Fundamentals of Space Life Sciences

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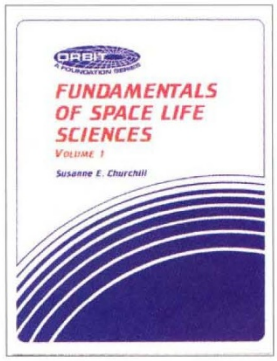
Fundamentals of Space Life Sciences was developed as a textbook for undergraduate students attending the International Space University. The text is oriented toward a class consisting of varying academic backgrounds and, as such, has something for everyone. The book also provides an introduction to those who are not in the field, but who are interested in the issues, key questions and direction of research into the future development of outer space. The focus of the book's thirty-three chapters, contained in two volumes, is the human exploration of the solar system.



While not organized as such, the book can be thought of as consisting of four main parts: the first describes the impetus for and experience of the exploration of space by humans; the second, the space environment; the third, the systems necessary for survival in a harsh environment to accomplish exploration; and the last part, the physiological consequences of this endeavor.

The starting premise is that humans have the "urge to explore" and, as a consequence, to expand life to fill available niches. This concept is illustrated by the personal experience of an astronaut who stated that his first opportunity to fly was the "accomplishment of a lifelong dream" and then waited another nine years to repeat the experience. While the psychological profile of space explorers shows them to be "comfortable, mature, well integrated individuals", they possess a factor for the excitement of spaceflight. Society as a whole, in turn, supports and fosters this activity to the point that there are now professional explorers of space.

Space indeed represents a new frontier. However, it is a hostile environment. A number of chapters in the book deal with the hazards of the space surroundings. These include radiation exposure, temperature extremes, the vacuum of space and microgravity. These subjects are presented in physical and engineering terms, setting the basis for the chapters dealing with the development of physical-chemical systems designed to sustain the existence of humans in space.

The book includes extensive descriptions of the requirements for and the design of systems to support the presence of humans in the space environment, including basic life support systems, space suits, counter-measures and medical support. While the facilities are adequately described, information regarding the effectiveness of these systems is limited. For example, decompression sickness (DCS) is suggested to be a major risk factor during space walks and is therefore a concern in planning the construction of the Space Station. Although the incidence of DCS in ground simulations is about 20%, there have been no reported cases of it during space flight. The discrepancy between observed versus expected complications appears to be due, in many cases, to a lack of concerted effort to collect the necessary information. A number of approaches for future long-term habitation of space are presented, including self-sustaining Closed Ecological Life Support Systems (CELSS). The design of CELSS appears to be based on limited knowledge gained from present systems used during space flight. Throughout the book the authors point out the lack of scientific data concerning the performance of systems and the available counter-measures, raising concern as to the design and success of future activities.

The limited availability of data on the performance and well-being of humans in the space environment is an issue reiterated throughout the book. While often well introduced and summarized, information on the consequences and impact of spaceflight on humans and of humans on their closed environment appears confined. What becomes clear by reading the book is that the focus of the space program is to assure the acute safety of humans to accomplish a specific mission. This operational environment appears to "relegate research questions to a low priority". In addition, constraints of the life support systems, mission operation requirements and the application of counter-measures, which may impact on the interpretation of research data, are often not considered. Data are often anecdotal and in some cases suspect ("data was not obtained through "official" channels, and may not be accurate"). The book presents descriptions of a variety of physiological changes in the cardiovascular, musculoskeletal, immunological and neurovestibular systems, which will require extensive further investigation to elucidate underlying mechanisms and impact on the long-term performance and well-being of humans in space.

As noted in the foreword of the book "results obtained from spaceflight have been published in highly specialized journals not easily accessible to the public and often difficult to trace back for references." This becomes evident when reviewing bibliographies, as in some chapters over one third of the references to spaceflight data are technical/contractor reports or meeting abstracts. Furthermore, many of the chapters appear to have been compiled years ago and have not been updated. In the summary to the chapter on the skeletal system the author states that, "Experiments on flights for the period of 1993–1995 will answer many of the questions posed...".

In summary, *Fundamentals of Space Life Sciences* is not well organized and, in instances, out of date. The book does provide a practical guide to the field and could be used as a student text with substantial supplemental material. *Fundamentals of Space Life Sciences* should be thought of as a primer to those who wish a career in the human exploration of space.

In the next issue of *Nature Medicine* . . .

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- The Measure of our Days (Jerome Groopman) reviewed by Michael Kilby
- Function and Dysfunction of the Nervous System (Cold Spring Harbor Symposium on Quantitative Biology) reviewed by Charles Jennings