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Publications of the NASA Controlled Ecological Life Support System (CELSS) Program, 1979–1989

Janice S. Wallace and Janet V. Powers

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Introduction

Food, water, and a breathable atmosphere are three elements fundamental to human survival. Expendable supplies of these elements may be carried onboard spacecraft for brief spaceflights; for permanent missions in low Earth orbit, they may be resupplied from Earth, though only at high cost. Missions to more distant places, such as the moon, Mars and beyond, however, will require regeneration of food, air, and water. An autonomous bioregenerative life support system that continually recycles the solid, liquid, and gaseous materials essential for human life is the goal of NASA's Controlled Ecological Life Support System (CELSS) Program.

NASA has conducted research in various aspects of closed regenerative life support systems since the 1960s. In 1979, the CELSS Program was established in the Life Sciences Division, located within NASA's Office of Space Science and Applications, to encompass Life Sciences' CELSS efforts in one program. CELSS research and technology development is currently being performed in a broad range of areas, including food production, nutritional requirements, waste management, and systems management and control.

Food Production. This subject area includes determining the optimal plant species (both higher and lower plants) that will provide a large percentage of edible plant biomass, maximum yield, and maximum nutrient value, while using a minimum of space and power. Another aspect of Food Production includes controlling the system's environment, i.e., examining and regulating such factors as temperature, airflow, humidity, CO_2 level, and illumination to provide for optimal growth and production. Researchers also explore methods to convert inedible biomass to food.

Nutritional Requirements. This area involves analyzing human nutritional requirements on Earth and in microgravity and determining which crop species under consideration for a CELSS will meet these requirements.

Waste Management. Research in this subject area examines the control of CO_2, O_2, and trace gas contaminants; atmospheric regeneration; water purification for spent nutrients and condensate; and recycling the constituents of solid and liquid human waste and nonedible biomass.

Systems Management and Control. This area examines the integration, monitoring, control, and stability of whole CELSS systems. This includes modelling and design of systems within sealed chambers that provide for atmospheric regeneration, food production and processing, and waste management, thus testing the research results obtained in the other research areas.

The purpose of compiling this bibliography is to provide the scientific community with a list of publications resulting from CELSS-related research, from its official beginnings in 1979 through mid-1989. Certain papers published prior to 1979 that involve background research leading to the development of the CELSS Program are also included. It is anticipated that the bibliography will stimulate the exchange of information and ideas between scientists working in different areas of the program and in the field of bioregenerative life support in general.

The arrangement of citations in this bibliography follows the four divisions of research outlined above. Publications are listed alphabetically by author within the research area with which they are most closely associated. Authors conducting research under the auspices of the CELSS Program have been identified with an asterisk.

The assistance of the CELSS Principal Investigators in providing lists of their publications and the technical assistance of Rodney P. Johnson are gratefully acknowledged.

Maurice M. Averner, Ph.D.
NASA CELSS Program Manager

FOOD PRODUCTION: Higher Plants

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Calcium amelioration of NaCl effects on leaf expansion, photosynthesis, and transpiration in *Phaseolus vulgaris* L. (Abstract).
HortScience 22(5): 1087, 1987. (GWU 11140)

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Comparative effect of selenite and selenate on nitrate assimilation in barley seedlings (Abstract).
Plant Physiology 86(4, Suppl.): 58, 1988. (GWU 11155)

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Plant Physiology 72(1, Suppl.): 129, 1983. (GWU 4487)

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Characteristics of high intensity discharge lamps (Abstract).
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In: *Space Life Sciences Symposium: Three Decades of Life Science Research in Space*, Washington, DC, June 21-26, 1987, p. 248-250. (GWU 10009)

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16. Abstract

Publications of research sponsored by the NASA CELSS (Controlled Ecological Life Support System) Program from 1979 to 1989 are listed. The CELSS Program encompasses research and technology with the goal of developing an autonomous bioregenerative life support system that continually recycles the solid, liquid, and gaseous materials essential for human life. The bibliography is divided into four major subject areas: food production, nutritional requirements, waste management, and systems management and control.

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