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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, however, they may be resupplied from Earth, though only at high cost. Missions to more distant places, such as the Moon, Mars and beyond, will require regeneration of food, air, and water. An autonomous bioregenerative life support system that is based upon the integration of biological and physical/chemical processes, and that will produce nutritious and palatable food, potable and hygienic water, and a breathable atmosphere by recycling metabolic and other wastes, is the goal of NASA's Controlled Ecological Life Support Systems (CELSS) Program.

NASA has conducted research in various aspects of closed regenerative life support systems since the 1960s. In 1978, the CELSS Program was initiated to encompass all of NASA's CELSS efforts into one program. CELSS research and technology development is currently being performed in a broad range of research areas, including biomass production and food processing, waste management, and systems management and control.

Biomass Production/Food Processing. This research area includes determining the optimal higher and lower plant species that will provide a large percentage of edible and palatable plant biomass, produce maximum yield and nutrient value, yet use a minimum of space and power. Another aspect of this research includes controlling the system's environment, i.e., examining and regulating such factors as temperature, airflow, humidity, CO₂ level, and illumination, to provide for optimal growth and production. Researchers also explore methods to convert inedible biomass to food.

Waste Management. Research in this subject area examines producing water of adequate quality to meet life support system requirements; maintaining a habitable atmosphere by regulating the concentrations of CO₂ and O₂; processing plant and human metabolic wastes for maximum recycling; and controlling the buildup of trace gas contaminants and other toxicological agents, such as pathogenic bacteria.

Systems Management and Control. This research 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 is to achieve and maintain stable, reliable operation of a CELSS to provide the crew with a predictable supply of life support consumables.

This bibliography has been compiled to provide the scientific community with a list of publications resulting from CELSS-related research during the period 1989 through mid-1992. 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 three research divisions 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, and a list of these investigators and their affiliations follows the bibliography.

The assistance of the CELSS Principal Investigators in providing lists of their publications and the technical assistance of Audrey Robin Brown are gratefully acknowledged.

Maurice M. Averner, Ph.D.
NASA CELSS Program Manager
BIOMASS PRODUCTION/
FOOD PROCESSING

Andre, M.; MacElroy*, R.D.
Plants and men in space: A new field in plant physiology.
Physiologist 33(1, Suppl.): S100-S101, 1990. (GWU 11708)

Aslam, M.; Harbit, K.B.; Huffaker*, R.C.
Comparative effects of selenite and selenate on nitrate assimilation in barley seedlings.

Aslam, M.; Huffaker*, R.C.
Role of nitrate and nitrite in the induction of nitrite reductase in leaves of barley seedlings.
Plant Physiology 91: 1152-1156, 1989. (GWU 10971)

Aslam, M.; Travis, R.L.; Huffaker*, R.C.
Comparative kinetics and reciprocal inhibition of nitrate and nitrite uptake in roots of uninduced and induced barley (Hordeum vulgare L.) seedlings.
Plant Physiology 99: 1124-1133, 1992. (GWU 15318)

Aslam, M.; Travis, R.L.; Huffaker*, R.C.
Comparative kinetics and reciprocal inhibition of nitrate and nitrite uptake in roots of uninduced and induced barley seedlings (Abstract).
Plant Physiology 96(1, Suppl.): 103, 1991. (GWU 14284)

Barnes, C.; Bugbee*, B.
Effects of photoperiod, blue light, and phytochrome photoequilibria on soybeans (Abstract).

Barnes, C.; Bugbee*, B.
Morphological responses of wheat to blue light.

Barnes, C.; Bugbee*, B.
Morphological responses of wheat to blue light and reduced phytochrome photoequilibria (Abstract).
Plant Physiology 93(1, Suppl.): 130, 1990. (GWU 11695)

Barnes, C.; Bugbee*, B.
Morphological responses of wheat to changes in phytochrome photoequilibrium.

Barta, D.J.; Bula, R.J.; Morrow, R.C.; Tibbits*, T.W.
Characteristics of light emitting diodes for use as a photosynthetic irradiance source for plants (Abstract).

Barta, D.J.; Bula, R.J.; Tibbits*, T.W.
Wheat growth under a light emitting diode irradiance source (Abstract).
Barta, D.J.; Edeen, M.A.; Eckhardt, B.D. (Henninger, D.L. = P.I.)

Barta, D.J.; Tennessen, D.J.; Bula, R.J.; Tibbitts*, T.W.
Wheat growth under a light emitting diode irradiance source with and without blue photon supplementation (Abstract).

Barta, D.J.; Tibbitts*, T.W.
Calcium localization in lettuce leaves with and without tipburn: Comparison of controlled-environment and field-grown plants.

Barta, D.J.; Tibbitts*, T.W.
Use of electron microprobe x-ray analysis for determination of low calcium concentrations across leaves deficient in calcium.

Barta, D.J.; Tibbitts*, T.W.; Bula, R.J.; Morrow, R.C.
Evaluation of light emitting diode characteristics for a space-based plant irradiation source.

Bennett, S.M.; Corey, R.B.; Bula, R.J.; Tibbitts*, T.W.
Potential use of ion exchange materials in controlling nutrient balance of a recirculating solution for use in a CELSS (Abstract).
ASGSB Bulletin 2: 38, 1989. (GWU 10427)

Bennett, S.M.; Tibbitts*, T.W.; Cao, W.
Diurnal temperature fluctuation effects on potatoes grown with 12 hr photoperiods.

Berry, W.L.; Goldstein, G.; Dreschel, T.W.; Wheeler, R.M.; Sager, J.C.; Knott*, W.M.
Water relations, gas exchange, and nutrient response to a long term constant water deficit.

Criteria for evaluating experiments on crop production in space.

Bishop, D.; Bugbee*, B.
Leaf size, plant height, and photosynthetic capacity in wheat.

Bishop, D.L.; Bugbee*, B.
Leaf size and its correlation with photosynthetic rate and leaf anatomy in wheat (Abstract).


Bugbee*, B.
Characterization of gas exchange in plant growth chambers (Abstract).

Bugbee*, B.
Determining the potential productivity of food crops in controlled environments.

Bugbee*, B.
Exploring the limits of crop productivity: A model to evaluate progress.

Bugbee*, B.
Food production in controlled environments: Energy efficiency of crop plants (Abstract).

Bugbee*, B.
Hydroponics on the Moon.

Bugbee*, B.
Long-term seed storage.

Bugbee*, B.
A model for nutrient management in recirculating, liquid hydroponic culture (Abstract).

Bugbee*, B.
NASA's research to grow food in space: The CELSS Project.

Bugbee*, B.
Steady-state canopy gas exchange: System design and operation. 

Bugbee*, B.; Monje, O.
The limits of crop productivity: Validating theoretical estimates and determining the factors that limit crop yields in optimal environments. 

Bugbee*, B.G.; Salisbury*, F.B.
Controlled environment crop production: Hydroponic vs. lunar regolith.

Bugbee*, B.G.; Salisbury*, F.B.
Current and potential productivity of wheat for a Controlled Environment Life Support System. 
Bula, R.J.; Morrow, R.C.; Tibbitts*, T.W.; Barta, D.J.; Ignatius, R.W.; Martin, T.S.
Light-emitting diodes as a radiation source for plants.

Bula, R.J.; Morrow, R.C.; Tibbitts*, T.W.; Corey, R.B.
Technology for subsystems of space-based plant growth facilities.

Bula, R.J.; Tibbitts*, T.W.
Commercial involvement in space-based plant growing technology development (Abstract).

Bula, R.J.; Tibbitts*, T.W.; Morrow, R.C.; Dinauer, W.R.
Commercial involvement in the development of space-based plant growing technology.
*Advances in Space Research* 12(5): 5-10, 1992. (GWU 15199)

Cao, W.; Tibbitts*, T.
Magnesium concentration effects on carbon dioxide exchange in potatoes (Abstract).
*Plant Physiology* 96(1, Suppl.): 133, 1991. (GWU 14288)

Cao, W.; Tibbitts*, T.
Physiological responses of potatoes to continuous irradiation (Abstract).
*Plant Physiology* 93(1, Suppl.): 138, 1990. (GWU 11697)

Cao, W.; Tibbitts*, T.W.
Broader pH range for potatoes with mixed N than with either NH₄ or NO₃ (Abstract).

Cao, W.; Tibbitts*, T.W.
Calcium concentration effect on growth, tuberization, and mineral accumulation in potatoes (Abstract).

Cao, W.; Tibbitts*, T.W.
Diurnal variation in nutrient uptake in potatoes (Abstract).

Cao, W.; Tibbitts*, T.W.
Effect of gradual temperature fluctuations on continuous irradiation injury in potatoes.

Cao, W.; Tibbitts*, T.W.
Effect of thermoperiods on growth and tuberization in potatoes (Abstract).

Cao, W.; Tibbitts*, T.W.
The effects of pH on growth and nutrient accumulation in potatoes grown with nitrate or ammonium (Abstract).
Cao, W.; Tibbitts*, T.W.
Growth, carbon dioxide exchange and mineral accumulation in potatoes grown at different magnesium concentrations.

Cao, W.; Tibbitts*, T.W.
NH₄/NO₃ mixtures enhance growth in potatoes (Abstract).

Cao, W.; Tibbitts*, T.W.
Nitrogen form and pH interaction on plant growth and mineral accumulation (Abstract).

Cao, W.; Tibbitts*, T.W.
Nutrient accumulation in potato plants grown in NFT at varied flow rates and solution concentrations (Abstract).
HortScience 25(9): 1151, 1990. (GWU 15221)

Cao, W.; Tibbitts*, T.W.
Photosynthetic responses of potatoes to K nutrition (Abstract).

Cao, W.; Tibbitts*, T.W.
Physiological responses in potato plants under continuous irradiation.

Cao, W.; Tibbitts*, T.W.
Potassium concentration effect on growth, gas exchange and mineral accumulation in potatoes.

Cao, W.; Tibbitts*, T.W.
Temperature cycling periods affect growth and tuberization in potatoes under continuous irradiation.

Cao, W.; Tibbitts*, T.W.
Uptake of N, P, K, Ca, and Mg at varied solution concentrations of each element (Abstract).

Carman, J.G.; Hess, J.R.; Bugbee*, B.
Cloning plant embryos by simulating ovular conditions in controlled environments (Abstract).

Expression of characteristics of ammonium nutrition as affected by pH of the root medium.

Controlled Ecological Life-Support System: Use of plants for human life-support in space.
A root moisture sensor for plants in microgravity (Abstract).
In: Abstracts, 29th Plenary Meeting of the Committee on Space Research, Washington, DC, August 28-September 5, 1992, p. 596. (GWU 15678)

Corey, K.A.; Wheeler, R.M. (Knott, W.M. = P.I.)
Gas exchange in NASA's biomass production chamber: A preprototype closed human life support system.

Carbon dioxide exchange of a wheat stand grown in NASA's Biomass Production Chamber (Abstract).
HortScience 25(9): 1151, 1990. (GWU 15223)

Effects of NaCl on metabolic heat evolution rates by barley roots.
Plant Physiology 90: 53-58, 1989. (GWU 10439)

Cushman, K.E.; Tibbitts*, T.W.
The ethylene-action inhibitor silver thiosulfate reduces continuous irradiation injury in potato (Abstract).

Cushman, K.E.; Tibbitts*, T.W.
Root-zone temperature effects on continuous irradiation injury on potato (Abstract).

Dreschel, T.W. (Knott, W.M. = P.I.)
Hydroponics.

Dreschel, T.W. (Knott, W.M. = P.I.)
Plant nutrient delivery system having a porous tubular member (Patent).

A prototype closed aquaculture system for controlled ecological life support applications.

Developing future plant experiments for spaceflight.

Development of a porous tube plant nutrient delivery system for the space shuttle mid-deck locker Plant Growth Unit (Abstract).
In: *Abstracts, 29th Plenary Meeting of the Committee on Space Research, Washington, DC, August 28-September 5, 1992*, p. 593. (GWU 15699)


Technologies for plant space biology investigations in the Space Shuttle mid-deck locker (Abstract).

Dreschel, T.W.; Cox, W.M.; Brown, C.S.; Knott*, W.M.
The Vacuum-Operated Nutrient Delivery System for hydroponics in space (Abstract).

Dreschel, T.W.; Sager, J.C. (Knott, W.M. = P.I.)
Control of water and nutrients using a porous tube: A method for growing plants in space.

Plant growth in a porous tube nutrient delivery system: The effects of pressure and pore size on productivity (Abstract).

Dreschel, T.W.; Wheeler, R.M.; Sager, J.C.; Knott*, W.M.
Factors affecting plant growth in membrane nutrient delivery.

Fortson, R.E.; Sager, J.C.; Bledsoe, J.O.; Wheeler, R.M.; Knott*, W.M.
Current performance of the NASA Biomass Production Chamber.

Frick, J.; Mitchell*, C.A.
Effects of nitrogen nutrition, timing of nitrogen application, and planting density on development and yield of *Brassica napus* (Abstract).

Frick, J.; Mitchell*, C.A.
Evaluation of dwarf rapid-cycling Brassica as a candidate oilseed crop for Controlled Ecological Life Support Systems (Abstract).

Frick, J.; Mitchell*, C.A.
Production of dwarf rapid-cycling brassica under optimizing environmental conditions (Abstract).
Frick, J.; Schonfeld, M.A.; Williams, P.H.; Mitchell*, C.A.

Fry, I.V.; Packer*, L.
Cyanobacteria in CELSS: Growth strategies for nutritional variation and nitrogen cycling.

Gale, J.; Smernoff, D.T.; Macler, B.A.; MacElroy*, R.D.
Carbon balance and productivity of *Lemna gibba*, a candidate plant for CELSS.

Galindo, C.; Henninger*, D.L.; Ming*, D.W.
The use of lunar simulants in plant growth experiments (Abstract).

Galindo, C.; Ming*, D.W.; Allen, E.A.; Henninger*, D.L.; Hossner, L.R.
Mineralogical and chemical properties of starting materials used in zeoponic plant growth systems (Abstract).

Galston*, A.W.
Photosynthesis as a basis for life support on Earth and in space: Photosynthesis and transpiration in enclosed spaces.

Garland, J.L. (Knott, W.M. = P.I.)
The structure and function of microbial communities in recirculating hydroponic systems (Abstract).

Garland, J.L.; Mackowiak, C.L. (Knott, W.M. = P.I.)

Garland, J.L.; Mackowiak, C.L.; Strayer, R.F. (Knott, W.M. = P.I.)
Utilization of the soluble fraction of cold water leachate from inedible wheat biomass in a Controlled Ecological Life Support System (Abstract).
*ASGSB Bulletin* 2: 37, 1989. (GWU 10423)

Golden, D.C.; Ming*, D.W.; Keller, L.P.
Synthetic micronutrient substituted apatites as direct application fertilizers (Abstract).

Granato, T.C.; Raper*, C.D., Jr.
Proliferation of maize (*Zea mays* L.) roots in response to localized supply of nitrate.
Granato, T.C.; Raper*, C.D., Jr.; Wilkerson, G.G.
Respiration rate in maize roots is related to concentration of reduced nitrogen and proliferation of lateral roots.
Physiologia Plantarum 76: 419-424, 1989. (GWU 11134)

Greene, C.; Bubenheim*, D.; Berry, W.
Lettuce seedling response to detergents recommended for space travel (Abstract).

Hardy, D.H.; Raper*, C.D., Jr.; Miner, G.S.
Chemical restrictions of roots in Ultisol subsoils lessened by long-term management.

Henninger*, D.L.; Galindo, C.; Allen, E.A.; Ming*, D.W.; Hossner, L.R.

Henninger*, D.L.; Galindo, C.; Ming*, D.W.
Dissolution of lunar simulants (Abstract).

Henninger*, D.L.; Ming*, D.W.
Solid support substrates for plant growth at a lunar outpost.

Henry, L.T.; Raper*, C.D., Jr.
Cyclic variations in nitrogen uptake rate of soybean plants.
Plant Physiology 91: 1345-1350, 1989. (GWU 10972)

Henry, L.T.; Raper*, C.D., Jr.
Effects of root-zone acidity on utilization of nitrate and ammonium in tobacco plants.

Henry, L.T.; Raper*, C.D., Jr.
Soluble carbohydrate allocation to roots, photosynthetic rate of leaves, and nitrate assimilation as affected by nitrogen stress and irradiance.

Henry, L.T.; Raper*, C.D., Jr.; Rideout, J.W.
Onset of and recovery from nitrogen stress during reproductive growth of soybean.

Hill, W.; Tibbits*, T.; Mackowiak, C.; Mortley, D.; Bonsi, C.; Loretan, P.; Morris, C.
Growing root and tuber crops hydroponically (Abstract).
Effects of environmental factors on sweetpotato growth (Abstract).
In: Abstracts, 29th Plenary Meeting of the Committee on Space Research, Washington, DC, August 28-September 5, 1992, p. 598. (GWU 15677)

Growing root, tuber and nut crops hydroponically for CELSS.

Hoehn, A.; Kliss*, M.H.; Luttges, M.W.; Robinson, M.C.; Stodieck, L.S.
Design and evaluation of a payload to support plant growth onboard COMET 1.

Hoenecke, M.E.; Bula, R.J.; Tibbitts*, T.W.
Importance of 'blue' photon levels for lettuce seedlings grown under red-light-emitting diodes.

Hoenecke, M.E.; Bula, R.J.; Tibbitts*, T.W.
Lettuce seedling response to red light-emitting diodes supplemented with varying levels of blue photons (Abstract).

Hossner, L.R.; Ming*, D.W.; Henninger*, D.L.; Allen, E.R.
Lunar outpost agriculture.

Huffaker*, R.C.
Proteolytic activity during senescence of plants.

Huffaker*, R.C.; Aslam, M.; Ward, M.R.
Efficiency of N use by wheat as a function of influx and efflux of NO3-.

Changes in membrane lipid composition during saline growth of the fresh water cyanobacterium Synechococcus 6311.
Plant Physiology 94: 1512-1521, 1990. (GWU 12503)

Irwin, T.W.; Tibbitts*, T.W.
Construction of P3 containment facilities for biotechnology research.
Paper presented at the 1990 International Summer Meeting of the American Society of Agricultural Engineers, Columbus, OH, June 24-27, 1990, 8 p. (ASAE Paper 904067) (GWU 15344)

Janik, D.; Macler, B.; Thorstenson, Y.; Sauer, R.; MacElroy*, R.D.
Effect of iodine disinfection products on higher plants.
Advances in Space Research 9(8): 117-120, 1989. (GWU 11692)
Karel*, M.
Advances in improving product quality by controlling conditions of processing and storage.

Karel*, M.
Advances in science and engineering: A challenge to food technology.

Karel*, M.
Focal issues in food science and engineering.

Karel*, M.
Future directions in food technology.

Karel*, M.
The future of irradiation applications on Earth and in space.
Food Technology 43(7): 95-97, 1989. (GWU 15286)

Karel*, M.
Impact of innovation in food technology on the use of refrigeration.

Karel*, M.
Physical structure and quality of dehydrated foods.

Karel*, M.; Lerici, C.R.
Factors affecting quality of processed fruit and vegetables: Scientific and technological aspects.

Karel*, M.; Nakhost, Z.

Khomutov, G.; Fry, I.V.; Huflejt, M.E.; Packer*, L.
Membrane lipid composition, fluidity, and surface charge changes in response to growth of the fresh water cyanobacterium Synechococcus 6311 under high salinity.
Archives of Biochemistry and Biophysics 277(2): 263-267, 1990. (GWU 14993)

Kliss*, M.; MacElroy*, R.D.
Salad Machine: A vegetable production unit for long duration space missions.
Knott*, W.M.
The Breadboard project: A functioning CELSS plant growth system.

Knott*, W.M.
The CELSS Breadboard Project: Plant production.
In: *Biological Life Support Technologies: Commercial Opportunities* (Nelson, M., Soffen, G., Eds.).

Knott*, W.M.
In: *Space Manufacturing 7: Space Resources to Improve Life on Earth*. Washington, DC: American
Institute of Aeronautics and Astronautics, p. 230-234, 1989. (GWU 16221)

Knott*, W.M.; Sager, J.C.; Wheeler, R.
Achieving and documenting closure in plant growth facilities.

Koontz, H.V.; Prince, R.P.; Berry, W.L. (Knott, W.M. = P.I.)
A porous stainless steel membrane system for extraterrestrial crop production.

Lim, J.T.; Gold, H.J.; Wilkerson, G.G.; Raper*, C.D., Jr.
A Monte Carlo/response surface strategy for sensitivity analysis: Application to a dynamic model of
vegetative plant growth.

Lim, J.T.; Raper*, C.D., Jr.; Gold, H.J.; Wilkerson, G.G.
Incorporation of measured photosynthetic rate in a mathematical model for calculation of non-
structural saccharide concentration.
*Photosynthetica* 23(4): 543-559, 1989. (GWU 15235)

Lim, J.T.; Wilkerson, G.G.; Raper*, C.D., Jr.; Gold, H.J.
A dynamic growth model of vegetative soya bean plants: Model structure and behaviour under varying
root temperature and nitrogen concentration.

Logendra, S.; Janes, H.W.; MacElroy*, R.
Factors affecting *in vitro* tomato fruit growth (Abstract).

Effects of elevated atmospheric carbon dioxide concentrations on water and acid requirements of
soybeans grown in a recirculating hydroponic system.
In: *Controlled Ecological Life Support Systems: CELSS '89 Workshop* (MacElroy, R.D., Ed.).

Effect of supraoptimal carbon dioxide concentrations on soybeans grown in controlled environments
(Abstract).
Mackowiak, C.L.; Wheeler, R.M.; Yorio, N.C. (Knott, W.M. = P.I.)
Increased leaf stomatal conductance at very high carbon dioxide concentrations (Abstract).

Macler, B.A.; MacElroy*, R.D.
Productivity and food value of Amaranthus cruentus under non-lethal salt stress.
Advances in Space Research 9(8): 135-139, 1989. (GWU 11693)

Shuttle locker-contained seed germination system (Abstract).

Mashinsky, A.L.; Ivanova, I.E.; Derendyaeva, T.A.; Nechitailo, G.S.; Salisbury*, F.B.
"From seed to seed" experiment with wheat plants under space flight conditions (Abstract).
In: Abstracts, 29th Plenary Meeting of the Committee on Space Research, Washington, DC, August 28-September 5, 1992, p. 592. (GWU 15691)

McKay, D.S.; Ming*, D.W.
Properties of lunar regolith.

Meyerhoff, P.A.; Huffaker*, R.C.
An EDTA-labile association between nitrate reductase and membranes (Abstract).
Plant Physiology 96(1, Suppl.): 104, 1991. (GWU 14294)

Ming*, D.; Stahl, R.; Henninger*, D.
Use of lunar regolith as a substrate for plant growth (Abstract).
In: Abstracts, 29th Plenary Meeting of the Committee on Space Research, Washington, DC, August 28-September 5, 1992, p. 602. (GWU 15689)

Ming*, D.W.; Allen, E.R.; Golden, D.C.
Fertilization by mineral dissolution and ion-exchange (Abstract).

Ming*, D.W.; Galindo, C.; Allen, E.A.; Henninger*, D.L.; Hossner, L.R.
Characterization of zeolite/phosphate rock substrate after zeoponic plant growth experiments: Exchangeable potassium, ammonium, and calcium (Abstract).

Ming*, D.W.; Galindo, C.; Henninger*, D.L.
Methods for determining cation exchange capacities and compositions of exchangeable cations for several natural zeolites (Abstract).

Ming*, D.W.; Henninger*, D.L. (Eds.)
Ming*, D.W.; Henninger*, D.L.
Lunar base agriculture: Synthetic soils for plant growth.

Ming*, D.W.; Henninger*, D.L.; Galindo, C.
Solid-support substrates for plant growth at a lunar base.
In: Controlled Ecological Life Support Systems: CELSS '89 Workshop (MacElroy, R.D., Ed.). Moffett

Ming*, D.W.; Lofgren, G.E.
Crystal morphologies of minerals formed by hydrothermal alteration of synthetic lunar basaltic glass.

Mitchell*, C.A.
Measurement of photosynthetic gas exchange in controlled environments.

Mitchell*, C.A.
Modification of plant growth and development by acceleration and vibration: Concerns and
opportunities for plant experimentation in orbiting spacecraft (Abstract).
In: Abstracts, Twenty-Eighth Plenary Meeting of the Committee on Space Research, The Hague,
The Netherlands, June 25-July 6, 1990, p. 59. (GWU 15042)

Mitchell*, C.A.; Leakakos, T.; Ford, T.L.
Modification of yield and chlorophyll content in leaf lettuce by HPS radiation and nitrogen treatments.

Mitchell*, C.A.; Nielsen, S.S.
Environmental modification of yield and food composition of leaf lettuce (Abstract).
HortScience 24(Suppl.): 96, 1989. (GWU 16367)

Mitchell*, C.A.; Nielsen, S.S.; Bubenheim*, D.L.
Environmental modification of yield and food composition of cowpea and leaf lettuce.
In: Controlled Ecological Life Support Systems: CELSS '89 Workshop (MacElroy, R.D., Ed.). Moffett

Monje, O.A.; Bugbee*, B.
Design and calibration of a meter for in-flight measurements of chlorophyll (Abstract).

Monje, O.A.; Bugbee*, B.
Inherent limitations of nondestructive chlorophyll meters: A comparison of two types of meters.

Monje, O.A.; Bugbee*, B.
Monitoring and control of plant growth in a CELSS (Abstract).

Monje, O.A.; Bugbee*, B.
Uses of canopy gas exchange in CELSS research (Abstract).
Morrow, R.C.; Bula, R.J.; Corey, R.B.; Tibbitts*, T.W.; Richards, E.E.
A porous-tube nutrient delivery system for plant growth in space (Abstract).
*ASGSB Bulletin 2: 35, 1989. (GWU 15119)

Morrow, R.C.; Bula, R.J.; Tibbitts*, T.W.
Light emitting diodes as a photosynthetic irradiance source for plants (Abstract).

Morrow, R.C.; Bula, R.J.; Tibbitts*, T.W.; Dinauer, W.R.
The ASTROCULTURE™ flight experiment series, validating technologies for growing plants in space (Abstract).
In: Abstracts, 29th Plenary Meeting of the Committee on Space Research, Washington, DC, August 28-September 5, 1992, p. 592. (GWU 15686)

Morrow, R.C.; Bula, R.J.; Tibbitts*, T.W.; Dinauer, W.R.
A matrix-based porous tube water and nutrient delivery system.

Morrow, R.C.; Dinauer, W.R.; Bula, R.J.; Tibbitts*, T.W.
ASTROCULTURE-1, a middeck flight experiment to evaluate nutrient delivery in microgravity (Abstract).

Morrow, R.C.; Vignali, J.C.; DeLuca, J.G.; Bula, R.J.; Tibbitts*, T.W.
ASTROCULTURE™ nutrient delivery hardware evaluations during parabolic flight tests (Abstract).

Nakhost, Z.; Karel*, M.
Potential utilization of algal protein concentrate as a food ingredient in space habitats.
Sciences des Aliments 9: 491-506, 1989. (GWU 11152)

Nitschmann, W.H.; Packer*, L.
NMR studies on Na⁺ transport in Synchococcus PCC 6311.

Ohler, T.A.; Mitchell*, C.A.
Evaluation of cowpea (Vigna unguiculata L. Walp) as a candidate species for inclusion in bioregenerative life-support systems (Abstract).

Owens, L.P.; Hall, C.R. (Knott, W.M. = P.I.)
Biomass production and nitrogen dynamics in an integrated aquaculture/agriculture system.

Petersen*, G.R.; Baresi, L.
The conversion of lignocellulosics to fermentable sugars: A survey of current research and application to CELSS.
Petersen*, G.R.; Baresi, L.
The conversion of lignocellulosics to fermentable sugars: A survey of current research and applications to CELSS.

Petersen*, G.R.; Seshan, P.K.; Dunlop, E.H.
Phase separated membrane bioreactor: Results from model system studies.

Tomato plant growth on a CELSS tubular membrane growth unit (Abstract).

Prince, R.P.; Knott*, W.M., III
CELS Breadboard Project at the Kennedy Space Center.

Raper*, C.D.; Tolley-Henry, L.

Increase in nitrate uptake by soybean plants during interruption of the dark period with low intensity light.

Cyclic variations in nitrogen uptake rate of soybean plants: Effects of pH and mixed nitrogen sources.

A novel membrane device for the removal of water vapor and water droplets from air.

Rideout, J.W.; Raper*, C.D., Jr.; Miner, G.S.
Changes in ratio of soluble sugars and free amino nitrogen in the apical meristem during floral transition of tobacco.

Roos, Y.; Karei*, M.
Applying state diagrams to food processing and development.

Ross, C.W.; Hendrix, J.E.; Sadeh*, W.Z.
Space agricultural sciences: An emerging discipline (Abstract).
In: Abstracts, 29th Plenary Meeting of the Committee on Space Research, Washington, DC, August 28-September 5, 1992, p. 543. (GWU 15696)
Ross, C.W.; Hendrix, J.E.; Sadeh*, W.Z.; Cornett, D.J.
Fluid management in a closed plant growth chamber (Abstract).
In: Abstracts, 29th Plenary Meeting of the Committee on Space Research, Washington, DC, August 28-September 5, 1992, p. 600. (GWU 15695)

Rupp, L.A.; Bugbee*, B.G.; Frisby, J.W.
A comparison of greenhouse cooling techniques (Abstract).

Sager, J.C.; Knott*, W.M.; Buchanan, P.
The Breadboard project: A functioning CELSS plant growth system (Abstract).

Sager, J.C.; Wheeler, R.M. (Knott, W.M. = P.I.)
Application of sunlight and lamps for plant irradiation in space bases.

Salisbury*, F.B.
Achieving maximum wheat yields in stress-free environments.

Salisbury*, F.B.
Biogenerative life-support system: Farming on the moon.

Salisbury*, F.B.
Farming on the moon: Reaching the potential of crop productivity.

Salisbury*, F.B.
Lunar farming: Achieving maximum crop yield for exploration of space (Abstract).
HortScience 25(9): 1023, 1990. (GWU 14013)

Salisbury*, F.B.
Lunar farming: Achieving maximum yield for the exploration of space.

Salisbury*, F.B.
Preparatory space experiments for development of a CELSS.

Salisbury*, F.B.; Gillespie, L.
Growth of super-dwarf wheat under low irradiance in preparation for two space-flight experiments (Abstract).

Salisbury*, F.B.; Gillespie, L.
Preparations for two space-flight experiments with a super-dwarf wheat cultivar (Abstract).
Plant Physiology 99(1, Suppl.): 34, 1992. (GWU 14935)
Salisbury*, F.B.; Gillespie, L.; Bingham, G.E.
Preparations for a CELSS flight experiment with wheat (Abstract).
In: Abstracts, 29th Plenary Meeting of the Committee on Space Research, Washington, DC, August 28-September 5, 1992, p. 592. (GWU 15692)

Salisbury*, F.B.; Gillespie, L.S.; Bugbee*, B.G.
Preparatory experiments with a super-dwarf wheat cultivar for flight experiments (Abstract).

Salisbury*, F.B.; Ross, C.W. (Eds.)

Sawhney, R.K.; Applewhite, P.B.; Galston*, A.W.
Plant regeneration from thin cell layers of tomato flower pedicels (Abstract).
Plant Physiology 99(1, Suppl.): 49, 1992. (GWU 14985)

Schönfeld, M.; Mitchell*, C.A.
Cowpea harvest scenarios and edible biomass production under controlled environments (Abstract).
HortScience 25(9): 1151, 1990. (GWU 15341)

Schuerger, A.C.; Brown, C.S. (Knott, W.M. = P.I.)
Spectral quality may be used to alter plant disease development in CELSS (Abstract).
In: Abstracts, 29th Plenary Meeting of the Committee on Space Research, Washington, DC, August 28-September 5, 1992, p. 604. (GWU 15698)

Schwartzkopf*, S.
Hazard and risk assessment for surface components of a lunar base Controlled Ecological Life Support System.

Schwartzkopf*, S.H.; Mancinelli, R.L.
Germination and growth of wheat in simulated Martian atmospheres.

Schwartzkopf*, S.H.; Oleson, M.W.; Cullingford*, H.S.
Conceptual design of a closed loop nutrient solution delivery system for CELSS implementation in a micro-gravity environment.

Schwartzkopf*, S.H.; Oleson, M.W.; Cullingford*, H.S.
Conceptual design of a closed loop nutrient solution delivery system for CELSS implementation in a micro-gravity environment.

Schwartzkopf*, S.H.; Oleson, M.W.; Cullingford*, H.S.
Conceptual design of an experimental, closed loop nutrient solution delivery system for supporting higher plants in microgravity environments (Abstract).

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Smernoff, D.T.; MacElroy*, R.D.
Use of Martian resources in a Controlled Ecological Life Support System (CELSS).

Spanarkel, B.; Johnson, S.; Bugbee*, B.
CO$_2$ toxicity to crop plants in optimal environments (Abstract).

Stahl, R.; Rykiel, E.; Henninger*, D.
Plant growth at reduced atmospheric pressure (Abstract).

Strayer, R. (Knott, W.M. = P.I.)
Dynamics of microorganism populations in recirculating nutrient solutions (Abstract).

Strayer, R.F. (Knott, W.M. = P.I.)

Strayer, R.F.; Brannon, M.A.; Garland, J.L. (Knott, W.M. = P.I.)
Use of inedible wheat residues from the KSC-CELSS Breadboard Facility for production of fungal cellulase.

Stroup, T.; Schwartzkopf*, S.
Crop interactions in polyculture and their implications for CELSS design.

Stroup, T.L.; Schwartzkopf*, S.H.; Marchin, G.L.
Iodine microbial control of hydroponic nutrient solution.

Takahashi, H.; Brown, C.S.; Dreschel, T.W.; Scott, T.K. (Knott, W.M. = P.I.)
Hydrotropism in pea roots in a porous-tube water delivery system.

Takahashi, H.; Brown, C.S.; Dreschel, T.W.; Scott, T.K. (Knott, W.M. = P.I.)
Root hydrotropism in a porous tube-water delivering system (Abstract).

Tibbitts*, T.W.
Hydroponic culture of plants in space.
Tibbitts*, T.W.
Plant considerations for lunar base agriculture.

Tibbitts*, T.W.; Bennett, S.M.
Avoidance of continuous light injury of potatoes using cycling temperatures (Abstract).
HortScience 24(Suppl.): 96, 1989. (GWU 16368)

Tibbitts*, T.W.; Bennett, S.M.; Cao, W.
Control of continuous irradiation injury on potatoes with daily temperature cycling.
Plant Physiology 93: 409-411, 1990. (GWU 12117)

Tibbitts*, T.W.; Bennett, S.M.; Morrow, R.C.
Environmental and cultural considerations for growth of potatoes in CELSS.

Tibbitts*, T.W.; Bennett, S.M.; Morrow, R.C.; Bula, R.J.
Utilization of white potatoes in CELSS.

Tibbitts*, T.W.; Bula, R.J.
Application of light emitting diodes for plant irradiation in space bases (Abstract).

Tibbitts*, T.W.; Bula, R.J.
Growing plant in space.

Tibbitts*, T.W.; Bula, R.J.; Morrow, R.C.; Corey, R.B.; Barta, D.J.
Requirements and technologies for automated plant growth systems on space bases.

Tibbitts*, T.W.; Cao, W.
Advantages of a soil material for tuber development of potatoes (Abstract).
In: Abstracts, 29th Plenary Meeting of the Committee on Space Research, Washington, DC, August 28-September 5, 1992, p. 602. (GWU 15685)

Tibbitts*, T.W.; Cao, W.
CO2 and temperature interaction on growth of three potato cultivars (Abstract).

Tibbitts*, T.W.; Cao, W.
CO2 interaction with irradiance and temperature in potatoes (Abstract).
In: Abstracts, 29th Plenary Meeting of the Committee on Space Research, Washington, DC, August 28-September 5, 1992, p. 597. (GWU 15684)

Tibbitts*, T.W.; Cao, W.
Comparison of nutrient film procedures for potato growth (Abstract).
Tibbitts*, T.W.; Cao, W.
Within-canopy lighting with light pipes (Abstract).

Tibbitts*, T.W.; Cao, W.; Bennett, S.M.
Utilization of potatoes for life support in space. V. Evaluation of cultivars in response to continuous light and high temperature.

Evidence for a plasma-membrane-bound nitrate reductase involved in nitrate uptake of Chlorella sorokiniana.


Velasco, P.J.; Tischner, R.; Huffaker*, R.C.; Whitaker, J.R.
Synthesis and degradation of nitrate reductase during the cell cycle of Chlorella sorokiniana.
Plant Physiology 89: 220-224, 1989. (GWU 9764)

Effect of root-zone pH on the uptake of nitrogen from nitrate and ammonium sources by soybean plants in hydroponic culture (Abstract).
Plant Physiology 89(4, Suppl.): 18, 1989. (GWU 11012)

Root-zone acidity affects relative uptake of nitrate and ammonium from mixed nitrogen sources.

Nitrogen nutrition and temporal effects of enhanced carbon dioxide on soybean growth.

Vessey, J.K.; Raper*, C.D., Jr.; Henry, L.T.
Cyclic variations in nitrogen uptake rate in soybean plants: Uptake during reproductive growth.

Vessey, J.K.; Raper*, C.D., Jr.; Henry, L.T.
Effect of ammonium sulfate, ammonium chloride and root-zone acidity on inorganic ion content of tobacco.

Volk, G.M.; Corey, K.A.; Wheeler, R.M.; Sager, J.C. (Knott, W.M. = P.I.)
Effects of environmental variables on carbon dioxide exchange rates of a soybean stand grown in NASA’s biomass production chamber (Abstract).

Volk, G.M.; Mitchell*, C.A.
Parameters evaluated in the rice (Oryza sativa L.) cultivar selection for inclusion in a Controlled Ecological Life Support System (Abstract).
ASGSB Bulletin 6(1): 37, 1992. (GWU 15897)
Volk*, T.; Bugbee*, B.
Modeling light and temperature effects on leaf emergence in wheat and barley.

Volk*, T.; Rummel*, J.D.
The case for cellulose production on Mars.

Volk*, T.; Rummel*, J.D.
Transpiration during life cycle in controlled wheat growth.
_Advances in Space Research_ 9(8): 61-64, 1989. (GWU 11688)

Volk*, T.; Rummel*, J.D.
Transpiration during life cycle in controlled wheat growth.

Wade, R.C. (Bredt, J. = P.I.)

Latent nitrate reductase activity is associated with the plasma membrane of corn roots.

Warner, R.L.; Huffaker*, R.C.
Nitrate transport is independent of NADH and NAD(P)H nitrate reductases in barley seedlings.
_Plant Physiology_ 91: 947-953, 1989. (GWU 10973)

Waterer, J.G.; Vessey, J.K.; Raper*, C.D., Jr.
Stimulation of nodulation in field peas (<i>Pisum sativum</i>) by low concentrations of ammonium in hydroponic culture.

Wheeler, R.M. (Knott, W.M. = P.I.)
Gas-exchange measurements using a large, closed plant growth chamber.

Wheeler, R.M.; Corey, K.A.; Sager, J.C.; Mackowiak, C.L.; Knott*, W.M.
Gas exchange rates by a stand of soybeans grown in a tightly sealed chamber (Abstract).
_HortScience_ 25(9): 1151, 1990. (GWU 15220)

Wheeler, R.M.; Corey, K.A.; Vieux, B.A.; Mosakowski, S.W.; Sager, J.C.; Knott*, W.M.
Ethylene evolution by crop stands grown in a closed, controlled environment (Abstract).

Wheeler, R.M.; Mackowiak, C.L.; Sager, J.C. (Knott, W.M. = P.I.)
Effect of high pressure sodium (HPS) radiation on stem elongation of soybean (Abstract).
_HortScience_ 24(Suppl.): 84, 1989. (GWU 16542)
Wheeler, R.M.; Mackowiak, C.L.; Sager, J.C. (Knott, W.M. = P.I.)

Wheeler, R.M.; Mackowiak, C.L.; Sager, J.C. (Knott, W.M. = P.I.)

Wheeler, R.M.; Mackowiak, C.L.; Sager, J.C.; Knott*, W.M.
Effects of atmospheric CO2 on photosynthetic characteristics of soybean leaves.

Wheeler, R.M.; Mackowiak, C.L.; Sager, J.C.; Knott*, W.M.
Growth of soybean and potato at high CO2 partial pressures (Abstract).

Wheeler, R.M.; Mackowiak, C.L.; Sager, J.C.; Knott*, W.M.
Proximate nutritional composition of CELSS crops grown at different CO2 partial pressures (Abstract).

*ASGSB Bulletin* 2: 37, 1989. (GWU 10421)

Potato growth and yield using nutrient film technique (NFT).

Growth of a lettuce crop in NASA's Biomass Production Chamber (Abstract).

Effect of high carbon dioxide concentrations on potatoes grown in controlled environments (Abstract).

Wheeler, R.M.; Sager, J.C. (Knott, W.M. = P.I.)

Wheeler, R.M.; Tibbitts*, T.W.
Utilization of potatoes for life support systems in space. IV. Effect of CO2 enrichment.

Wheeler, R.M.; Tibbitts*, T.W.; Fitzpatrick, A.H.
Carbon dioxide effects on potato growth under different photoperiods and irradiance.
Wheeler, R.M.; Tibbitts*, T.W.; Fitzpatrick, A.H. 
Potato growth in response to relative humidity. 
*HortScience* 24(3): 482-484, 1989. (GWU 11136)

Wignarajah, K.; Bubenheim*, D.; Wydeven*, T., Jr.; Berry, W.; Schlick, G. 
Growth of lettuce in anionic surfactants (Abstract). 

Williams, K.M.; Scheld, H.W.; Prince, R.P.; Knott*, W.M. 
A computer controlled nutrient delivery system for micro-gravity biosystems (Abstract). 
*ASGSB Bulletin* 2: 35, 1989. (GWU 10426)

Yorio, N.C.; Wheeler, R.M.; Weigel, R.C. (Knott, W.M. = P.I.) 
Barzana, E.; Klibanov, A.M.; Karel*, M.
A colorimetric method for the enzymatic analysis of gases: The determination of ethanol and formaldehyde vapors using solid alcohol oxidase.

Boyle, M.; Ford, T.; Maki, J.S.; Mitchell*, R.
Biofilms and the survival of opportunistic pathogens in recycled water.

Boyle, M.; Ford, T.; Mitchell*, R.; Maki, J.
Survival of pathogenic bacteria under nutrient starvation conditions.

Bubenheim*, D.L.; Wydeven*, T.
In: *Abstracts, 29th Plenary Meeting of the Committee on Space Research, Washington, DC, August 28-September 5, 1992*, p. 595. (GWU 15694)

Dean, R.B.; Golub, M.A.; Wydeven*, T. (Eds.)
Waste Management in Space: A NASA symposium (Special Issue)


Ford, T.; Maki, J.S.; Mitchell*, R.
Biodeterioration of materials in water reclamation systems.

Ford, T.; Mitchell*, R.
Corrosion consequences of microfouling in water reclamation systems.

Characterization of exopolymers of aquatic bacteria by pyrolysis-mass spectrometry.

Friedman, M.A.; Styczynski, T.E.; Schwartzkopf*, S.H.; Teimat, B.W.; Teimat, M.C.
Gray water recycling with a unique vapor compression distillation (VCD) design.

George, C.E.; Cullingford*, H.S.
Microwave irradiation of cellulose and enzymatic hydrolysis of waste paper for long space missions.


Verostko, C.E.; Packham, N.J.C.; Henninger*, D.L.  

Impact of diet on the design of waste processors in CELSS.  

Williams, D.W.; Kull, R.; Schwartzkopf*, S.H.  
Anaerobic treatment of organic wastes from Controlled Ecological Life Support Systems.  

Wydeven*, T.; Golub, M.A.  
Waste streams in a crewed space habitat.  

Wydeven*, T.; Tremor, J.; Koo, C.; Jacquez, R.  
Sources and processing of CELSS wastes.  
SYSTEMS MANAGEMENT
AND CONTROL
Averner*, M.M.
Controlled ecological life support system.

Averner*, M.M.
The NASA CELSS program.

Bates, M.E.; Bubenheim*, D.L.
Applications of CELSS technology to Controlled Environment Agriculture.

Black, K.M.; Blackwell*, C.C.
A relaxed mismatch criterion for reducing conservatism in a Lyapunov stability analysis.

Blackwell*, A.L.
A perspective on CELSS control issues.

Blackwell*, A.L.; Blackwell*, C.C.
Development of a model for control of the NASA CELSS crop growth research chamber.

Blackwell*, A.L.; Blackwell, C.C.
A modeling system for control of the thermal and fluid dynamics of the NASA CELSS Crop Growth Research Chamber.

Blackwell*, C.
Synthesis of disturbance attenuating, noise rejecting regulator control via the matrix Riccati equation.

Blackwell*, C.C.
Control system design concepts.

Blackwell*, C.C.
Robustness analysis in the time domain and output space.

Blackwell*, C.C.; Blackwell*, A.L.
CELSS system control: Issues, methods, and directions.
Blackwell*, C.C.; Blackwell*, A.L.

Blackwell*, C.C.; Ha, C.M.
Model reference adaptive control of nominally linear uncertain deterministic systems (Abstract).

Blackwell*, C.C.; Yu, I.H.
The impact of the choice of gains on the robustness of control systems and observers.

Bubenheim*, D.
CELSS Research and Development Program.

Bubenheim*, D.L.; Straight, C.L.; Luna, P.M.; Wagenbach, K.M.; Haslerud, M.
The Crop Growth Research Chamber: A ground-based facility for CELSS research.

Buchanan*, P.
NASA closed ecological life support system (CELSS) research project.

Chamberland, D. (Knott, W.M. = P.I.)
Advanced life support systems in lunar and martian environments utilizing a higher plant based engineering paradigm.

Clark, C.A.; Henninger*, D.L.
Controlled Ecological Life Support Systems development at NASA’s Johnson Space Center (Abstract).
American Journal of Botany 79(6, Suppl.): 73, 1992. (GWU 15350)

Cullingford*, H.S.
Development of the CELSS Emulator at NASA JSC.

Cullingford*, H.S.
Development of the CELSS Emulator at NASA JSC.

Cullingford*, H.S.; Bennett, W.P.; Holley, W.A.; Carnes, J.G.; Jones, P.S.
CELSS simulations for a lunar outpost.
Cullingford*, H.S.; Schwartzkopf*, S.H.
Conceptual design for a Lunar-Base CELSS.

Drysdale, A.; Thomas, M.; Fresa, M.; Wheeler, R. (Knott, W.M. = P.I.)
OCAM - A CELSS modeling tool: Description and results.

Edeen, M.; Henninger*, D.

Farrance, M.A.; Tremor, J.; Straight, C.L.; MacElroy*, R.D.
Use of CELSS Test Facility for crop productivity research in microgravity: Engineering challenges (Abstract).

Fortson, R.E.; Sager, J.C.; Bledsoe, J.O.; Wheeler, R.M.; Knott*, W.M.
Performance and reliability of the CELSS biomass production chamber (Abstract).
In: Abstracts, 29th Plenary Meeting of the Committee on Space Research, Washington, DC, August 28-September 5, 1992, p. 599. (GWU 15681)

Henninger*, D.; Barta, D.; Stahl, R.
Regenerative life support systems: Why do we need them? (Abstract)
In: Abstracts, 29th Plenary Meeting of the Committee on Space Research, Washington, DC, August 28-September 5, 1992, p. 601. (GWU 15690)

Henninger*, D.L.
Life support systems research at the Johnson Space Center.

Controlled Ecological Life Support Systems (CELSS) flight experimentation (Abstract).
In: Abstracts, 29th Plenary Meeting of the Committee on Space Research, Washington, DC, August 28-September 5, 1992, p. 593. (GWU 15697)

Knott*, W.M.

Knott*, W.M.; Bubenheim*, D.L.
Providing effective closure in plant growth facilities (Abstract).
Knott*, W.M.; Sager, J.C.
Monitoring and control technologies for bioregenerative life support systems/CELSS.
(NASA-CP-3109) (GWU 14303)

MacElroy*, R.D.
The Controlled Ecological Life Support Systems (CELSS) research program.

MacElroy*, R.D. (Ed.)

MacElroy*, R.D.; Kliss*, M.; Straight, C.
Life support systems for Mars transit.
Advances in Space Research 12(5): 159-166, 1992. (GWU 15206)

MacElroy*, R.D.; Kliss*, M.; Straight, C.L.
A feasible life support system for a trip to Mars: Physical chemical and biological methods (Abstract).

MacElroy*, R.D.; Straight, C.L.
The CELSS Test Facility project: An example of a CELSS flight experiment system.
Advances in Space Research 12(5): 75-81, 1992. (GWU 15201)

MacElroy*, R.D.; Straight, C.L.
The ECLSS/FEAST project: An example of a flight experiment system (Abstract).

MacElroy*, R.D.; Thompson, B.G.; Tibbitts*, T.W.; Volk*, T. (Eds.)

MacElroy*, R.D.; Tibbitts*, T.W.; Thompson, B.G.; Volk*, T. (Eds.)
Natural and Artificial Ecosystems.

MacElroy*, R.D.; Tremor, J.; Bubenheim*, D.L.; Gale, J.
The CELSS research program: A brief review of recent activities.

MacElroy*, R.D.; Wydeven*, T., Jr.
Bio-regenerative life support.
Miller, A.M.; Edeen, M.; Sirko, R.J. (Henninger, D.L. = P.I.)
Plant growth modeling at the JSC variable pressure growth chamber: An application of experimental design.

Biomass productivity and sustainability of a bioregenerative life-support system.

Petersen*, G.R.; Seshan, P.K.
Model system studies with a phase separated membrane bioreactor.

Roberts, D.R.; Andersen, D.T.; McKay*, C.P.; Wharton, R.A., Jr.; Rummel*, J.D.
Antarctic analogs as a testbed for regenerative life support technologies.

Rummel*, J.D.
Development of life support requirements for long-term space flight (Abstract).
In: Abstracts, Twenty-Eighth Plenary Meeting of the Committee on Space Research, The Hague, The Netherlands, June 25-July 6, 1990, p. 82. (GWU 14458)

Rummel*, J.D.
Life support for solar systems exploration (Abstract).
Aviation, Space, and Environmental Medicine 61(5): 475, 1990. (GWU 14278)

Rummel*, J.D.
Long term life support for space exploration.

Rummel*, J.D.
Towards a Mars base: Critical steps for life support on the moon and beyond.

Rummel*, J.D.; Averner*, M.
Bioregenerative life support: The initial CELSS reference configuration.

Sager, J.; Drysdale, A.; Thomas, M. (Knott, W.M. = P.I.)
Object-oriented model-driven control (Abstract).
In: Abstracts, 29th Plenary Meeting of the Committee on Space Research, Washington, DC, August 28-September 5, 1992, p. 601. (GWU 15674)

Salisbury*, F.B.
Some challenges in designing a lunar, Martian, or microgravity CELSS.
Schwartzkopf*, S.
A closed-loop nutrient solution delivery system flight experiment (Abstract).
In: Abstracts, 29th Plenary Meeting of the Committee on Space Research, Washington, DC, August 28-September 5, 1992, p. 593. (GWU 15683)

Schwartzkopf*, S.H.
Design of a controlled ecological life support system.

Schwartzkopf*, S.H.; Brown, M.F.
Evolutionary development of a lunar CELSS.

Schwartzkopf*, S.H.; Brown, M.F.; Styczynski, T.E.
Evolutionary development of a lunar CELSS.

Seshan, P.K.; Petersen*, G.R.
Design challenges for space bioreactors.

Sirko, R.J.; McCormack, A.C.; Edeen, M.A. (Henninger, D.L. = P.I.)
Plant canopy transpiration in bioregenerative life support systems: The link between mechanistic and empirical models.

Straight, C.L.; MacElroy*, R.D.
The CELSS Test Facility: A foundation for crop research in space.

Tri, T.; Edeen, M.; Henninger*, D.
Development of a monitoring and control strategy for NASA's human rated regenerative life support systems test facility (Abstract).
In: Abstracts, 29th Plenary Meeting of the Committee on Space Research, Washington, DC, August 28-September 5, 1992, p. 599-600. (GWU 15688)

Regenerative Life Support Systems (RLSS) development at NASA-Johnson Space Center.

Tri, T.O.; Thompson, C.D. (Henninger, D.L. = P.I.)
Development of the advanced life support Systems Integration Research Facility at NASA's Johnson Space Center.
Wheeler, R.M. (Knott, W.M. = P.I.)
NASA's Biomass Production Chamber: A tool for Controlled Ecological Life Support System (CELSS) crop studies.


Wilson, T.A.; Blackwell*, C.C.
The constrained Lyapunov problem applied to the case of a linear plant with an ad hoc linear output feedback nominal stabilizing controller.

Yendler, B.S. (MacElroy, R. = P.I.)
An approach to the functional optimization of the CELSS Test Facility.
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Abstract:
Publications of research sponsored by the NASA CELSS (Controlled Ecological Life Support System) Program are listed. The CELSS Program encompasses research and technology with the goal of developing an autonomous bioregenerative life support system, which is based upon the integration of biological and physical/chemical processes, and that will produce nutritious and palatable food, potable and hygienic water, and a breathable atmosphere by recycling metabolic and other wastes. This research and technology development is being performed in the areas of Biomass Production/Food Processing, Waste Management, and Systems Management and Control. The bibliography follows these divisions. Principal investigators whose research tasks resulted in publication are identified by an asterisk. Publications are identified by a record number corresponding with their entry in the Life Sciences Bibliographic Database, maintained at the George Washington University.

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closed ecological systems, food processing, phytotrons, waste treatment, systems integration, biotechnology biological models

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