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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.; Tibbitts*, T.W.
Characteristics of light emitting diodes for use as a photosynthetic irradiance source for plants (Abstract).

Barta, D.J.; Bula, R.J.; Tibbitts*, 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)

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).
Porous Tube Plant Nutrient Delivery System development: A device for nutrient delivery in
microgravity (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.
In: Controlled Ecological Life Support Systems: CELSS '89 Workshop (MacElroy, R.D., Ed.). Moffett

Fortson, R.E.; Sager, J.C.; Bledsoe, J.O.; Wheeler, R.M.; Knott*, W.M.
Current performance of the NASA Biomass Production Chamber.
Paper presented at the 1992 International Summer Meeting of the American Society of Agricultural

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

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 Lemma gibba, a candidate plant for CELSS.

Galindo, C.; Henning*, 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).
In: Abstracts, 29th Plenary Meeting of the Committee on Space Research, Washington, DC, August 28-September 5, 1992, p. 604-605. (GWU 15675)

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 (Ze a 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.; Tibbatts*, 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.

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).

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.

Monje, O.A.; Bugbee*, B.
Design and calibration of a meter for in-flight measurements of chlorophyll (Abstract).
*ASGSB Bulletin* 3(1): 57, 1989. (GWU 12075)

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 Synechococcus 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.

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