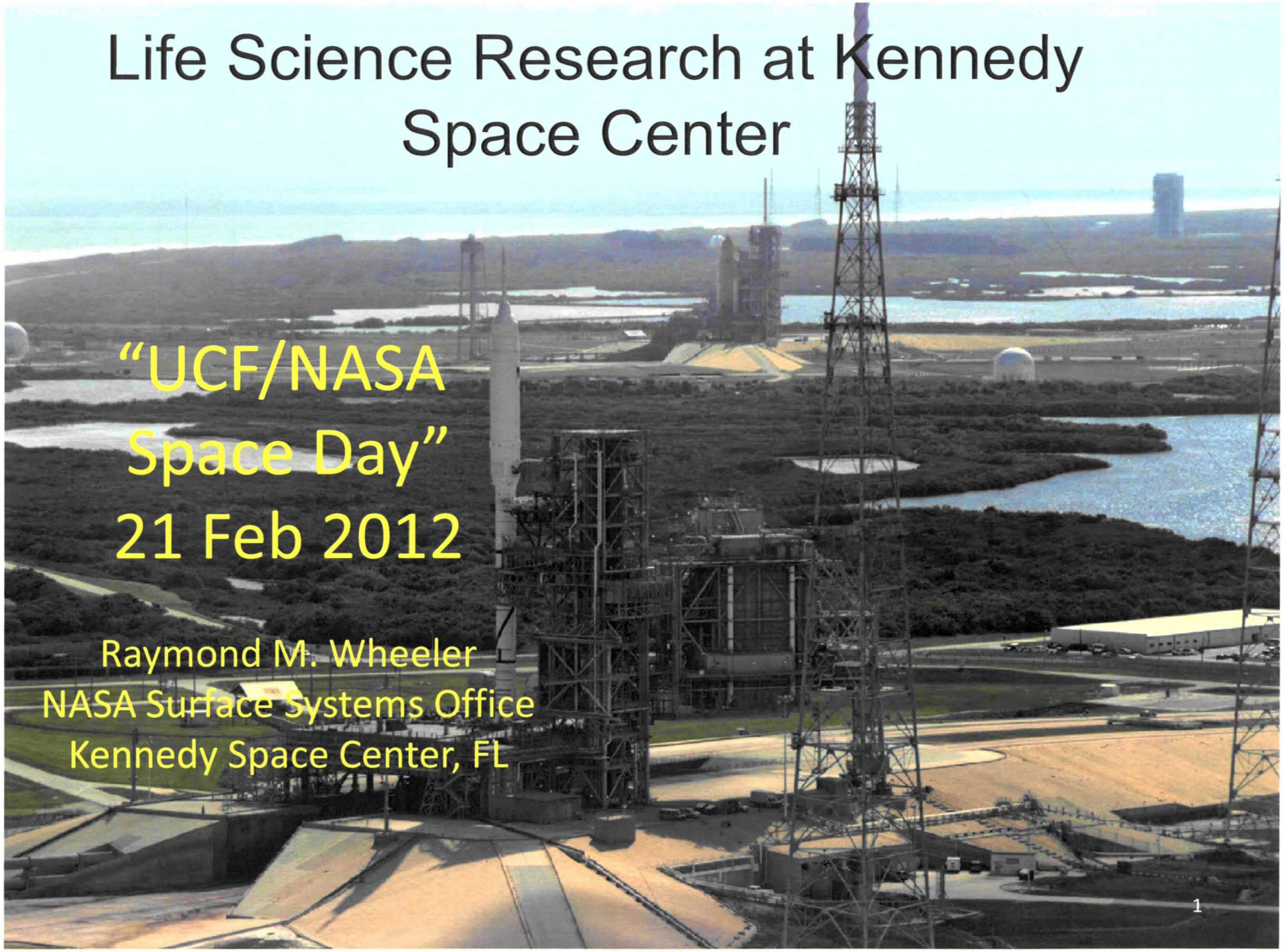
Life Science Research at Kennedy Space Center



"UCF/NASA Space Day"
21 Feb 2012

Raymond M. Wheeler
NASA Surface Systems Office
Kennedy Space Center, FL

KSC Life Sciences: Background

- KSC has been the Agency's lead for testing bioregenerative life support technology from ca. 1985 to the present
  - Controlled environment crop production testing
  - Solid waste processing / recycling
  - Wastewater processing / recycling
  - Environmental monitoring and control technology
  - Microbial characterization and management
- Support of life science payload development, processing and management from ca. 1985 to present, and the agency's lead center for plant research payloads
  - 53 KSC life science payloads since 1989 (beginning with STS 29)
  - Includes flight hardware development for biological research
- Provide ecological research / information for conducting launch operations on Merritt Island National Wildlife Refuge

Life Science Resources and Users:

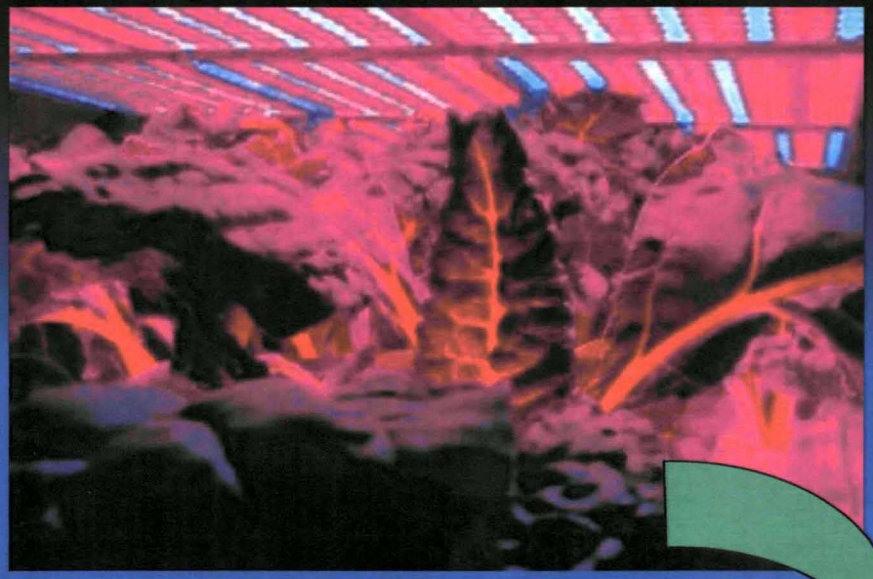
- Space Life Sciences Laboratory
  - Microbiology Lab
  - Biochemical Analytical Chemistry Lab
  - Molecular Biology Lab
  - Controlled Environment Laboratory
  - Life Science Payload Engineering Team
- Co-Location with University of Florida IFAS faculty (microbiologists, pathologists)
- CASIS -- Center for the Advancement of Science in Space / Space Florida for the ISS National Lab Program
- Access to μ–gravity launch support and testing
  - Parabolic flights, suborbital flights, free flyers, access to ISS
- Commercial Users; e.g., Petro Algae Corp., Burnham Institute, Monsanto Comp., Lighting Sciences Group

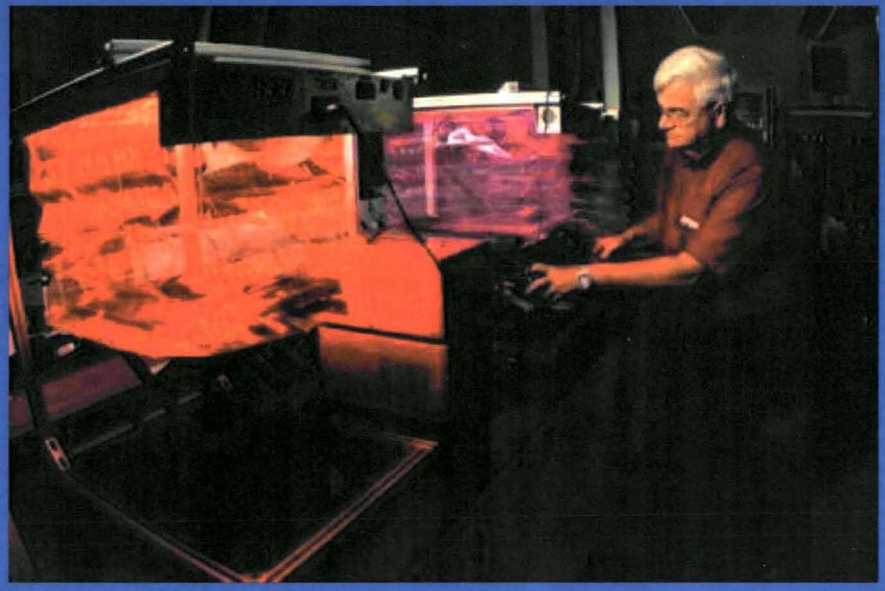
Current Areas of Life Science R&D

- Plant lighting technology for controlled environment agriculture
- Wastewater treatment and recycling
- Solid waste management
- Microbial risk assessment / management
- Air trace contaminant control
- Life science payload experiments
- Astrobiology (Univ. of Florida IFAS)

LEDs for Plant Lighting

Red...photosynthesis
Blue...photomorphogenesis
Green...human vision

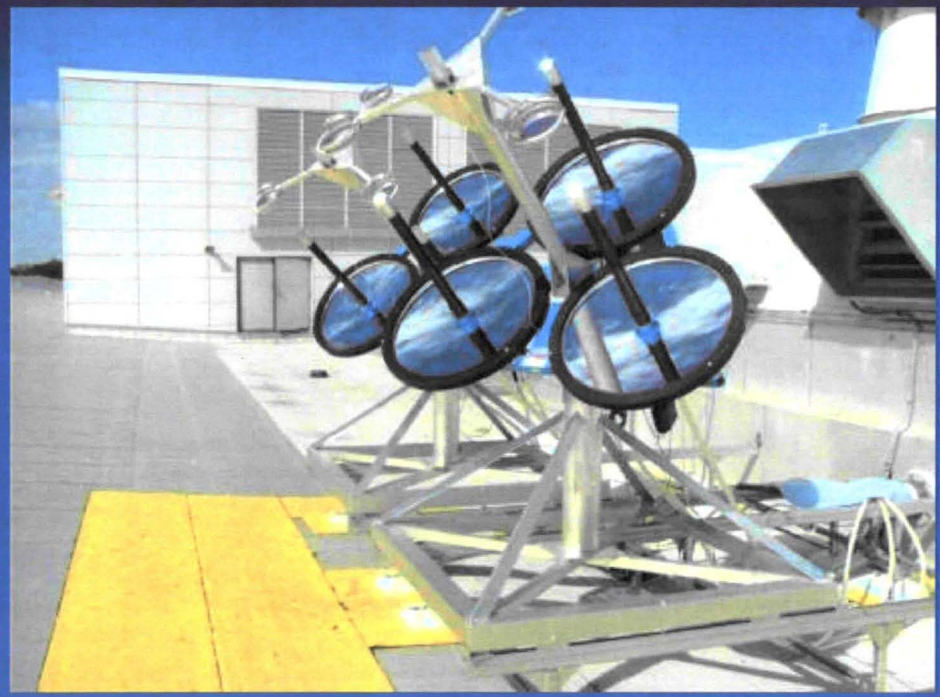




John Sager, KSC, Testing Prototype Flight Plant Chambers with LEDs

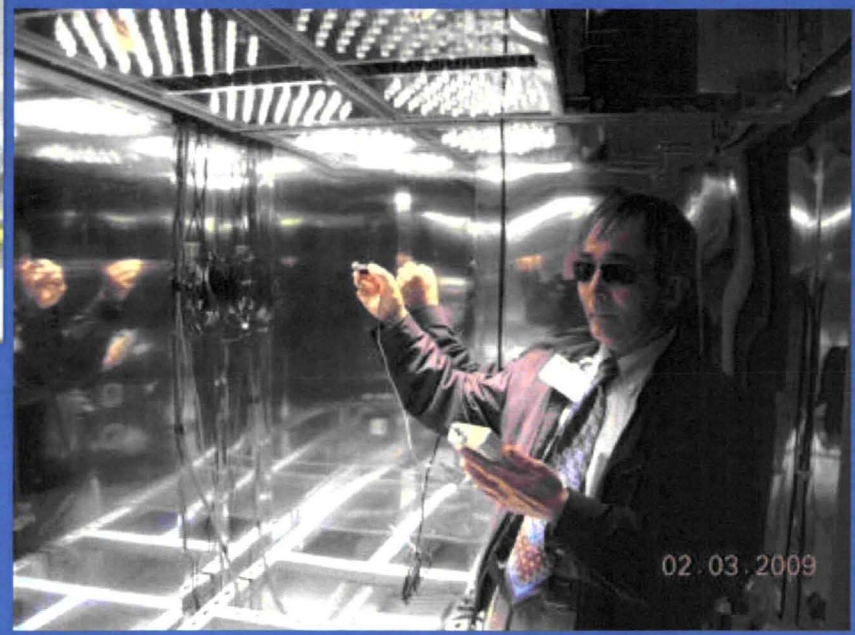
Goins et al., 1997. J. Exp. Botany
Kim et al. 2004 Annals of Botany

Solar Collector / Fiber Optic Demonstration



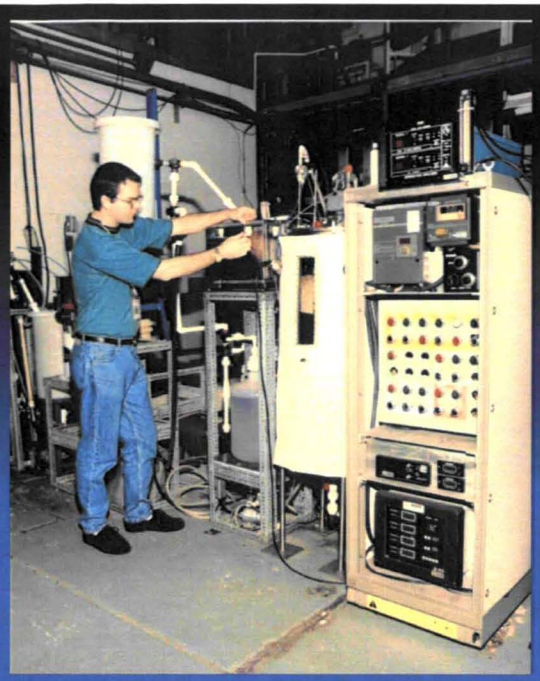
2 m^2 of collectors on solar tracking drive --
roof of Space Life Sciences Lab, KSC

Up to 400 W of solar light delivered to
a plant chamber
(40-50% of incident light)

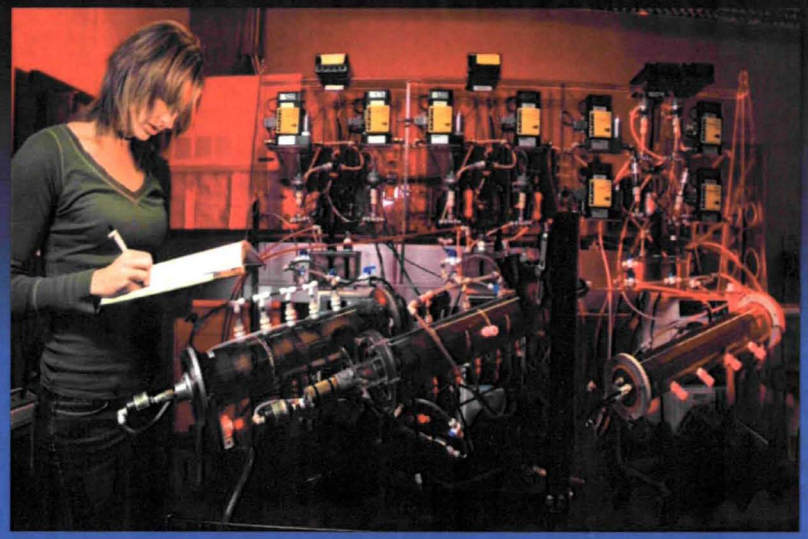


Cuello et al. 1998. Life Sup Biosphere Sci.
Drysdale et al., 2008 . Adv. Space Res.

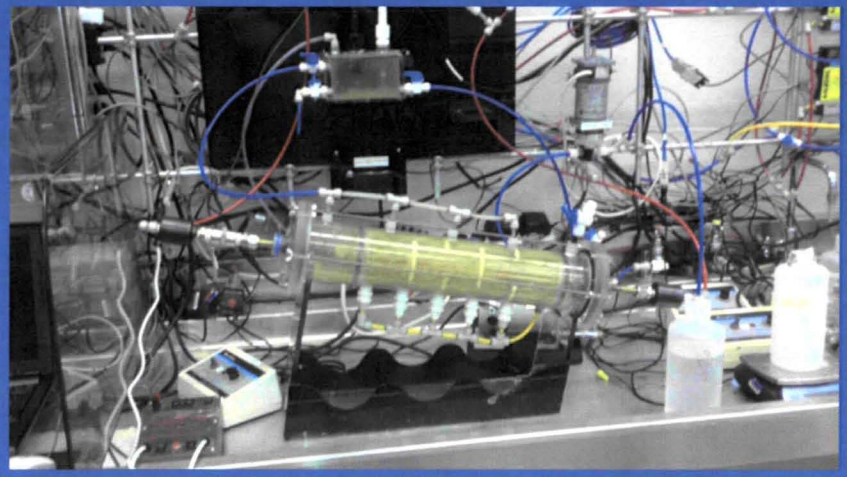
Wastewater / Solid Waste Treatment



Solid Waste Stirred Tank Reactors



Graywater and Septic Effluent Treatment



Urine Hydrolysis and Nitrification

Solid Waste / Aquaculture Systems

Mackowiak et al. 1996. Acta Hort; Garland et al. 1997. Adv. Space Res.; Morales et al. 1996. FEMS Microb. Ecol. 20:155-162.

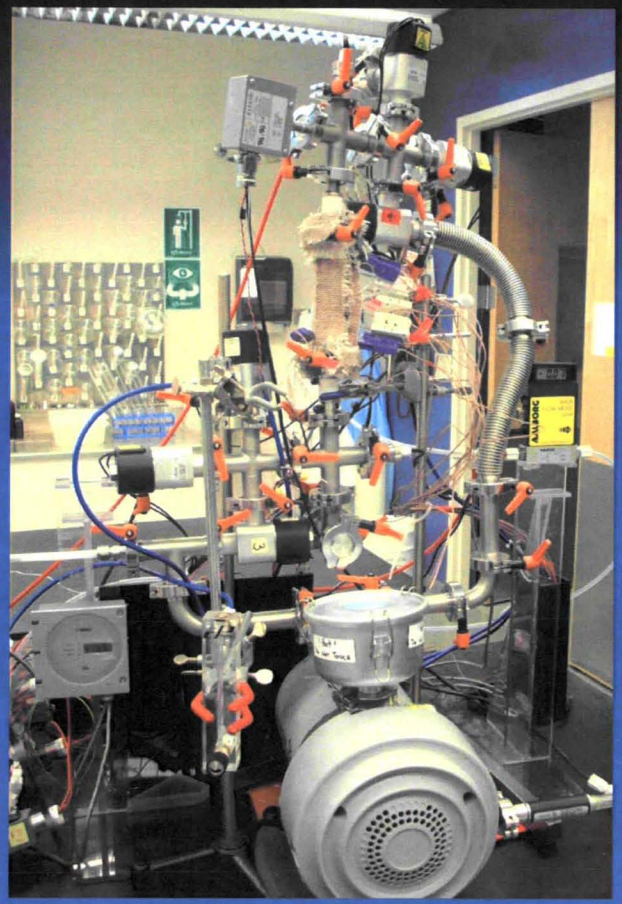
Reducing Nutrient Discharge from Wastewater

Reducing Water Pollution
in Florida

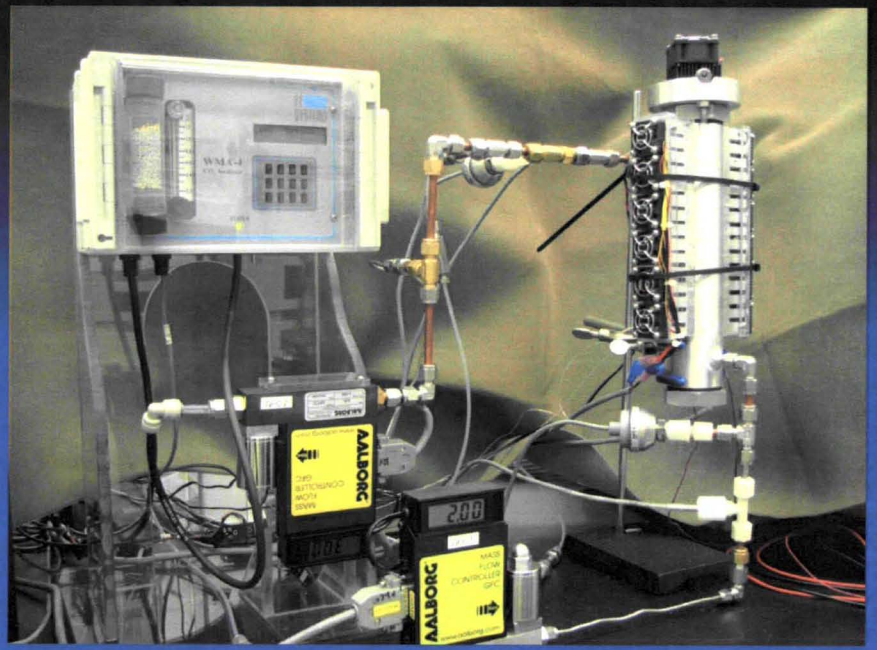
Plant and Soil Beds to Reduce
Nutrient Discharge into
Coastal Waters and Estuaries

Loader et al., 1997, 1999. Life Sup. Biosphere Sci.

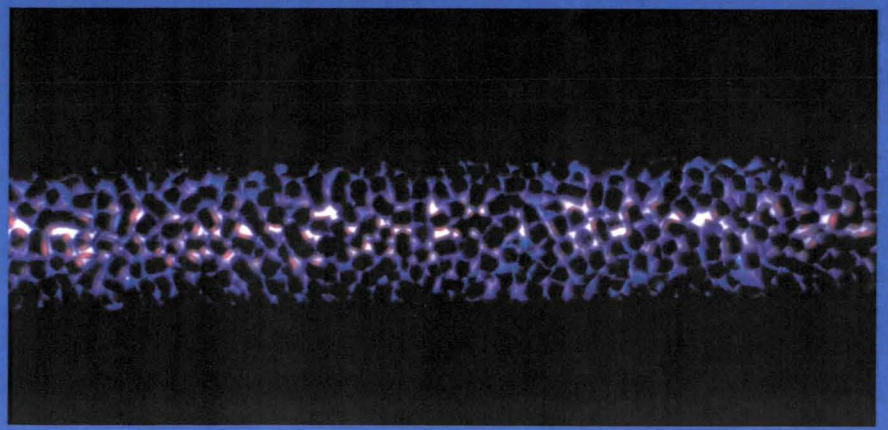
Air Trace Contaminant Control



Test Bed for Regenerable Sorbents



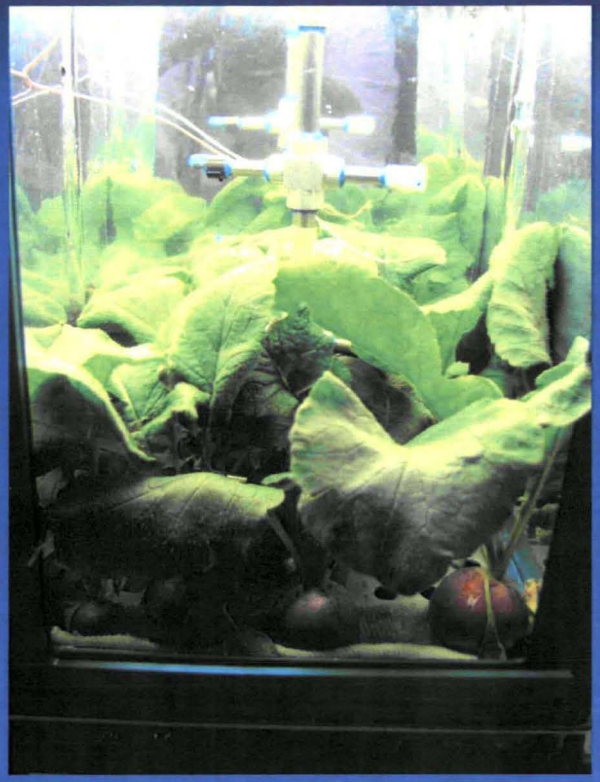
Photocatalytic Oxidation (PCO) Test Stand



Titania Pellets Surrounding
UV Lamp (PCO)

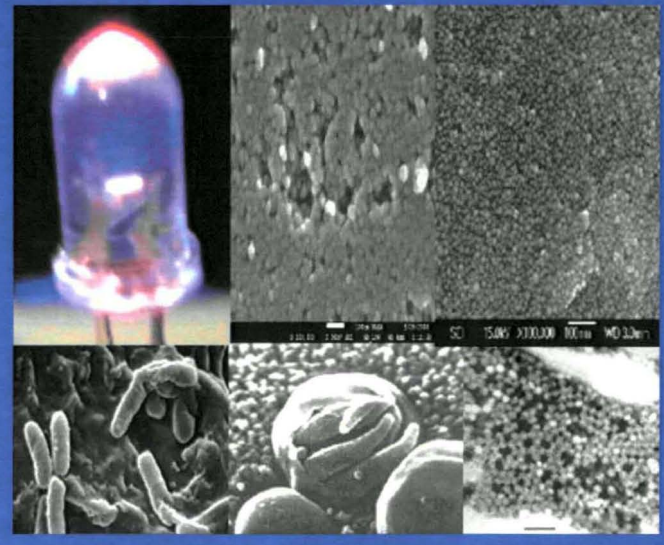
Ray Wheeler

Microbial Risk Assessment



Lada Plant Chamber
on Intl Space Station
(ISS) and Food Safety

Solid Waste Retrieved from ISS

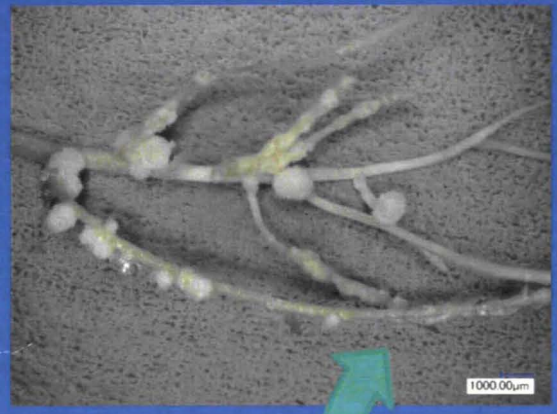


UV Radiation and Antimicrobial Materials for Potable Water

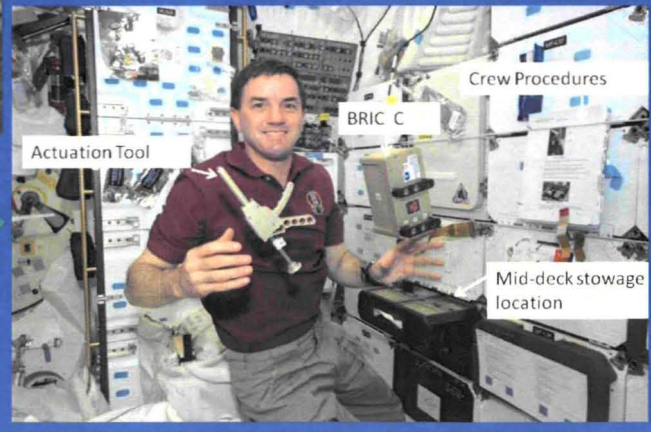
Life Science Space Flight Experiments

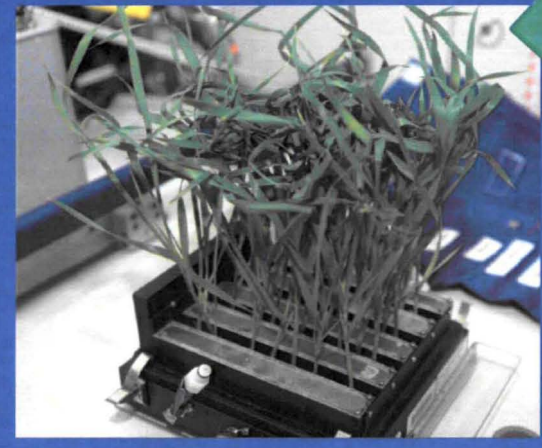
Potato Tubers in Space (STS 73)

Photosynthesis in µ-gravity
(STS 110 / 8A)



Plant / Bacterial
Nitrogen Fixation
In Space (STS 135)



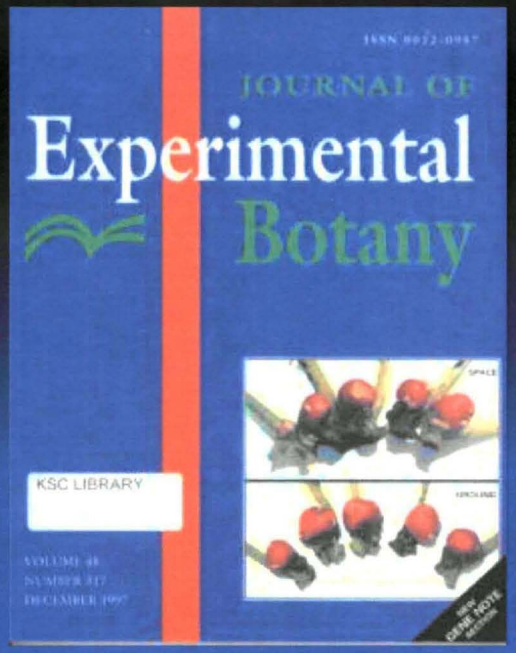


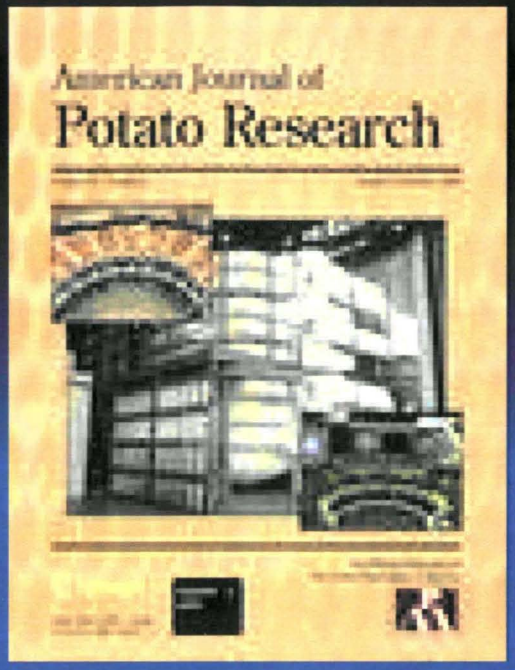
Croxdale et al. 1997. J. Exp Bot.
Monje et al. 2005. Planta

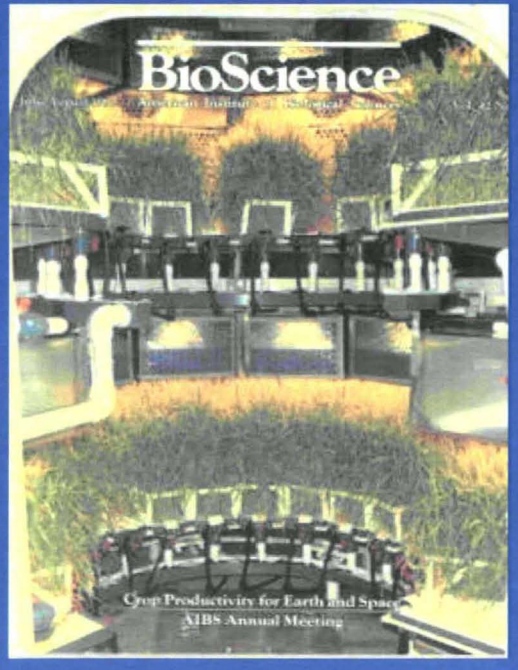
KSC Life Sciences

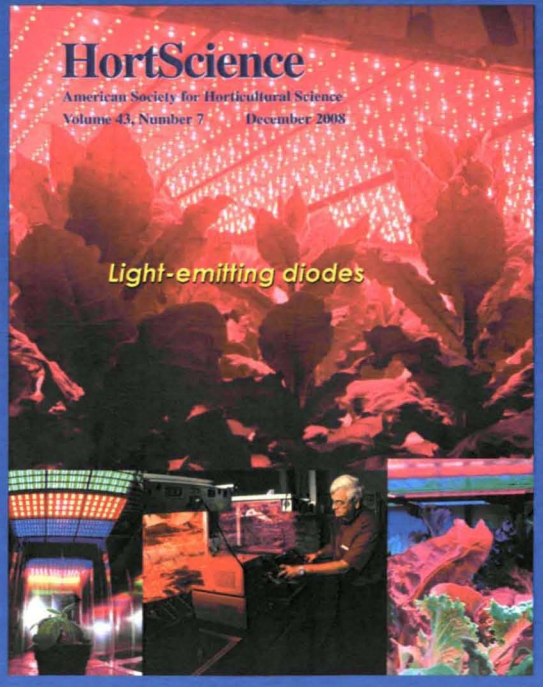
- Scientific Publications since 1990:
  - 480 peer-reviewed scientific articles
  - 61 book chapters and proceedings
  - 60 NASA technical memoranda
- Education / Training
  - 33 postdoctoral fellows
  - 29 visiting faculty / sabbaticals
  - 37 NASA graduate student fellowships; 19 NASA planetary biology interns
  - 24 Irish FAS and Limerick Institute of Technology interns
  - 25 HBCU interns (Florida A&M, Tuskegee Univ., Bethune-Cookman Univ.)
  - Brevard Community College Veterinarian Technician Course (20 students / yr for 8 yrs)
  - > 100 summer interns over past 15 years (from Universities across US)
  - SLSTP Program students, ~30 students / yr for 20 years (managed by Florida A&M)
- Some KSC Life Science "Alumni"
  - 14 University Professors (Maryland, Cornell, Flor., Arizona, Rutgers, Purdue, NC A&T)
    - Vice Chancellor Res., NC State Univ.; Dean Research, Univ. Virginia; Chair Biology, UCF
  - 4 USDA / ARS Research Scientists (CA, KY, OH, PA)
  - Director of Research, EPA National Exposure Research Lab, Cincinnati
  - LEED Program Manager, Canada Green Building Council, Vancouver, BC
  - 6 Bioengineers in private industry (Paragon, Hamilton Sundstrand, Bigelow Aerospace)

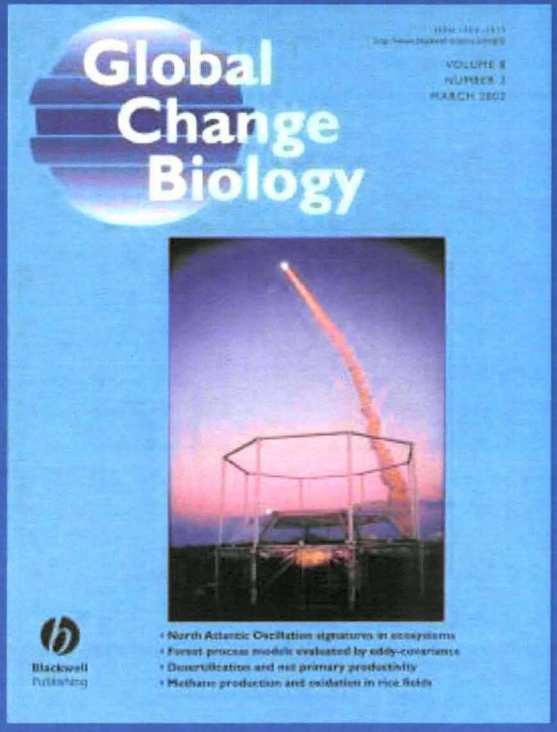
Journal Cover Photos from KSC Biological Research





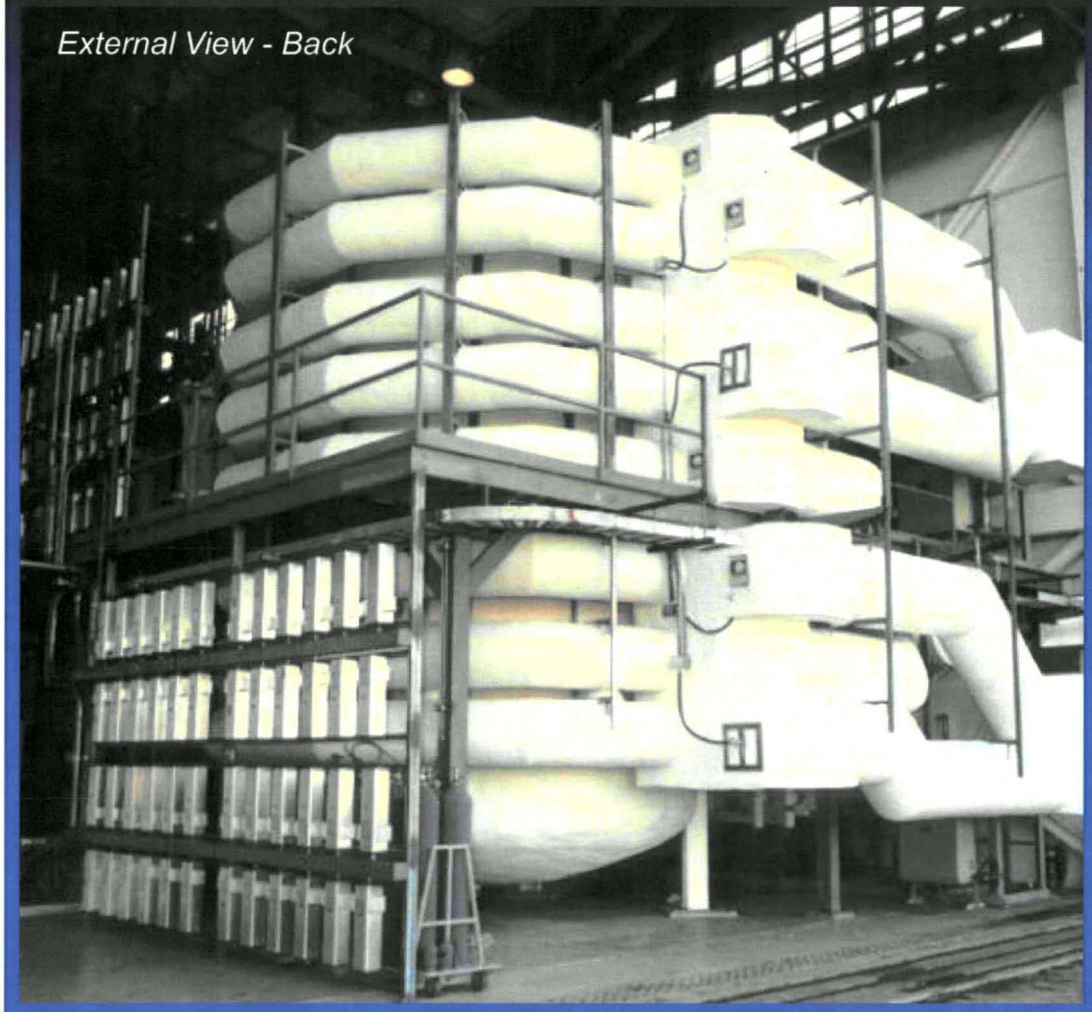




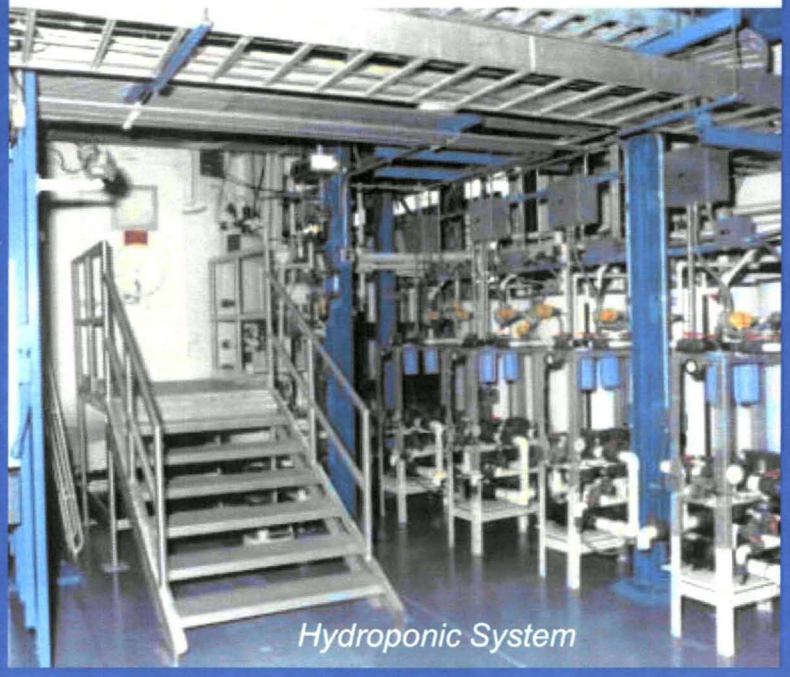


Back Up Slides

NASA's Biomass Production Chamber (BPC)

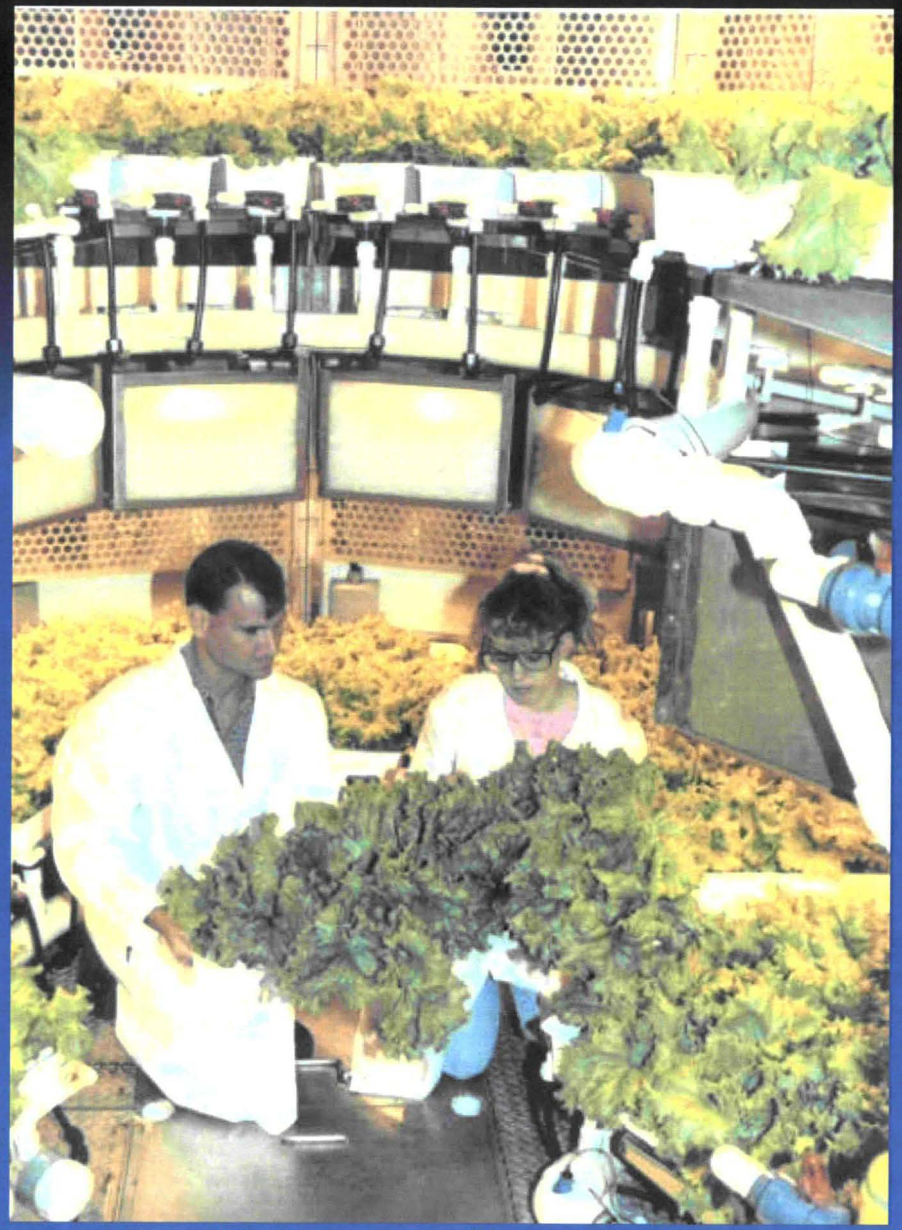

External View - Back

Control Room


Hydroponic System

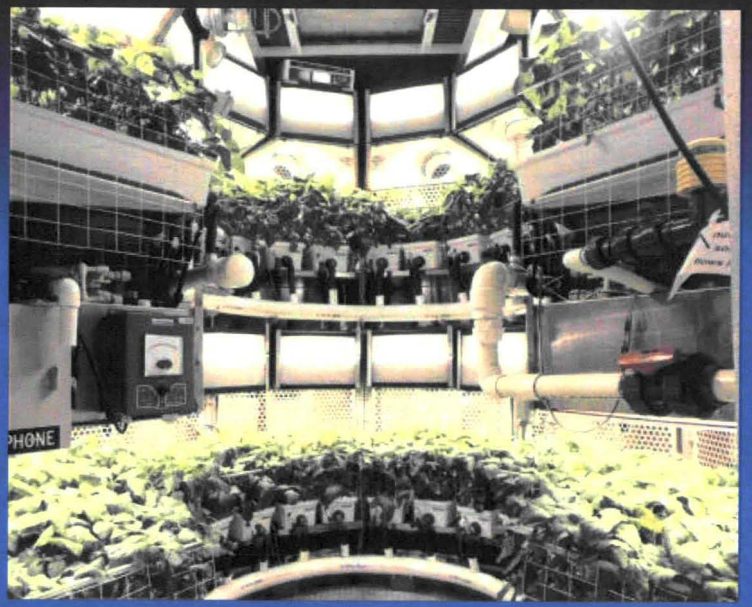
20 m^2 growing area; 113 m^3 vol.; 96 400-W HPS Lamps;
400 m^3 min^{-1} air circulation; two 52-kW chillers

KSC Controlled Environment Crop Production



Recirculating Hydroponics

⇨ *Similar Challenges for Terrestrial Systems*



Wheeler et al. 1998. Acta Hort; Wheeler et al. 1993. Crop Science

Bioregenerative Testing for Space Exploration

→ Mars surface inflatable, greenhouses for oxygen and food production

Rygalov et al. 2004. Habitation .
Wheeler et al. 2011,.Adv. Space Res.