

“Modular Biospheres” – A new platform for education and research

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Abstract

A new type of testbed platform for education and research: a “modular biosphere” has emerged from research which dates back to the Biosphere 2 and the effort to develop bioregenerative technologies for space life support. Two examples of this type of facility are the Biosphere 2 Test Module, a glass and spaceframe structure which runs on incident sunlight for plant growth; and the Laboratory Biosphere, a cylindrical opaque chamber which uses artificial lights for plant growth. Both types of system require a variable volume (“lung”) chamber to relieve pressure differences between the modular biosphere and the outside environment. Modular biosphere facilities offer unique research and public education opportunities. Ecosystem behavior can be studied since all state conditions can be precisely specified and tracked over different ranges of time periods. With material closure (apart from small air exchange rate which can be determined), biogeochemical cycles can be studied as elements transit between soil, water, plants and atmosphere. Such studies offer a major step upward from studies conducted with phytotrons which because of their small size, limit the number of organisms to a very small number. Modular biospheres differ from ecological microcosms because of their material closure; thus a much more thorough examination of nutrient cycling can be conducted, and their larger volume. Though large in comparison with phytotrons and microcosms, modular biospheres are small enough that they can be reconfigured – with elements changed – to reflect a changing research agenda. For example, the Biosphere 2 Test Module in Arizona had a volume of around 400m³, and provided enough growth space for plants to support humans in closure experiments lasting several weeks. The Laboratory Biosphere, in New Mexico, with a soil bed of 2.6m² inside the cylinder, with horizontal axis 3.68 meters long and 3.65 meters diameter, has a volume of 34-43m³ including variable volume chamber depending on pressure conditions. Modular biospheres are thus operable at several sizes and configurations.

The research capabilities include examining specific cycles in ecosystem behavior by adjusting some variables while holding others constant; e.g. atmospheric composition and cycles (of the utmost importance because of global warming and widespread pollution of the atmosphere); water cycle and composition; changes in total biomass as well as changes in individual organisms and species; changes in soils with cyclic or discontinuous changes in life forms; total system effects of changing variables such as temperature, humidity, radiation, light, introduction of a new species, introduction of a specific pollutant. Because of its scale, a Modular Biosphere, while it is being used for cutting edge eco-system/and or extreme conditions (such as Space and Mars) related research on habitation, makes an ideal real-time educational tool. Real-time because a proper viewing station as well as internet data and image streaming give visitors, students and the general public access to exactly the same data as the operating scientists themselves are using. The paper will include examples of specific experiments run in modular biospheres, as well as an idea of its many research and educational uses.