is used for the benefit of ecology.

Recycling systems: One of the most striking accomplishments for Biosphere 2 was its massive recycling systems that recycled the air, water and wastewater. Biosphere 2 was not large enough for weather processes to occur entirely naturally, as they do over large areas on Earth. Mechanical systems assisted the heating, cooling, and air and 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 ecosystem. Water effluent was tested before returning to the irrigation system.

Development of new environmental technologies: Biosphere 2 pioneered new environmental technologies back in wastewater management, air purification, water recycling, etc. Wastewater Gardens (http://www.pcrf.org/wastew.html) 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 was developed from the Biosphere 2 experience is Biosphere Foundation's "Space-based Coral Reef Mission" (http://www.pcrf.org/pcrfinspace.html).

Ecological restoration: All biomes pioneered new studies and insights about the study and practice of ecological restoration. Just by the fact that they were built as distinct areas of rainforest, coral reef, mangrove marsh, savannah and desert pioneered the practice of ecological restoration.

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*

Biosphere 2 publications: http://www.biospheres.com/publications.html

Papers relating to Biosphere 2 and the study of Biospherics:
http://www.biospheres.com/otherpapersonbiospherics.html

Space-based publications:
http://www.biospherefoundation.org/MOE_Publications.html

To view footage of the 1991 – 1993 Biosphere 2 experiment, please see
http://www.biospherefoundation.org/ourworld.html

Life Under Glass: The Inside Story of Biosphere 2. A. Alling, M. Nelson, S. Silverstone. *The Biosphere Press. 1993.*

Earth-based ecological systems, Wastewater Gardens®:
http://www.pcrf.org/wastew.htm

A Google Earth-Ocean Demonstration: *http://www.pcrf.org/google-demo.html*

Planetary coral reef stewardship, a space-based mission:
http://www.biospherefoundation.org/crsm.html

Mars On Earth®, a space-based biosphere:
http://www.biospherefoundation.org/MOE_index.html

For more information about on-going work with the biosphere, please see
www.biospherefoundation.org

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