



INTRODUCTION

The objectives of this symposium were to define and establish the requirements for living systems for space vehicles and extraterrestrial stations. The biologistics for space systems involves the timely supply of the necessities for sustaining life where the biological entity is required to perform functions that cannot be accomplished by machines. Weight, size, simplicity of operation, and, in particular, reliability are important factors. A completely closed ecological system with total regeneration is the ultimate goal. Systems involving physical and chemical processes, or both, are being studied and will serve until the bioregenerating system can be perfected. The nonbiological systems are time-limited to the amount of essential food, water, and oxygen that can be carried or recovered. These physical-chemical processes show great potential, but they also present many difficulties, including requirements for extremely high temperatures, considerable amounts of power, the formation of highly toxic materials, high susceptibility to inactivation, and insufficiency. None of the presently studied modes of these nonbiological processes can function as completely as a closed bioregenerating system. All of these nonbiological systems have unrealistic supply requirements and produce unusable wastes. Consequently, the biological regenerative systems, which also are beset with problems and difficulties, are potentially far superior to their physical and chemical counterparts. The closed bioregenerating system also has far greater potential for reliable long-term supply for space stations or bases that will be occupied for extended periods. Biologistics is predicated on the presence of man in the space vehicle or station. To support man through the use of other biological systems or processes, a thorough knowledge of not only man, but also each living component of the closed ecology is required. In addition, these systems may have to operate in environments very much different from those found on earth. Fortunately, there is considerable information already available on the essential characteristics and requirements of many of the biological entities that may be used to support man in the space systems.

The daily intake of an average man has been well established as about ½ kilogram of food, nearly 1 kilo of oxygen, and a little more than 2 kilos of water. The intake of food must be carefully balanced in terms of carbohydrate, fat, and protein. This information can serve as a baseline from which experimentation can be initiated. A problem arises, however, because the statistically proved average man probably could not qualify as an astronaut. Much more information is needed on the requirements in relation to performance of individuals. Perhaps individuals should be



studied on the basis of body type, and their metabolic needs should be determined in relation to actual conditions under which they will be performing their duties. The waste products of the average man have been determined at about 60 grams of solids, nearly 1 kilo of carbon dioxide and 2.5 kilos of water. The development of biological processes to properly manage and return these wastes into the system will be extremely important. In fact, the length of time people can live and perform in extraterrestrial environments will depend upon the efficiency and reliability of the bioregenerating system. It will be necessary to establish whether algae or higher plants are best suited as gas exchange mechanisms. Then, it will be essential to determine whether the plants selected are more efficient in pure culture or mixed culture with other autotrophic forms or with heterotrophic kinds. Perhaps mixtures of both autotrophic and heterotrophic species will give the most efficient system, since some of the lowest plants, such as algae, bacteria, and fungi, can perform functions that will be required for balancing a closed ecological system. The green plants use carbon dioxide and produce oxygen while bacteria and fungi perform very well in the disposal of solid organic wastes. It seems essential that pestiferous kinds of biological entities be left behind. In plant photosynthesis, carbon dioxide is utilized to form carbohydrates and oxygen is derived from the water. Nevertheless, much more information is required to elucidate the mechanism of oxygen formation and production before the first attempts can be made to produce synthetic systems. The processes of screening and selecting the various bioforms that will be required to support man in the extraterrestrial environment must continue at an increased rate. In fact, it may be necessary to develop special new forms as requirements become more sharply defined. Our selections may well extend to gastropods, fish, birds, the smaller or miniaturized forms of higher animals, and other kinds before the final selection is made. These, especially, may be valuable as dietary supplements for men on extremely long-term missions. They would serve, as they do here on earth, as intermediary metabolizers, consuming materials indigestible or otherwise unusable to man and, in turn, furnishing him with highly acceptable forms of food. Actually, our real future probably lies in finding ways to produce and control, as required, functions that now are carried on only in the living cell. The complete biochemistry of the living cell is probably as unknown as space itself. Certainly, a more astute and complete understanding of the essential functions of oxygen evolution, carbohydrate and protein metabolism, and water production will be necessary to assure the future astronaut an efficient and reliable system that will sustain him for indefinite periods in space. In summary, the final choice of a logistics system will depend on several prime factors. Included among these factors will be efficiency, reliability, and compatibility, and these will apply equally to all components whether they are biological, chemical, or physical.