Space Microbiology
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Space microbiology is still a largely unrecognized area of study within astronautics or microbiology. In spite of this, extensive efforts have been undertaken, mostly directed at preventing astronaut illnesses due to microbes, habitat microbial ecology, and the spread of microbes from artificial habitats to new planets and *vice versa*.

Astronaut microbial illness. theoretically, astronaut microbial illness could occur from effective exposure to bacteria, fungi, protozoa, mycoplasmas, rickettsioses, viruses, [prions,] or microbial products. These could be acquired from other humans before, during, or immediately after astronaut additions or spacecraft closure; zoonotically from exposure to animal cohabitants, their products, or their wastes; phytonically from plant cohabitants, their products, or their wastes (for example, from plant soil or used nutrient water); from exposure to environmental microbes (for example, conditional pathogens on filters or rubber seals); or xenotically from space or other extraterrestrial sources. Of these, person-to-person exposures have received the most critical scrutiny.

Microbial illnesses could be acquired by direct contact, by vectors (biological intermediaries), or by fomites (inanimate intermediaries, such as [surfaces,] water or air). Of these, intra-/interpersonal direct contact and spred via surfaces and air have been stdied to some extent. Spred via vectors and water has not been judged to be a problem because nonhuman cohabitants have been restricted to [short duration] space flights, and when present have been provided with separate, isolated habitats. Water is always carried, or made aloft such as on United States Shuttle flights [and currently on International Space Station "Freedom"], and not reused. Single-use and permanent-disposal water technologyies appear to provide no major microbial problms in space. See INFECTIOUS DISEASE TRANSMISSION.

Altered conditions for transmission. Space could introduce unique conditions that would effectively modify natural infectious disease control processes. For instance, reduced gravity might not affect microbial adherence onto airborne particles; however, it might increase the number of such particles in direct contact with the skin, mucous membranes, or lungs. A sneeze in space may thus be more effective at transmitting airborne disease than its terrestrial counterpart. Reduced habitat volume, a phenomenon common to spacecraft and currently projected planetary bases, means generally reduced microbial sinks, increased contaminated surface area, and the potential for rapid microbial change. Reuse, reclamation, and recycling of life-support elements could alter usual background environmental microbial populations necessary to dilute out pathogens and deny them access to niches where they could grow or proliferate; select for new and unique conditional pathogens (for example pseudomonads in reclaimed [and/]or recycled water systems); and diminish or promote microbial exchange of virulence or resistence plasmids often responsible for determining microbial pathogenicity. In addition, spaceflight factor clearly effect the human immune system and may affect host resistance to disease.

Experimental results. Infectious diseases have occurred on United States and Soviet [now Russian] crewed spaceflights, indicating that at least some of these concerns are founded. However, infectious disease patterns on medium-duration Soviet flights, for example, *Soyuz* and *Salyut*, seem to more closely approximate United States experiences in nuclear submarines. That is, an initial increase in the number of microbial illnesses may be experienced immediately following opening or closure of the habitat, a decrease in rate of microbial illnesses during closure, a general reduction in the kinds of microbes (in some instances, kinds or numbers of pathogens and conditional pathogens), and an increase in numbers of specific microbes favored by unique characteristics of the habitat.

Soviet experiments with human-higher-plant closed ecological systems, such as *Bios 1*, *2* and *3*, indicate that microbial simplification in closely recycled habitats is actually very complex, and have given rise to a new area of study called *biospherics*. Major questions for biospherics [research] are: Which of the observed effects are space-related, which are related to small habitat volumes, which are related to inhabitant interactions, whether changes are temporary or permanent, and how such changes will affect the overall stability of the habitat microbial population.

Spread of microbes. The spread of microbes from a spacecraft or planetary base to a planet or *vice versa* may be viewed as another example of biospherics, [namely] that of biosphere-to-biospher microbial contamination. An extreme example is microbial terraformation, the intentional microbial contamination of a new planet in order to make it somehow more amenable to human habitation. A terrestrial analog might be the introduction of genetically engineered, ice-melting bacteria to increase planetary [potable] water when such water is largely bound in soil or polar caps. Definitive work in this important area is only beginning. It is hoped that study of microbial ecology in biospheres will shed new light on such phenomena.

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Fig 1. Soviet Unition's Cosmos 782 spacecraft.

Fig 2. Drawings of United States' space shuttle. (a) Shuttle orbiter. (b) Spacelab module.