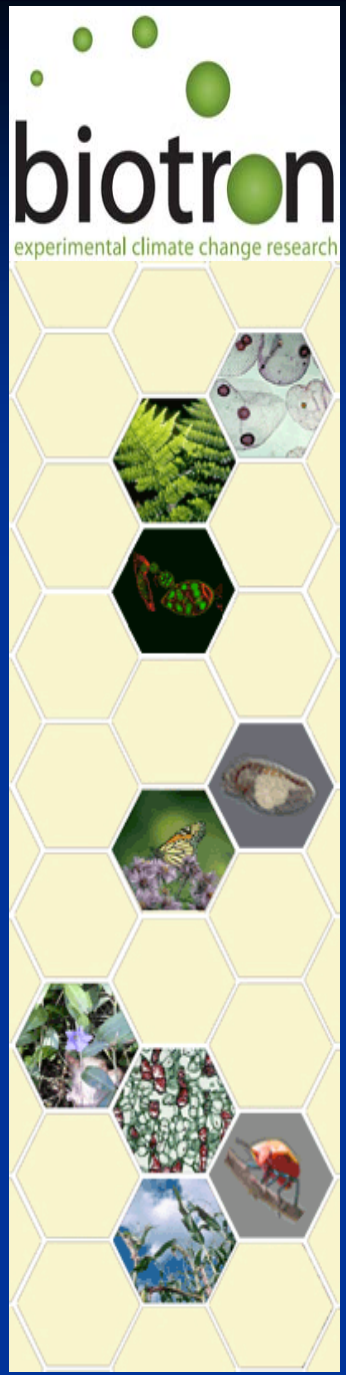

The Biotron and Guelph's Plant Productivity Module

E.D. Leonardos[1], M.J. Iqbal[1], A. Singh[2], N. Hüner[2] and B. Grodzinski[1]

1 2

UNIVERSITY of GUELPH

Western

Agriculture and Agri-Food Canada | Agriculture et Agroalimentaire Canada

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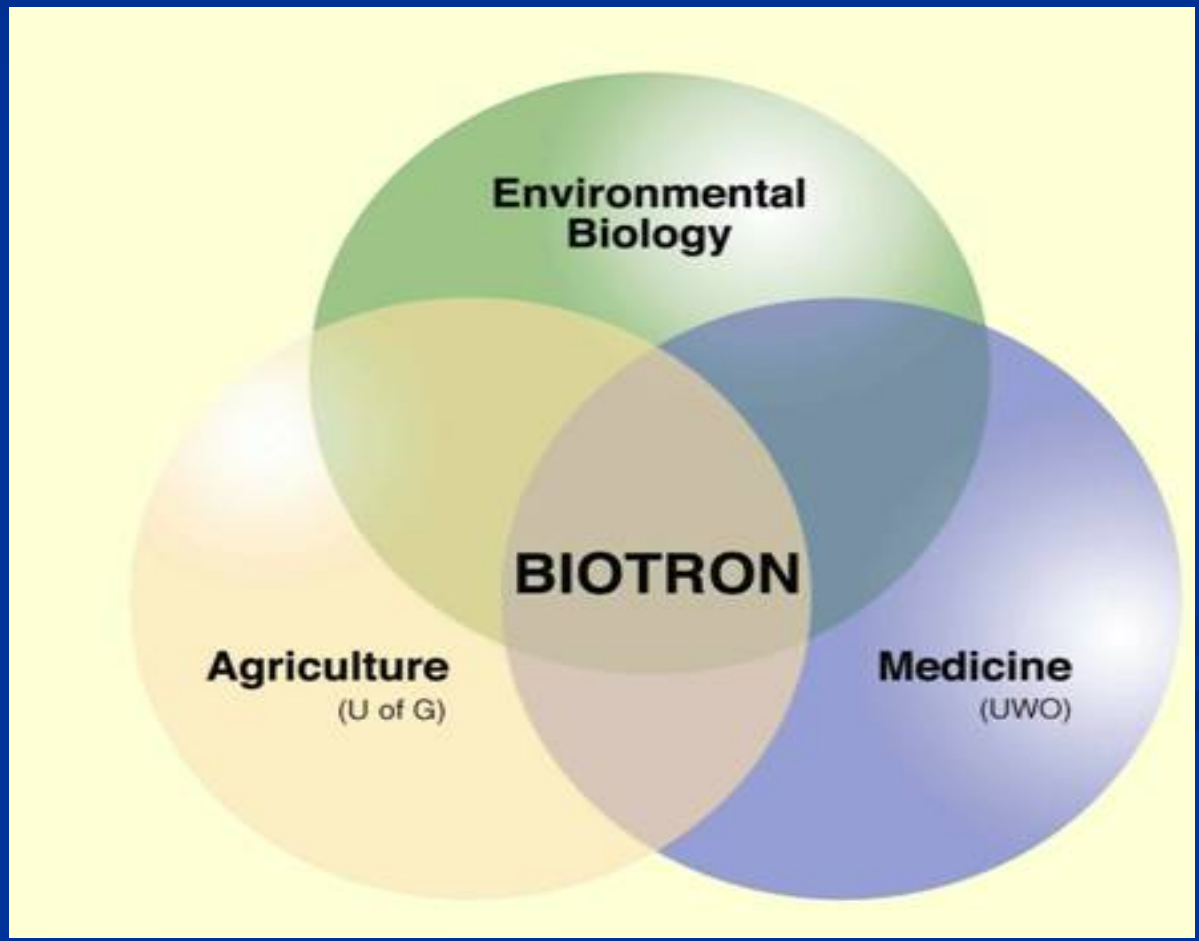
What is the Biotron?

- An interdisciplinary controlled environment research facility focusing on critical environmental issues and biotechnology



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Principal Investigator

- Dr. Norm Hüner, DSc(hc), FRSC
  - Distinguished Research Professor
    - Plant Physiology, Photosynthesis
  - Canada Research Chair in Environmental Stress Biology
  - Biotron Scientific Director

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Research Mission

- Accelerate our understanding of the consequences of climate change and other forms of environmental stress on ecosystems
- Support and stimulate the shift of markets towards a “bioeconomy”
- Assess potential environmental benefits and risks of emerging biotechnologies on biodiversity and ecosystem health

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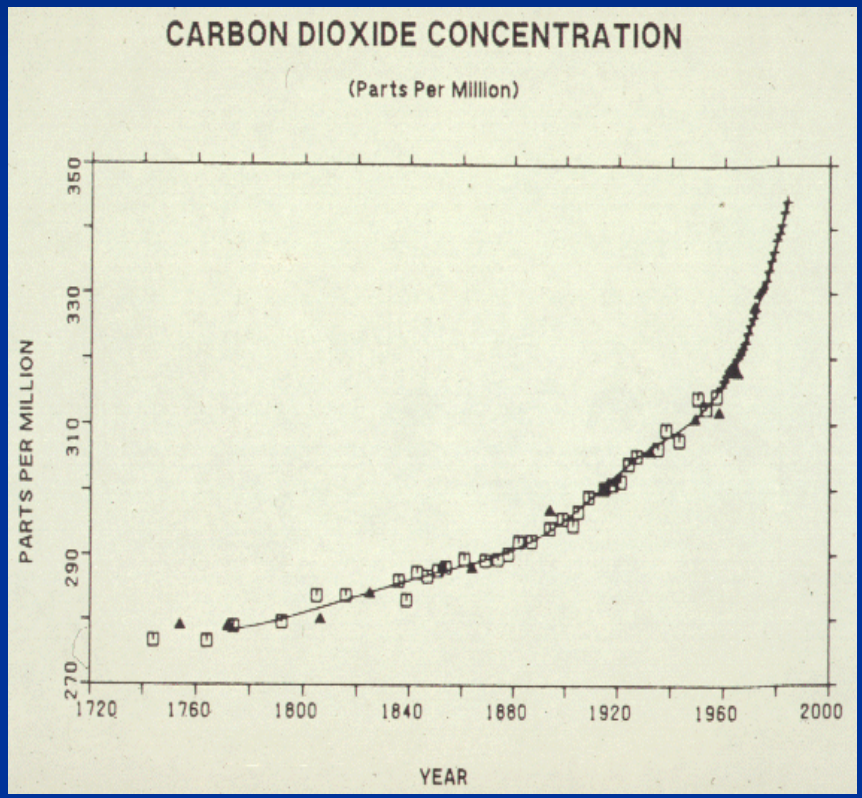
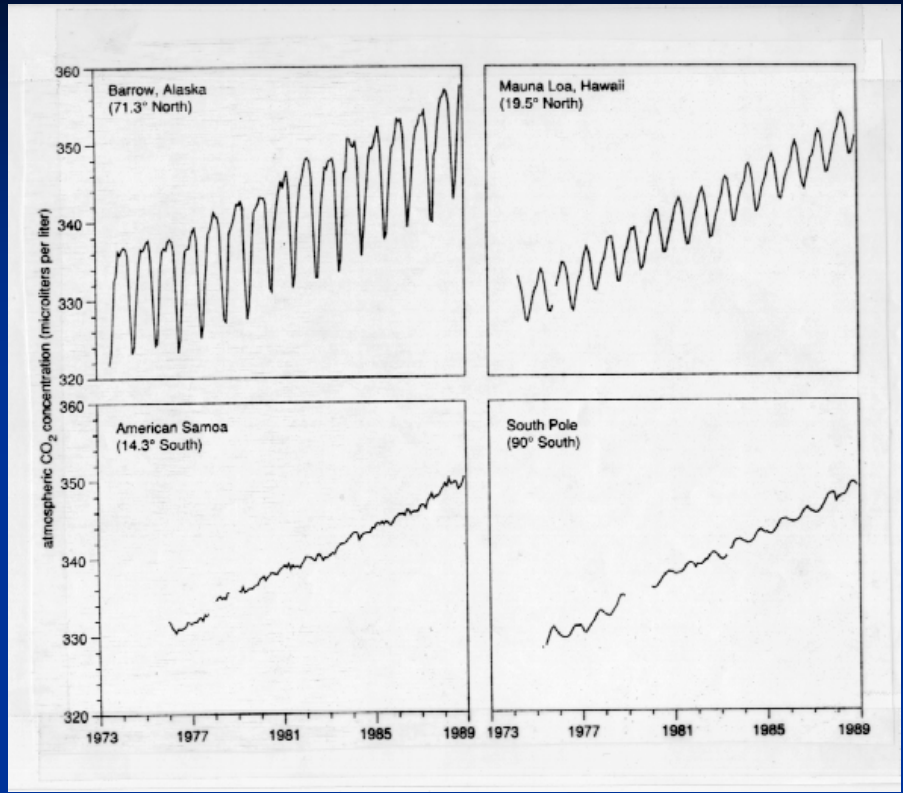
Why Now?

- *Assumption:* Earth will experience worsening circumstances under the current regime of anthropogenic pollution

ENVIRONMENT
Atmospheric CO_2

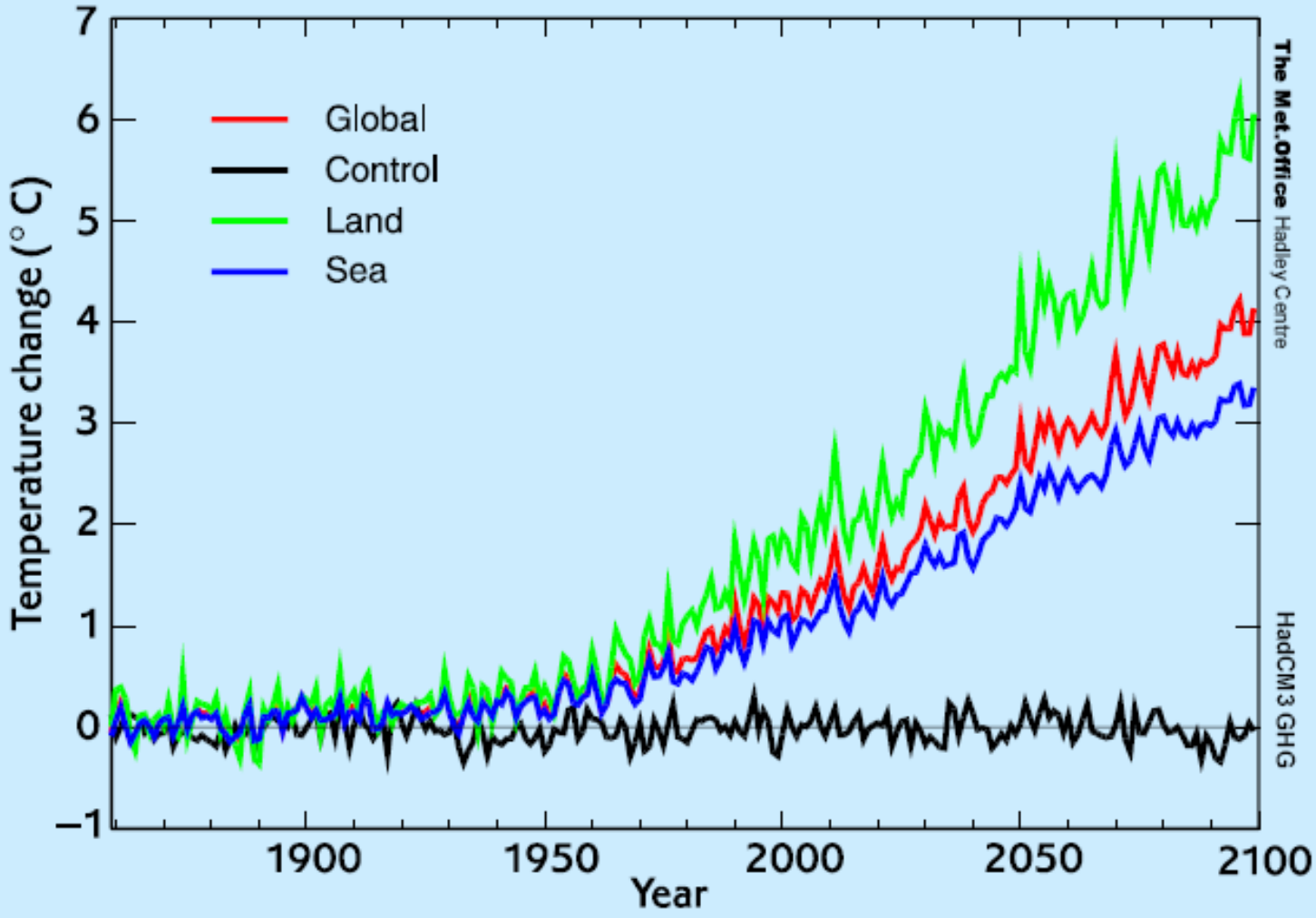




=> Global Warming ??

GLOBAL TEMPERATURE RISE

due to "business-as-usual" greenhouse gas emissions



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Environmental Research Examples / Questions

- How do these stresses affect biodiversity and the survival and productivity of organisms?
- What is the effect of transgenic organisms and other emerging technologies on natural ecosystems?
- How do we identify and minimize the impact of plant diseases and pests on our agricultural and forestry industries?
- How can we address the spread of insect-borne diseases such as West Nile virus?
- How do we protect our food supply in the face of a changing environment?

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Biotechnology Development Examples / Questions

- Water purification
  - Bioactive paper
- Sustainable agriculture and forestry
  - Pest (invasive species), drought, cold resistance
  - Enhanced nutritional and medicinal properties (e.g. gossypol-free cottonseed)
  - Postharvest preservation
- Bioproducts
  - Industrial and medical molecules (e.g. vaccines, antibodies, proteins, enzymes, and polymers)
  - Renewable fibres, plastics
  - Biofuels (e.g. biodiesel, bioethanol)

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Award

Canada Foundation for Innovation
Fondation canadienne pour l'innovation

Ontario Innovation Trust

Ontario

- $28.4 million project cost
  - Federal (CFI - 40%)
  - Provincial (OIT/ORF - 40%)
  - Western (Hüner)
  - Guelph (Grodzinski)
  - Agriculture & Agri-Food Canada
  - Industry
  - Donors

⅔ Construction : ⅓ Equipment

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Tower (UWO)

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Main Tower (UWO)

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North Campus Building (UWO)

Plants & Algae Module

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UWO-Biosecurity

- Containment Level 3 Labs
  - PHAC — Public Health Agency of Canada / Agence de santé publique du Canada
  - CFIA — Canadian Food Inspection Agency / Agence canadienne d'inspection des aliments
- Biomes – Level 2++
- Containment Level 2 Overall

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Biomes

AGRITECHNOVE
PROFESSIONAL ENGINEERING AND CONSULTING inc.

frank Jonkman and sons ltd.

ARGUS CONTROLS

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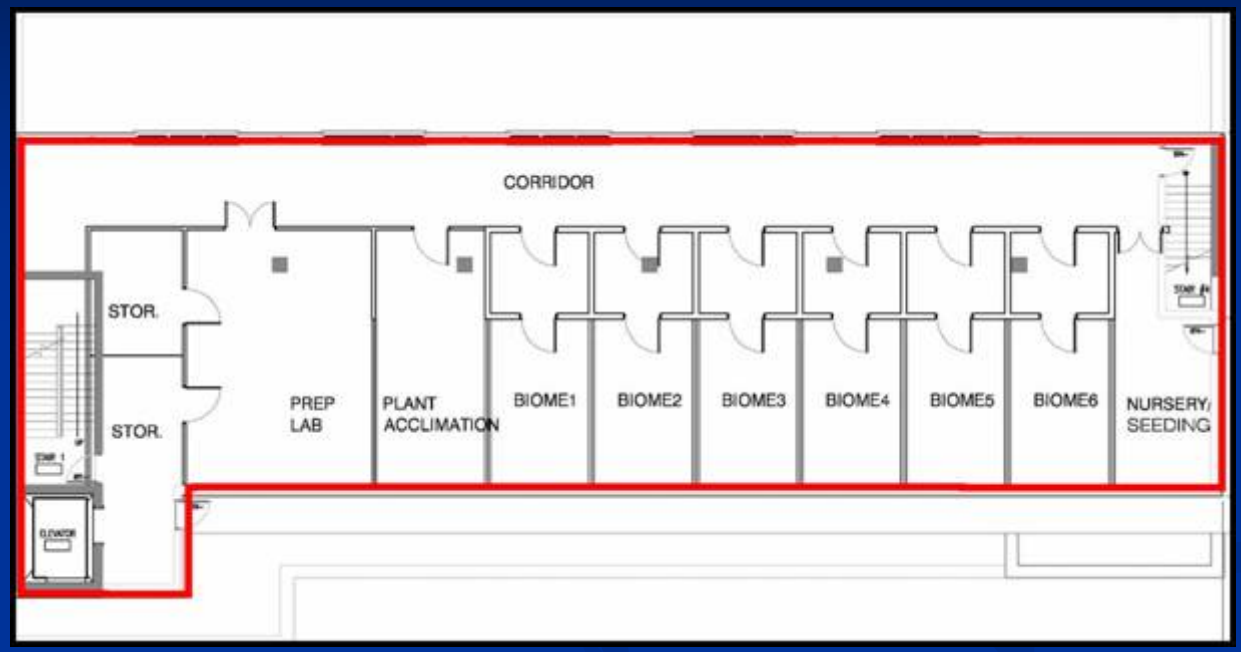
Biomes



Assess the impact of environmental stress at the mini-ecosystem level
Food chain impacts of pesticides
Biorisk assessment – pre-field trials
Carbon dioxide capture and storage techniques
Scale experiments up or down

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Biomes

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Biomes

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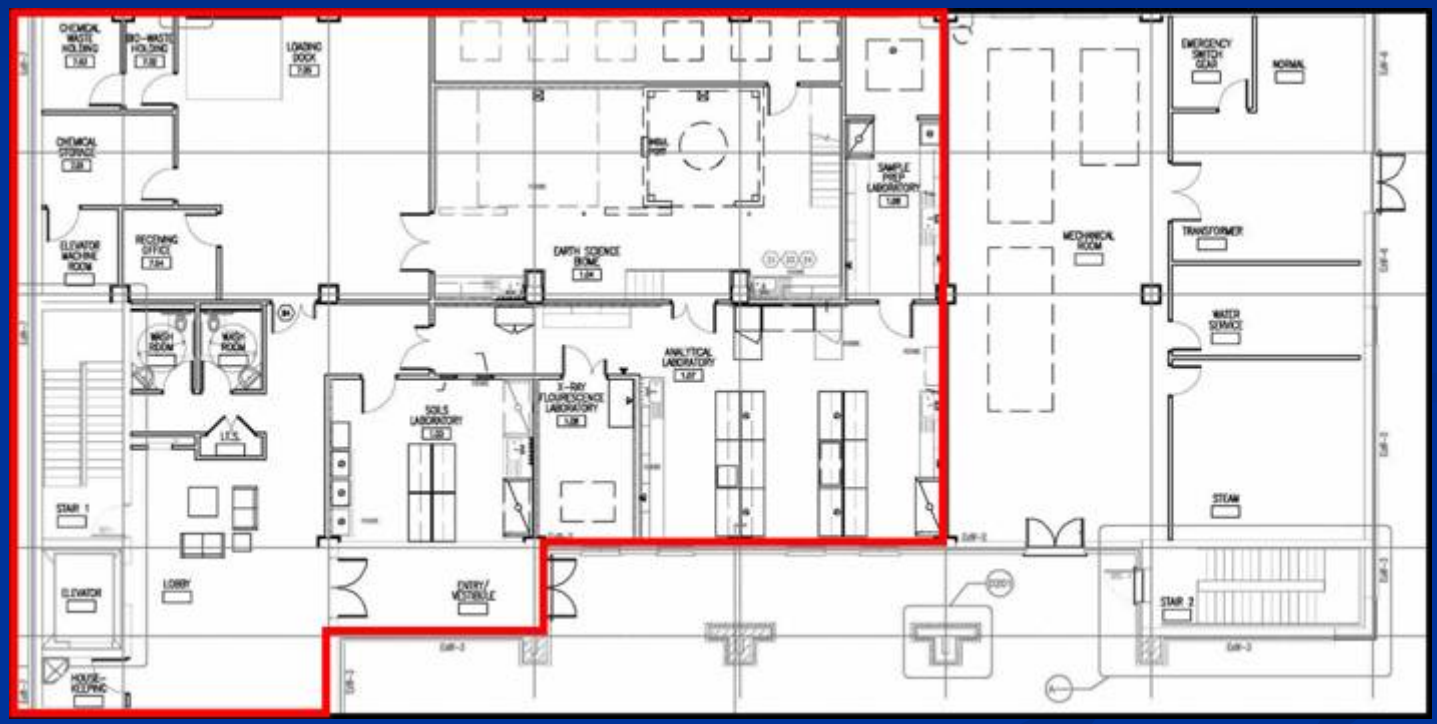
Earth Sciences



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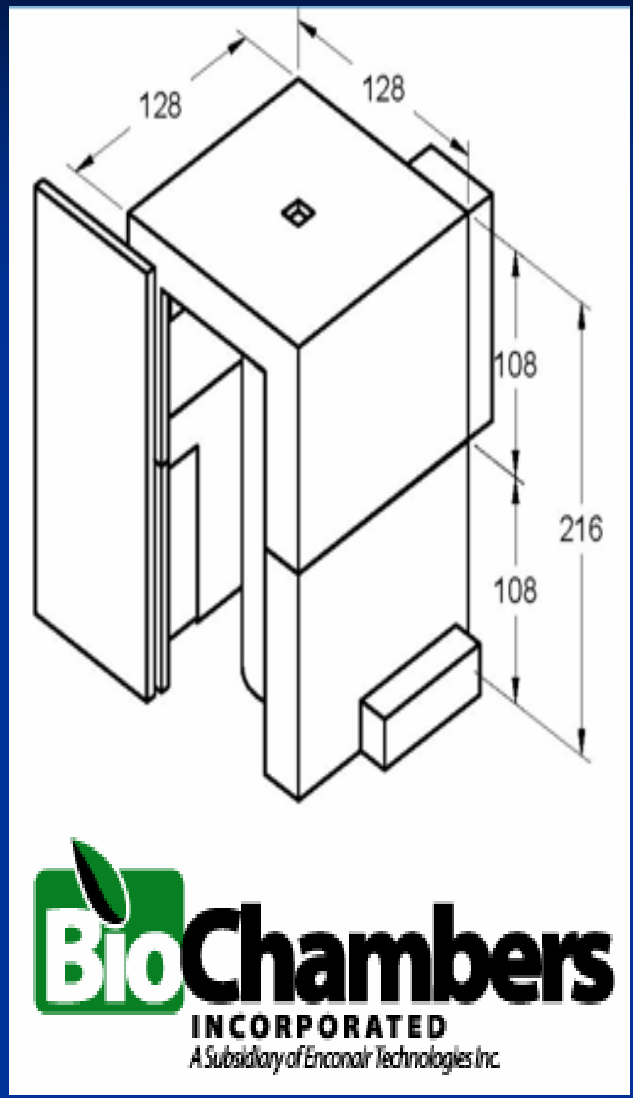
Earth Science Climate Chamber



- **Install and preserve INTACT soil samples ranging from Arctic to modern agricultural**
- **Bioremediation of mine tailings, landfill leachate, and other contaminants**
- **Oil and gas pipeline optimization in permafrost and the active layer**

Custom designed : -40ºC to +40ºC

10,000 kg soil core sample

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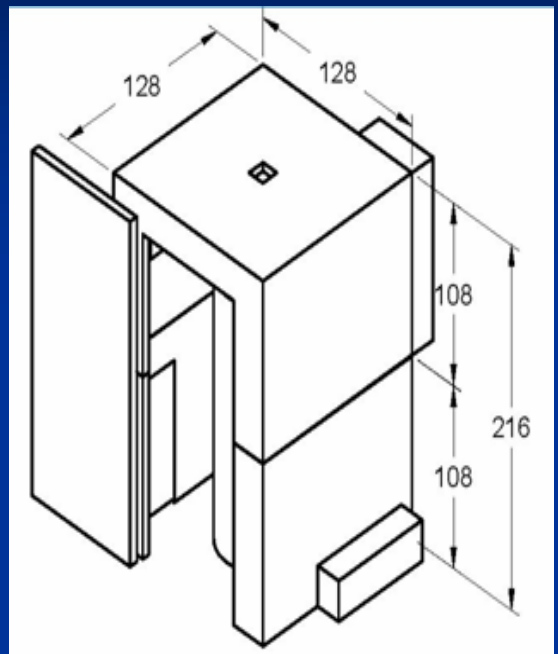
Earth Science Climate Chamber



BioChambers
INCORPORATED
A Subsidiary of Enconair Technologies Inc.

Custom designed :

-40ºC to +40ºC

10,000 kg soil core sample

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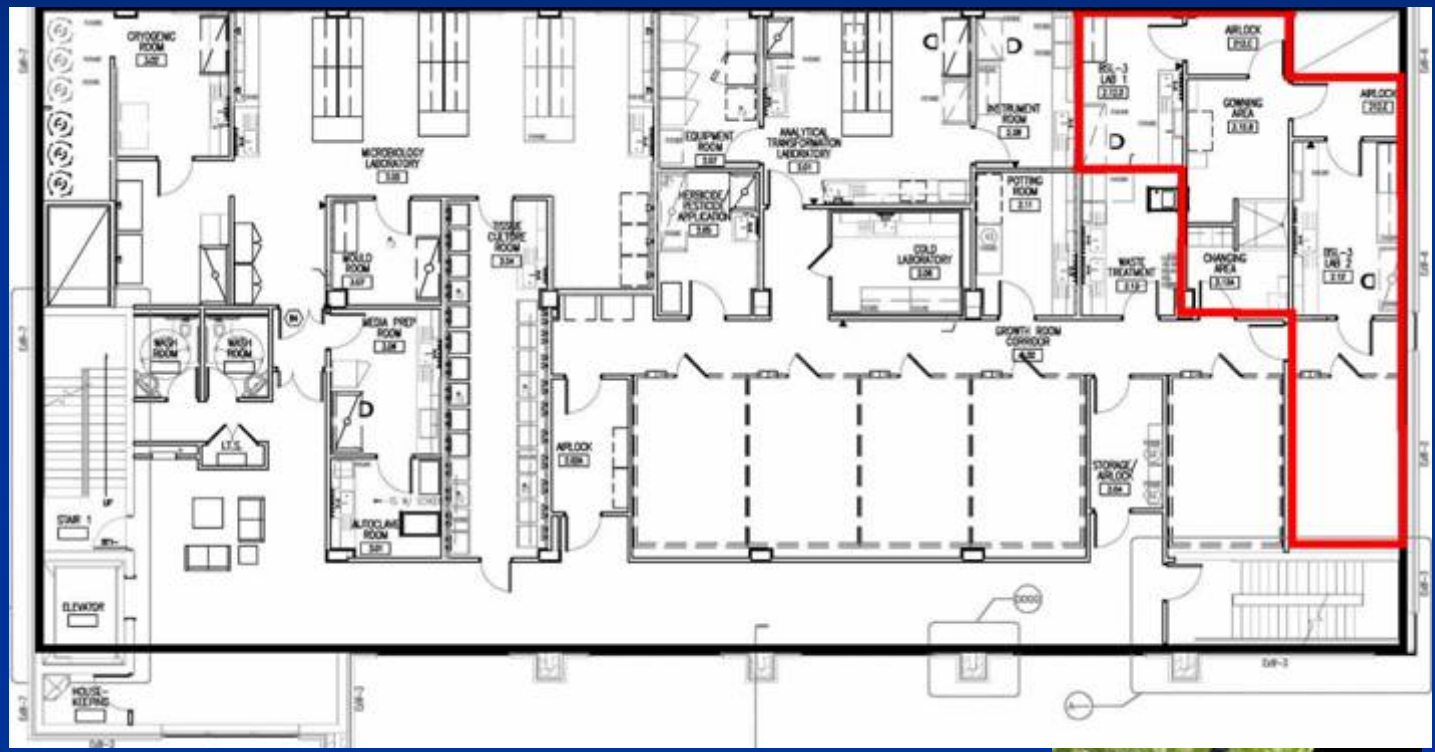
Containment Level 3 Module



Microbial and Insect Threats

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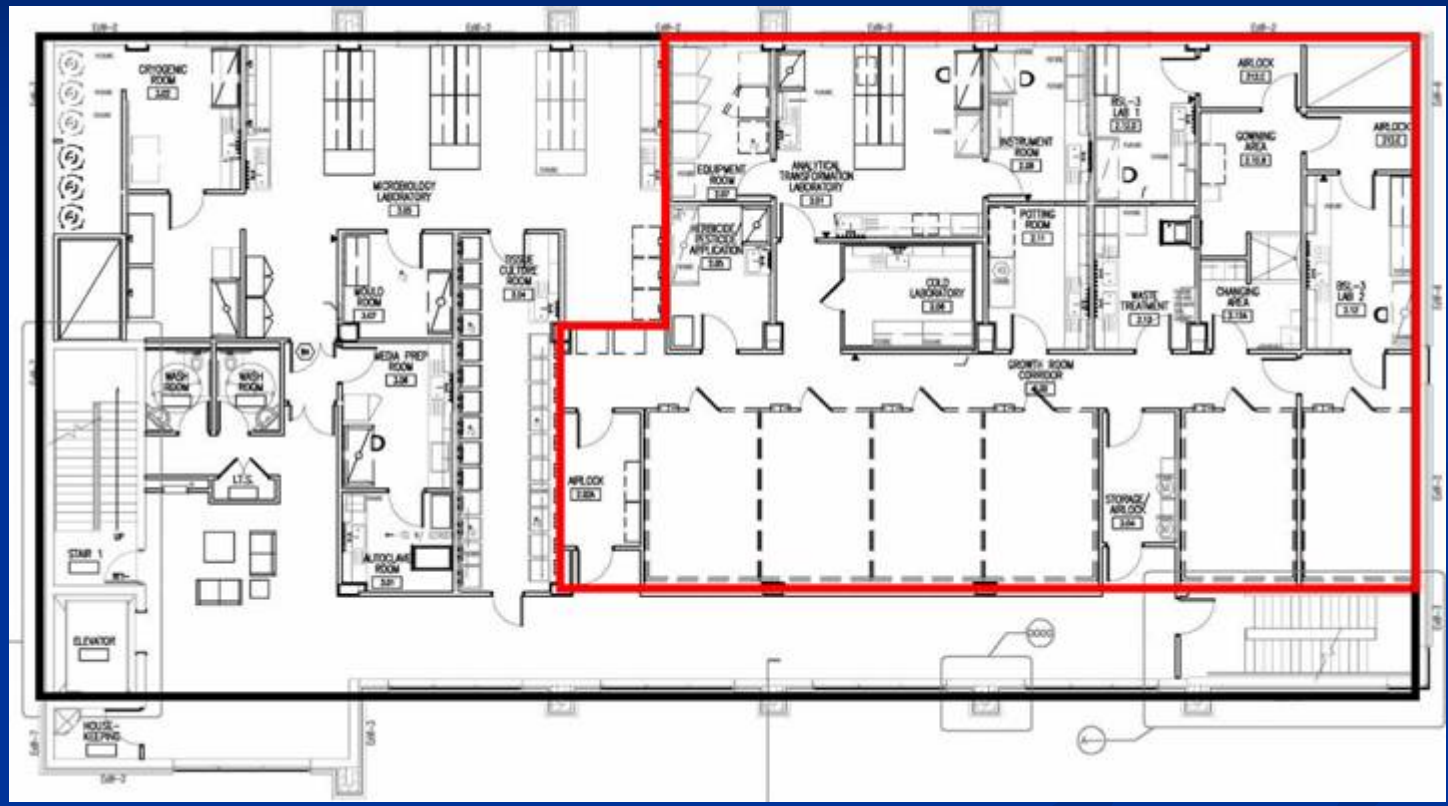
Transgenic Plants



Industrial and medical bioproduct development

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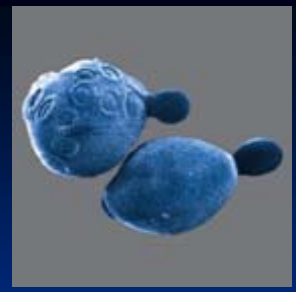
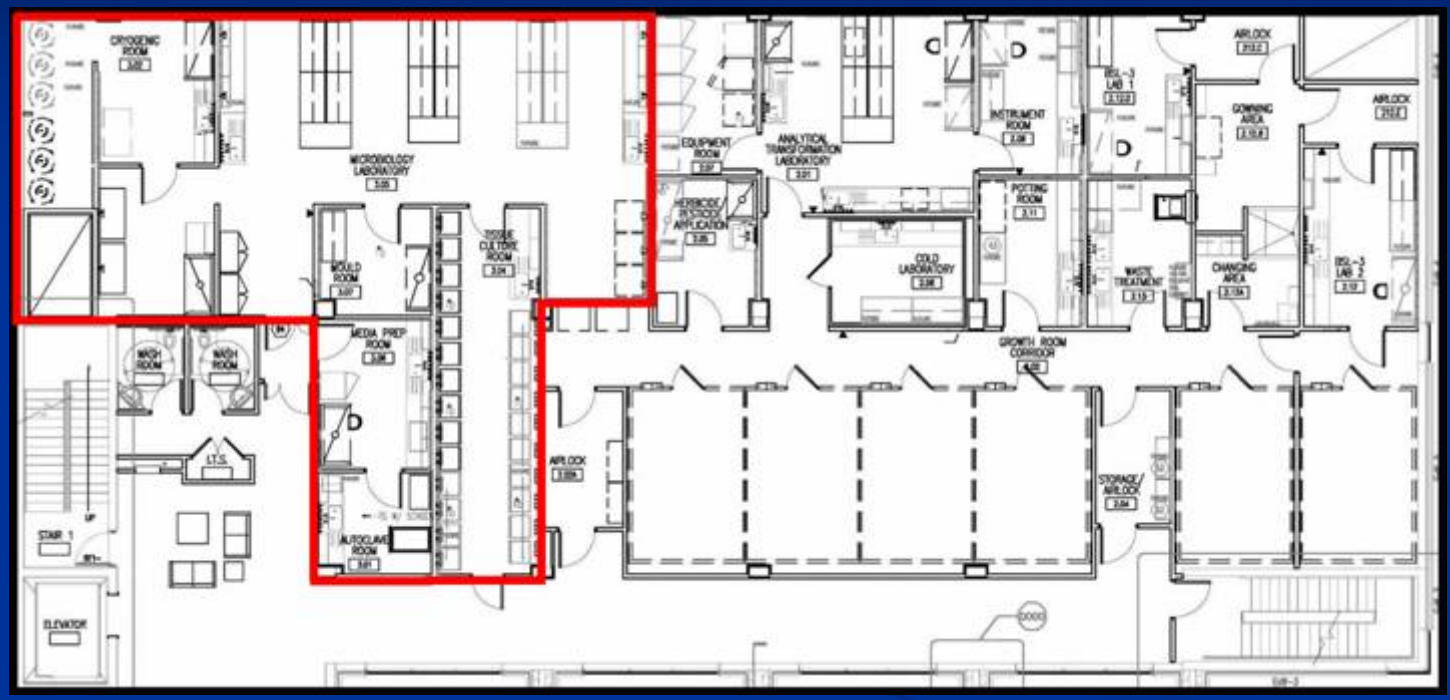
Microbiology





Microbial Pathogenesis
Microbial Molecular Ecology & Biodiversity

PRAXAIR

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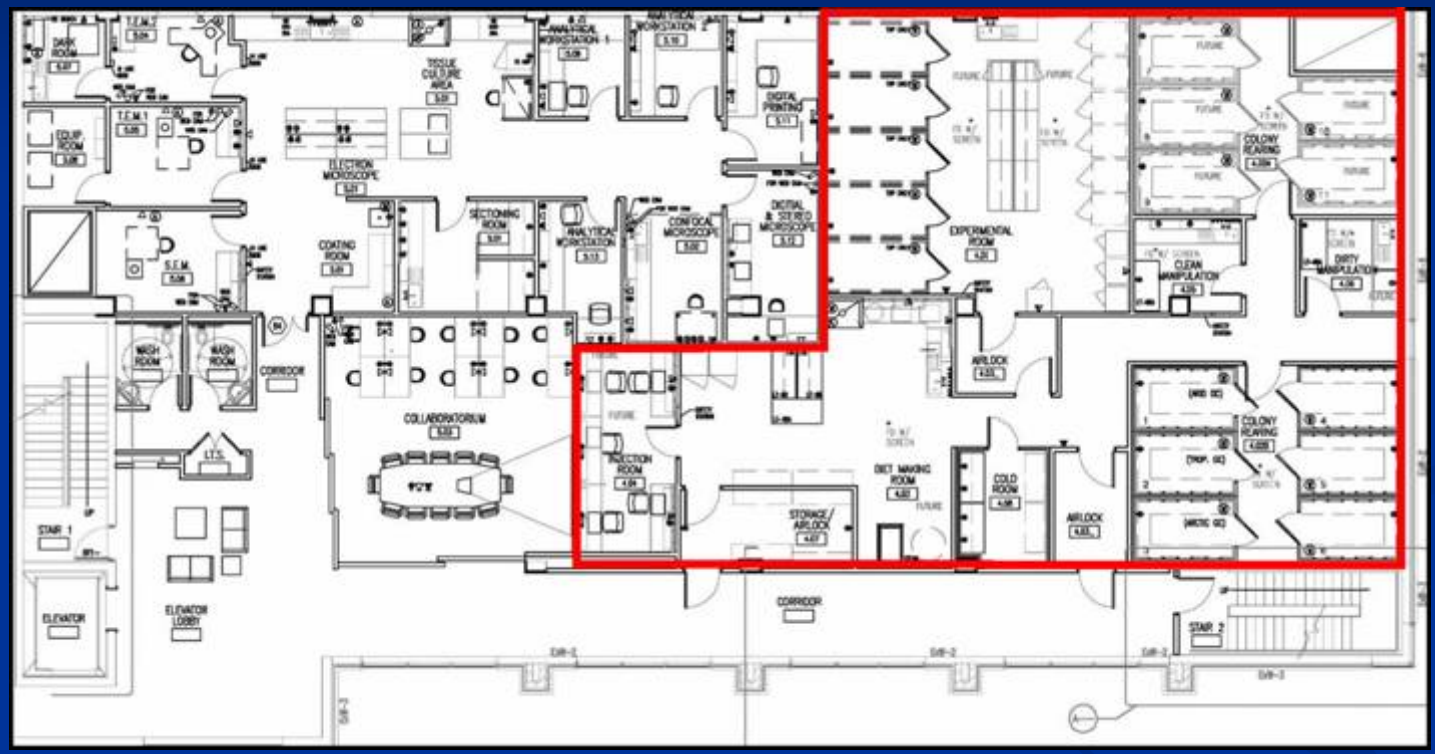
Insects



Environmentally-acceptable crop pest control
Insect-borne disease control

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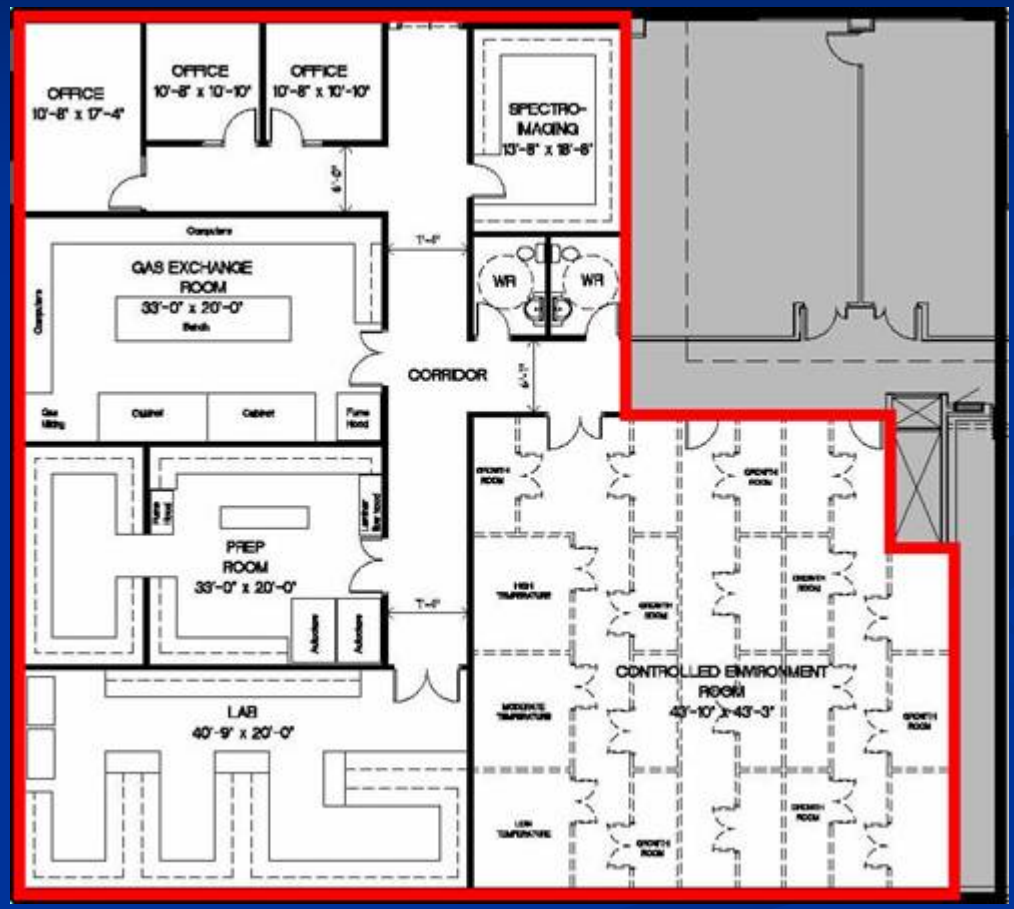
Plants & Algae



Sustainable crop development
Environmental biosensors

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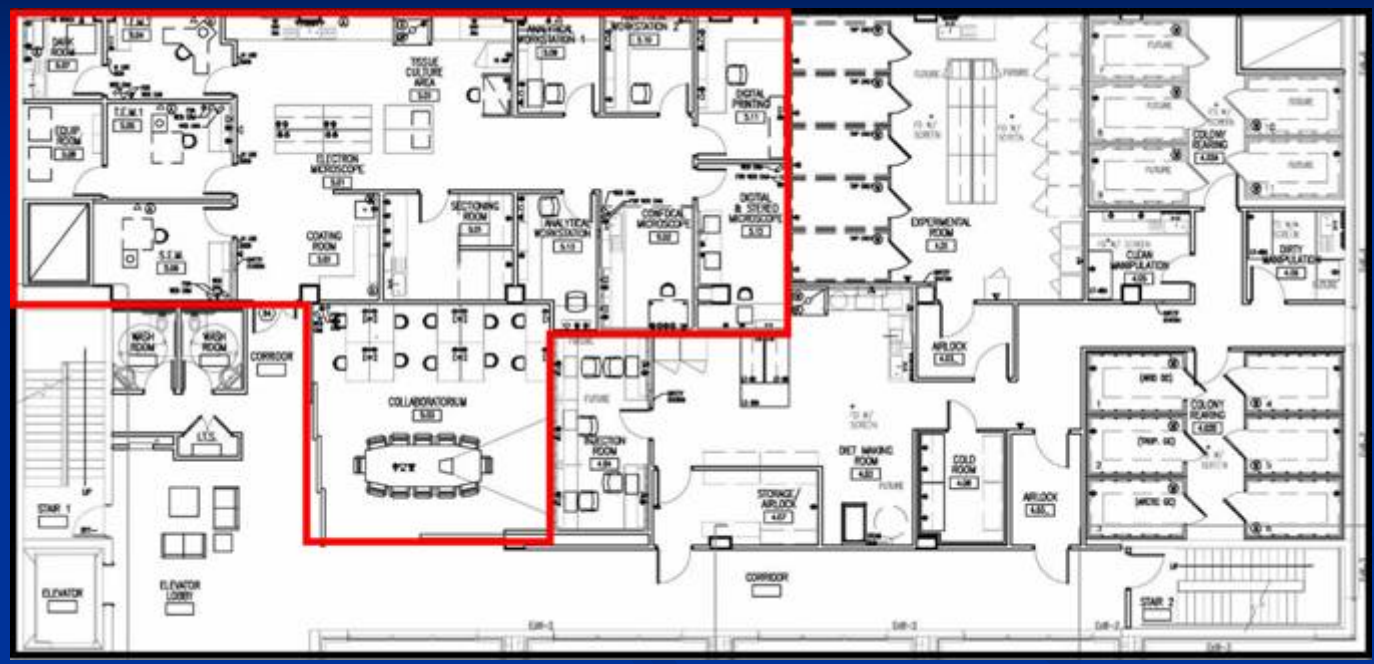
IT & Imaging



Remote access & control
Sophisticated multimedia database
Connectivity to SHARCNET cluster supercomputers
Confocal, SEM, TEM (2), & Digital Light Microscopy

SHARCNET™

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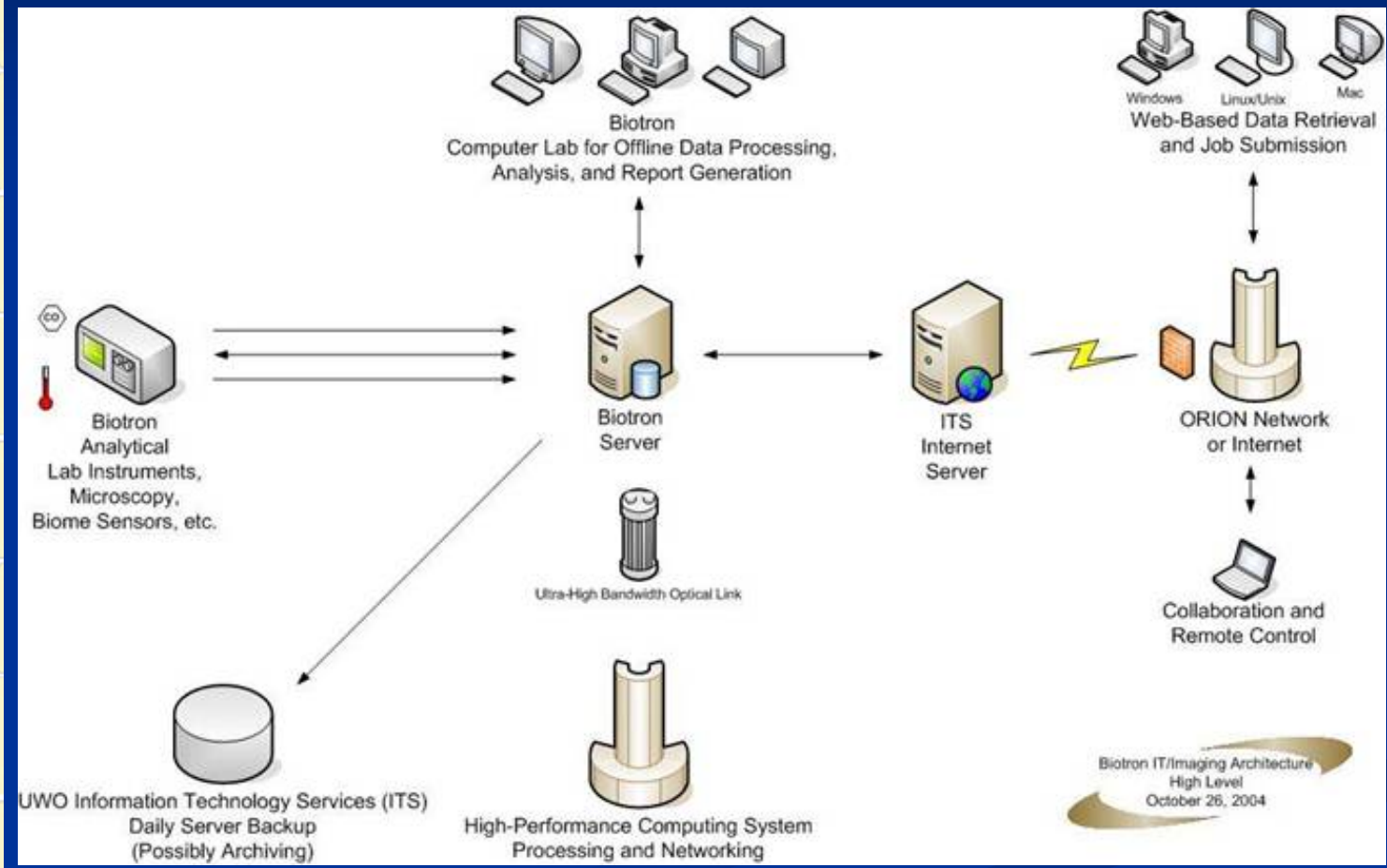
IT & Imaging



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Vision

- To generate a blueprint for long-term, ecosystem health

  through

  sustainable economic growth in medicine, agriculture, and energy.

- To generate actionable, socially valuable recommendations for our leaders in government and industry
  - (through collaboration with the Richard Ivey School of Business, government, and industry partners)

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AAFC-London
Environmental Chambers

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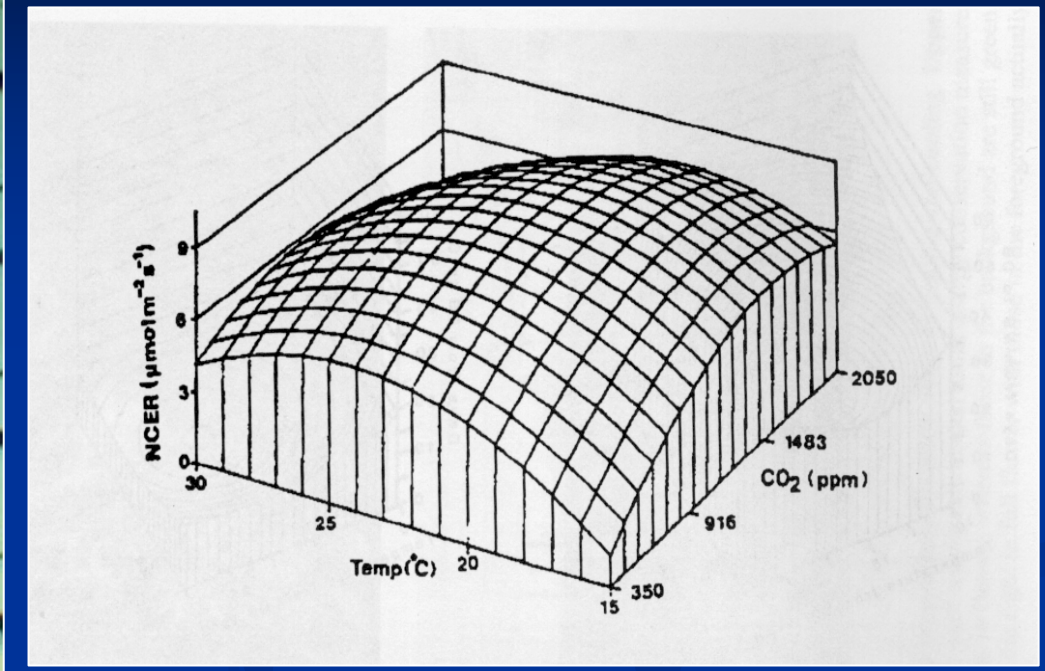
Biotron 's LTRF in Guelph

and Controlled Environment Systems Research Facility

Closed Environment Systems

- Commercial Greenhouses
- Space Exploration Program
- Guelph CESRF/Biotron LTRF
- Biodiversity/Bioproducts
- Environmental Studies (climate change, plant-pathogen interactions, plant-microbial interactions, etc.)

Whole Plant NCER

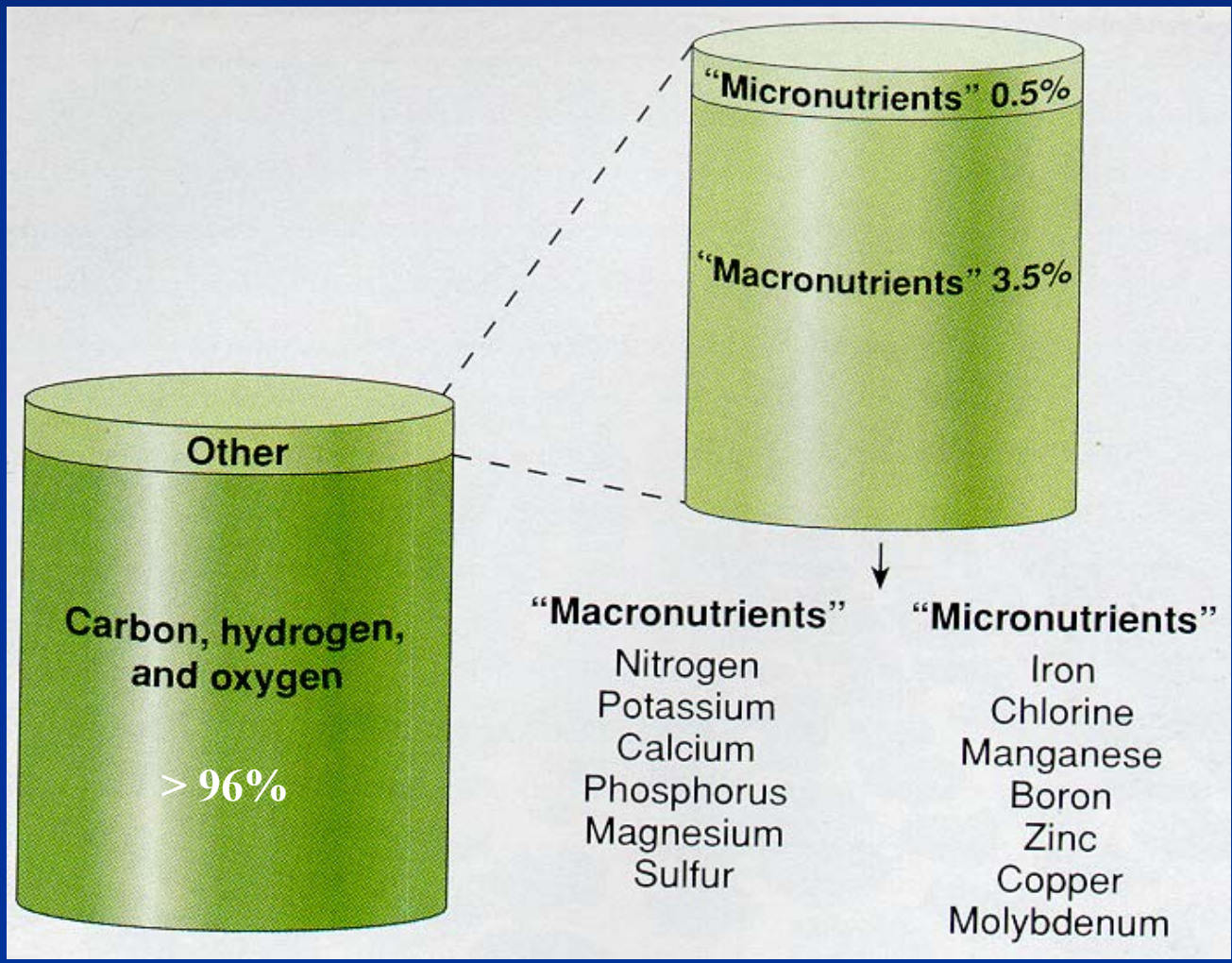


Biomass -YES

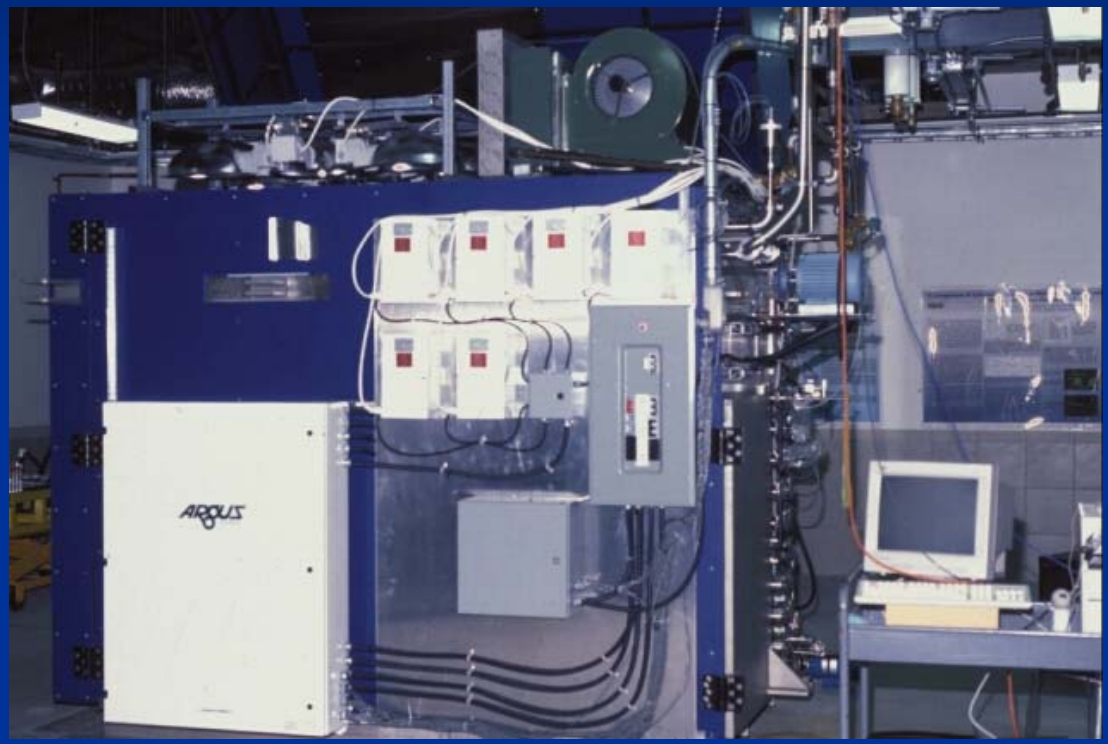
Partitioning /

Quality - NO

Carbon, Hydrogen and Oxygen

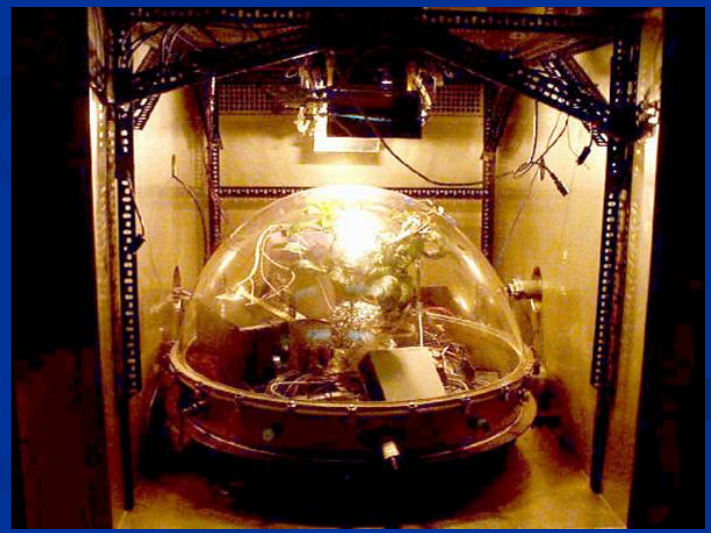


Hypobaric Plant Growth Chambers

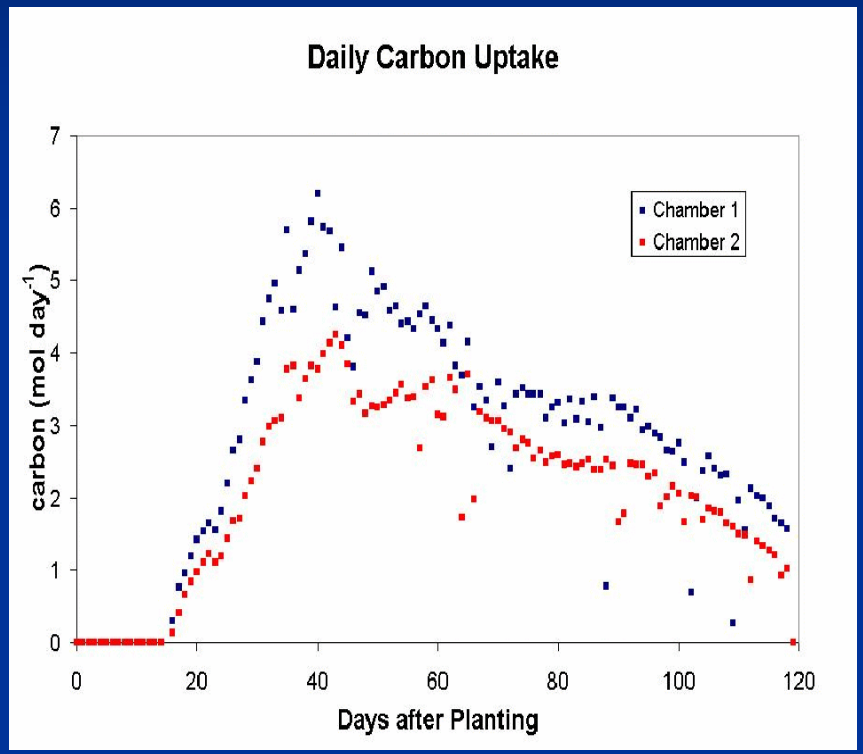


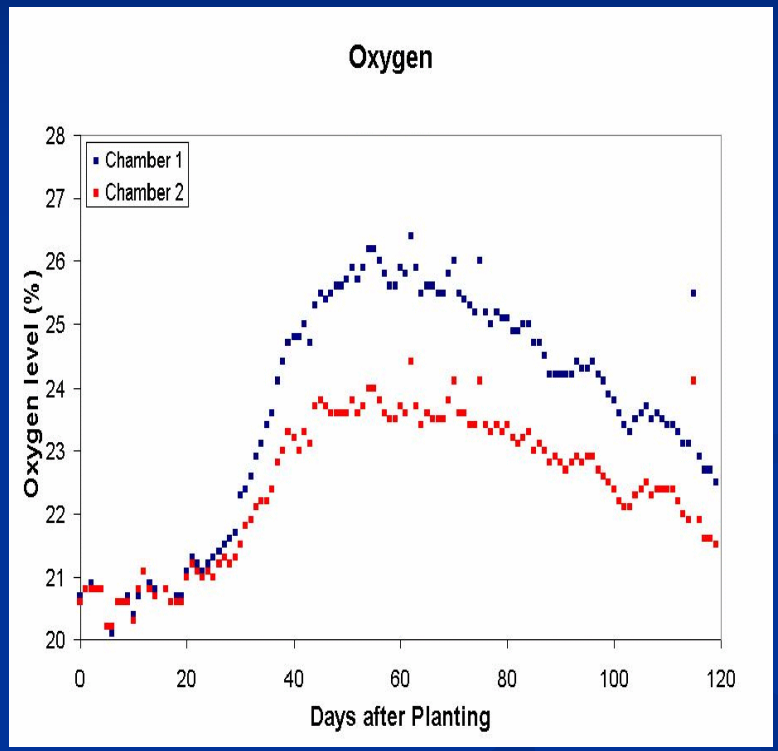
CESRF

KSC



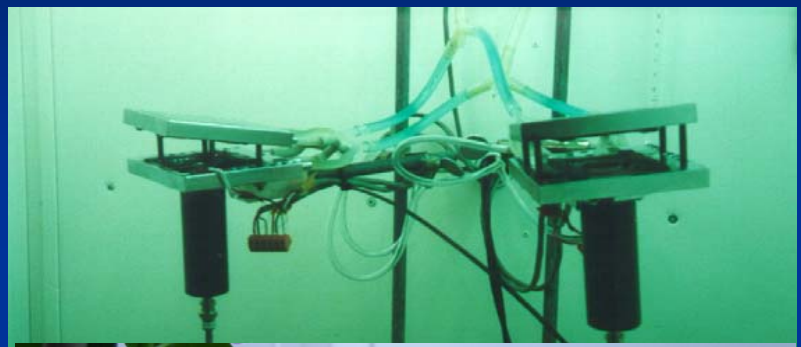
ENHANCED CO_2 REMOVAL & O_2 PRODUCTION

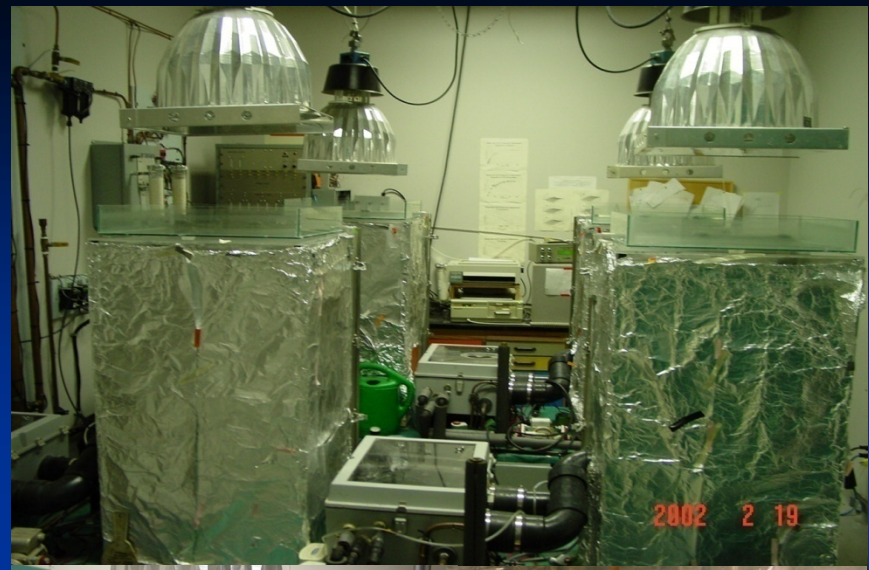


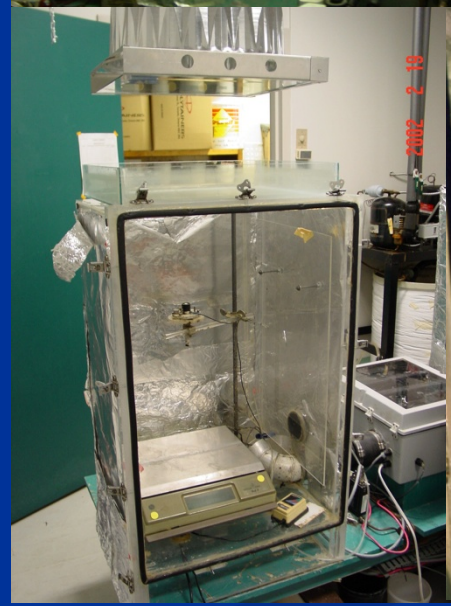


Cuvette Systems

Leaf System, “ORGAN”







Whole Plant System,
“ORGANISM”

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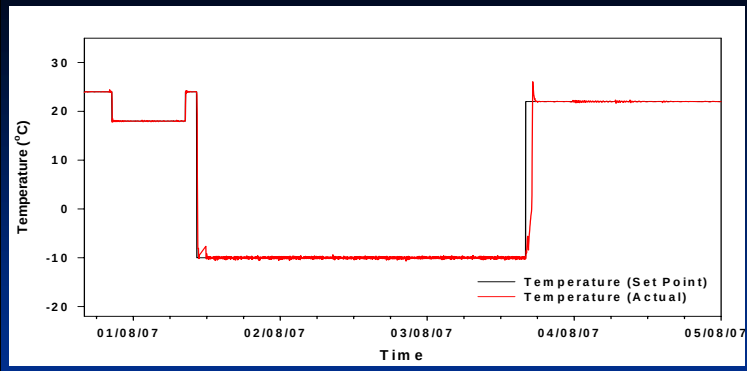
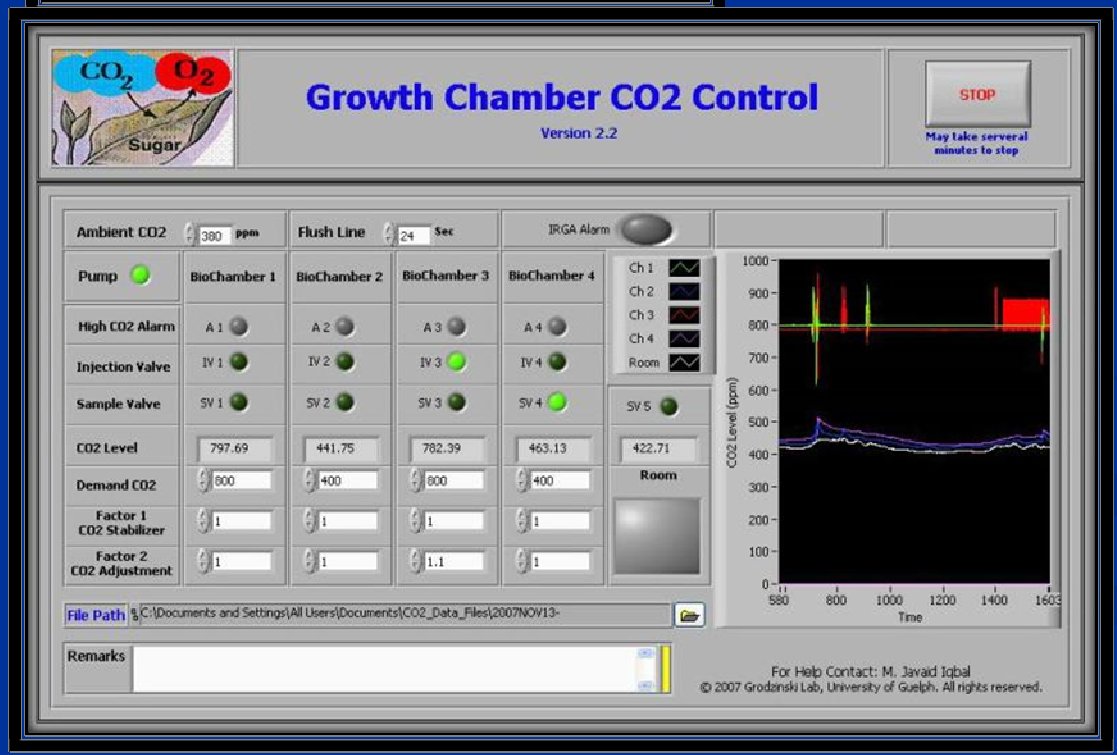


Guelph's Biotron-LTRF



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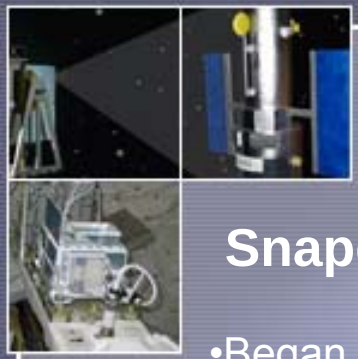


Snapdragon Experiment

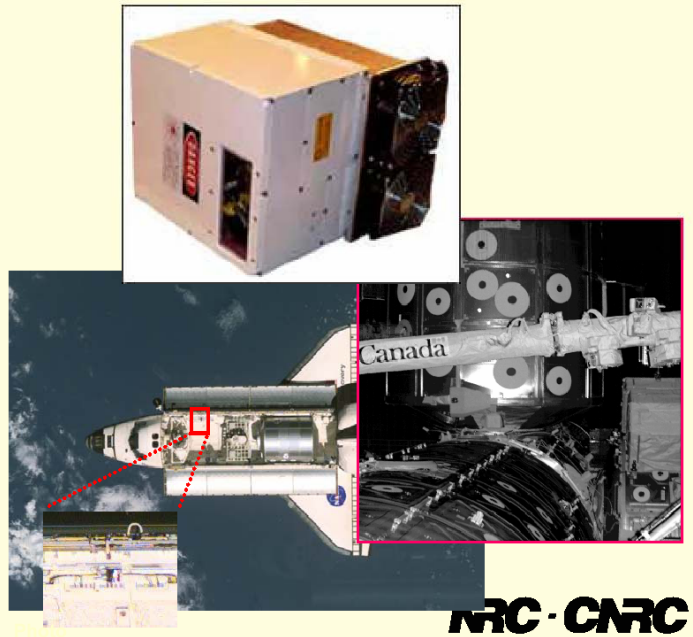
- Began with a population of Snapdragons *(Antirrhinum majus L.)*
- Half were treated with root pathogen (*Pythium aphanidermatum)*
- Some of the plants grown in growth chambers to measure gas exchange
- Some of the plants attached to transducers to measure height
- Monitored for 5 days to characterize the impact of the root pathogen
- Metrics:
  - Gas exchange
  - Height (Destructive, non, transducers)
  - Leaf Area (Destructive & Non)
  - NPQ etc. . .

Experiment

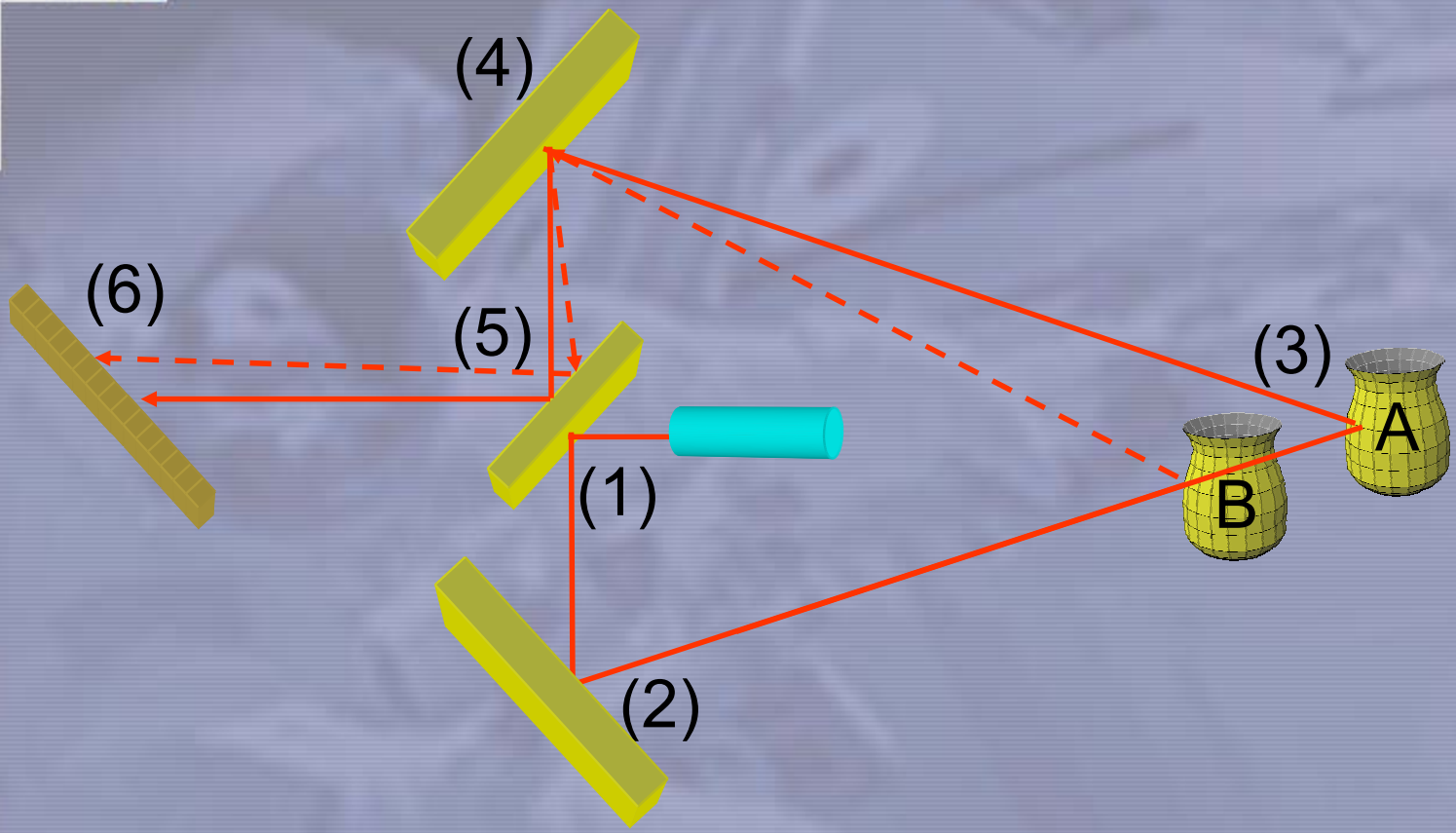
neptec.com

Neptec

- Space qualified system
  - Mission STS-105
  - August 2001
- High immunity to sun
- Range 1 m to 10 m
  - 0.1 mm @ 1m
  - 10 mm @ 10 m
- 30 deg x 30 deg FOV
- 1.5 um (eye-safe laser)



NRC · CNRC



Triangulation

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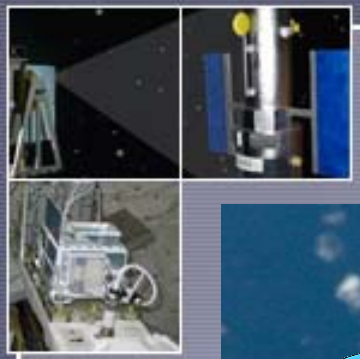
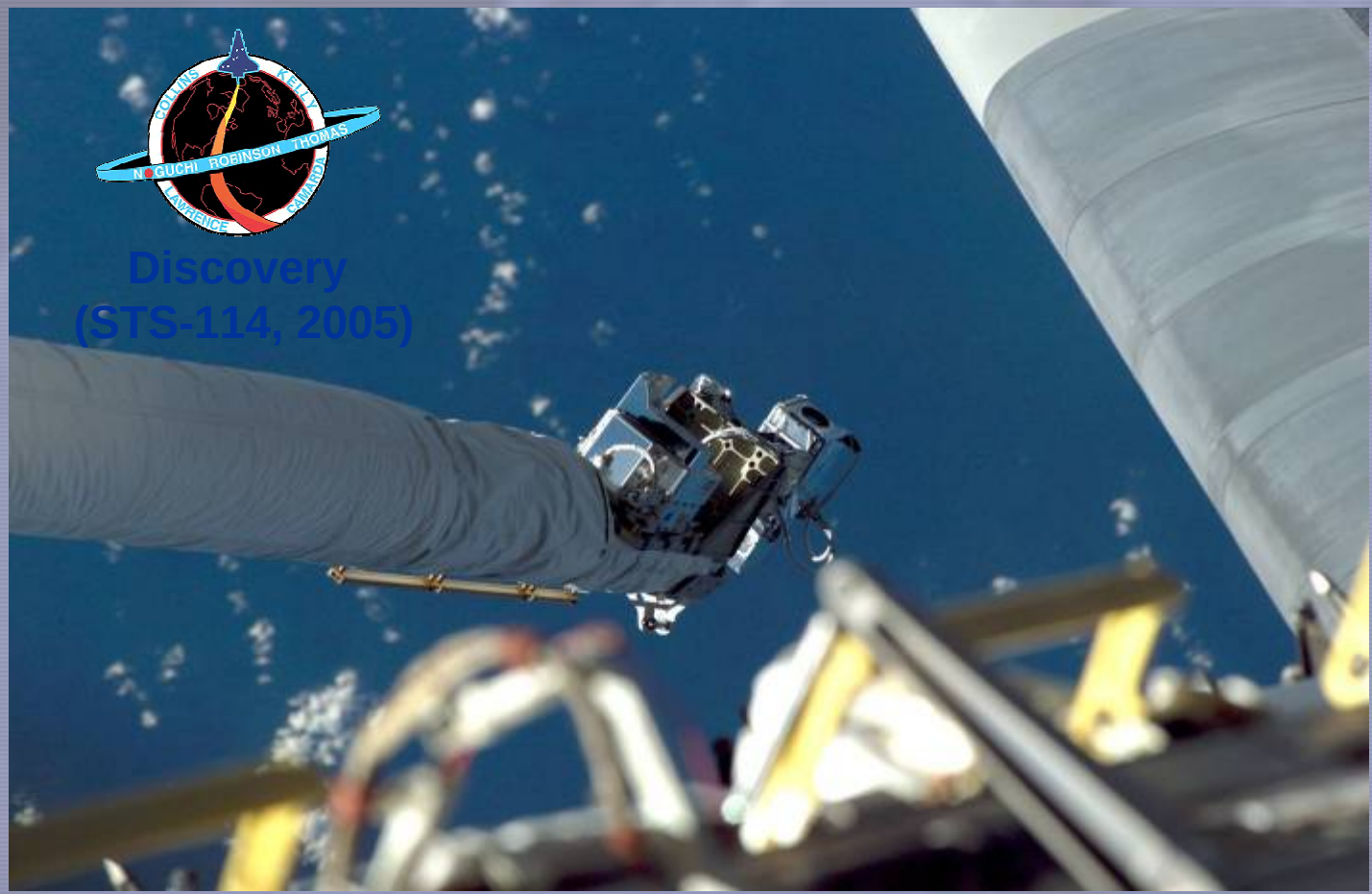
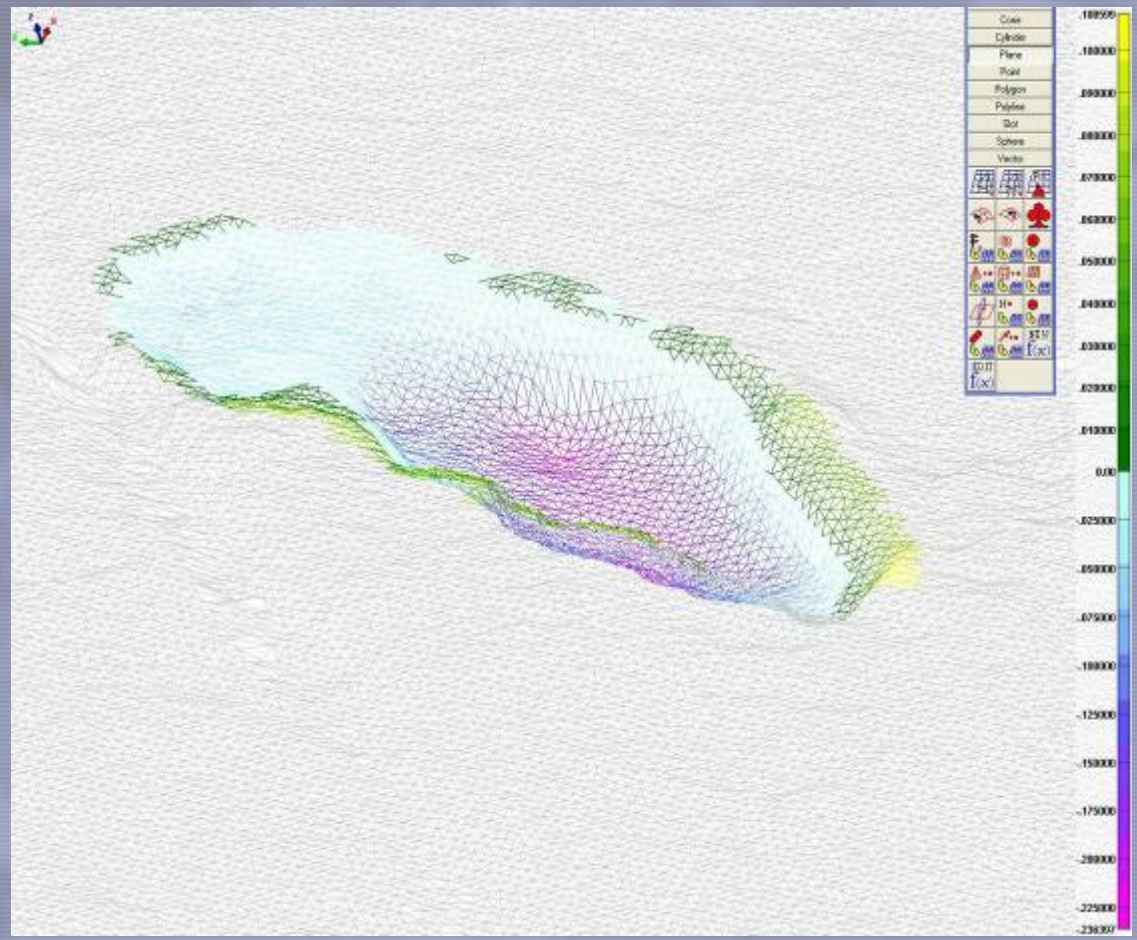
neptec
neptec.com





Discovery
(STS-114, 2005)

Triangulation



Discovery
(STS-114, 2005)

Triangulation

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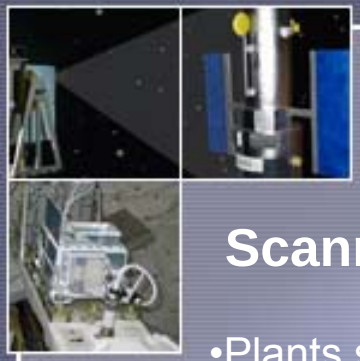
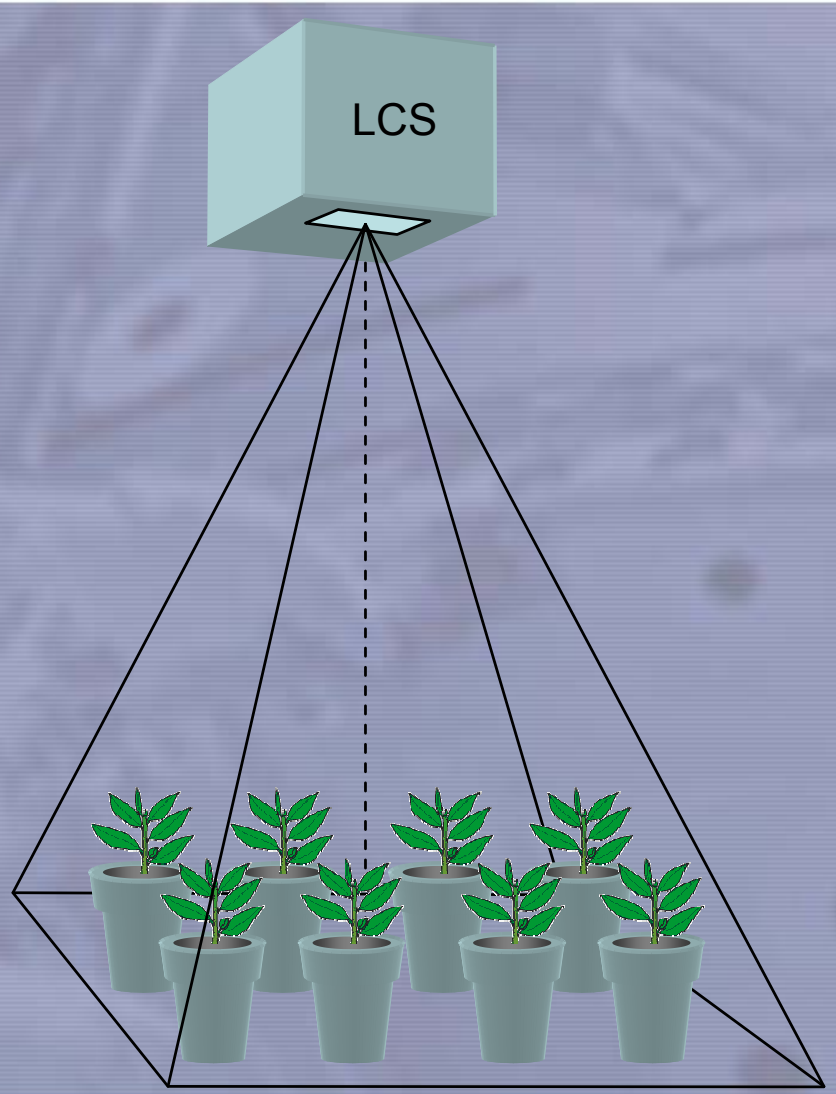


Scanning The Plants

- Plants scanned from above
- Stand-off distance of 1.2m
- Height & leaf area measured non-destructively for each plant
- Measured once for destructive tests
- Measured 1x per day for gas exchange population
- Measured 6x per day for linear-encoder population

- At the end of the experiment, all plants scanned and sacrificed to add to the standard curves



Experiment

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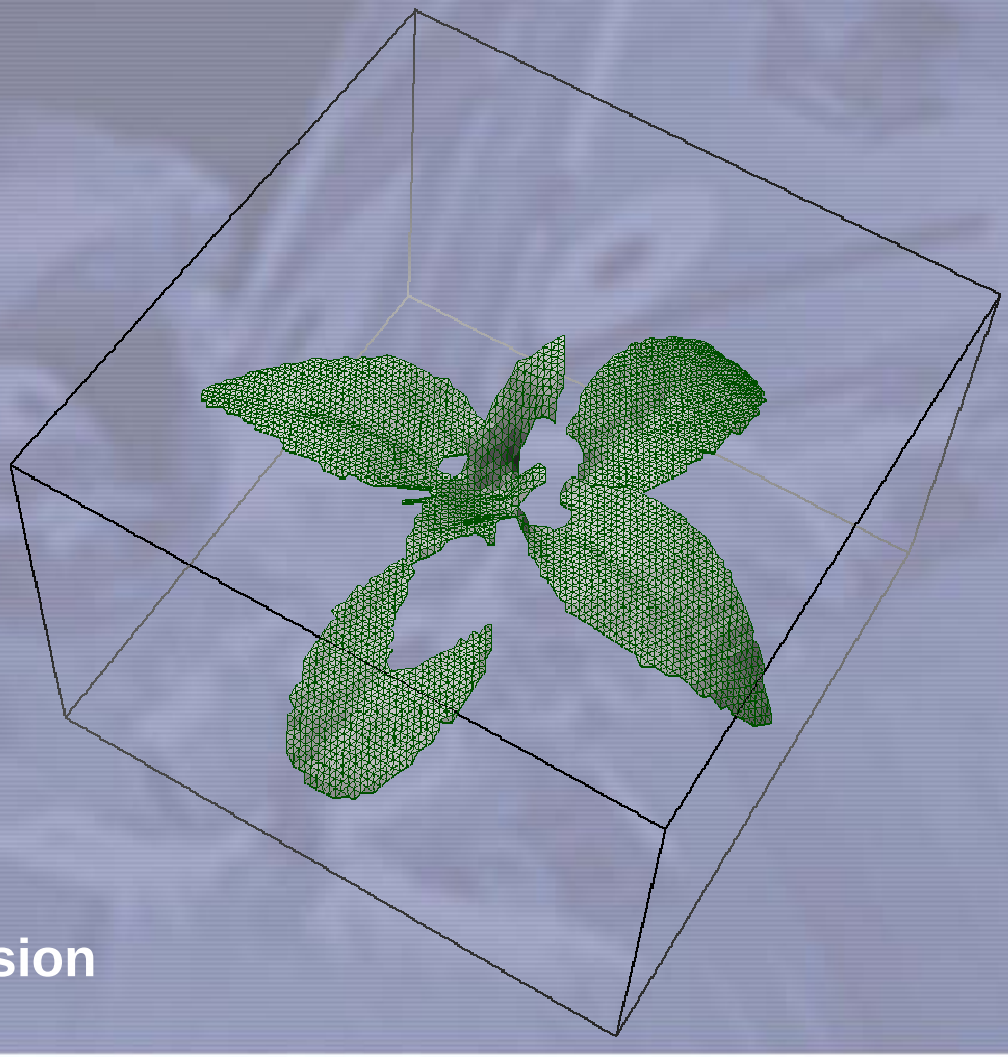

Self-Occlusion

Correlation

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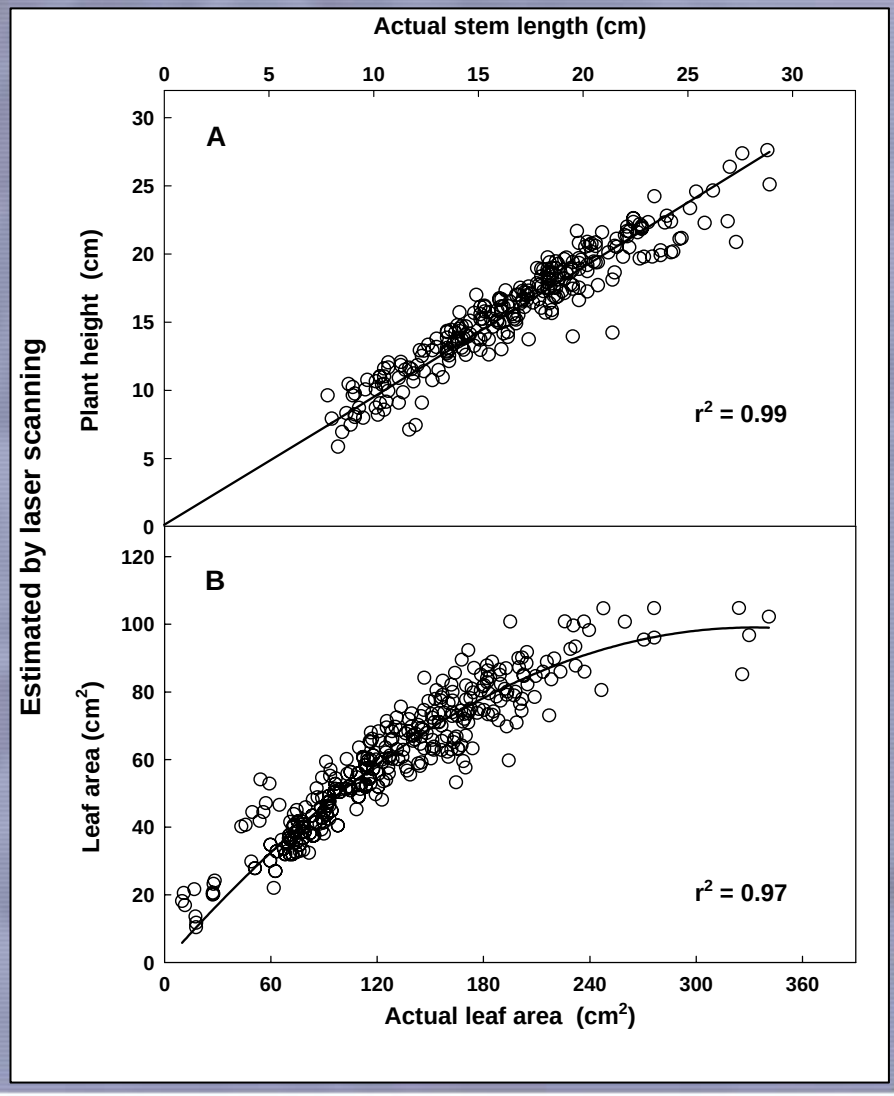
Correlation with Destructive Harvests

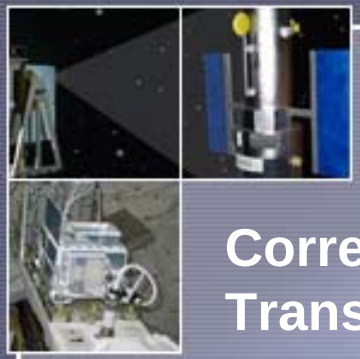
- LCS Measurements compared to ruler for height
- LCS measurements compared to flat-bed scanner for leaf area

- Leaf area shows increasing bias with increasing area
  - Use the standard curve to correct for the bias



Correlation

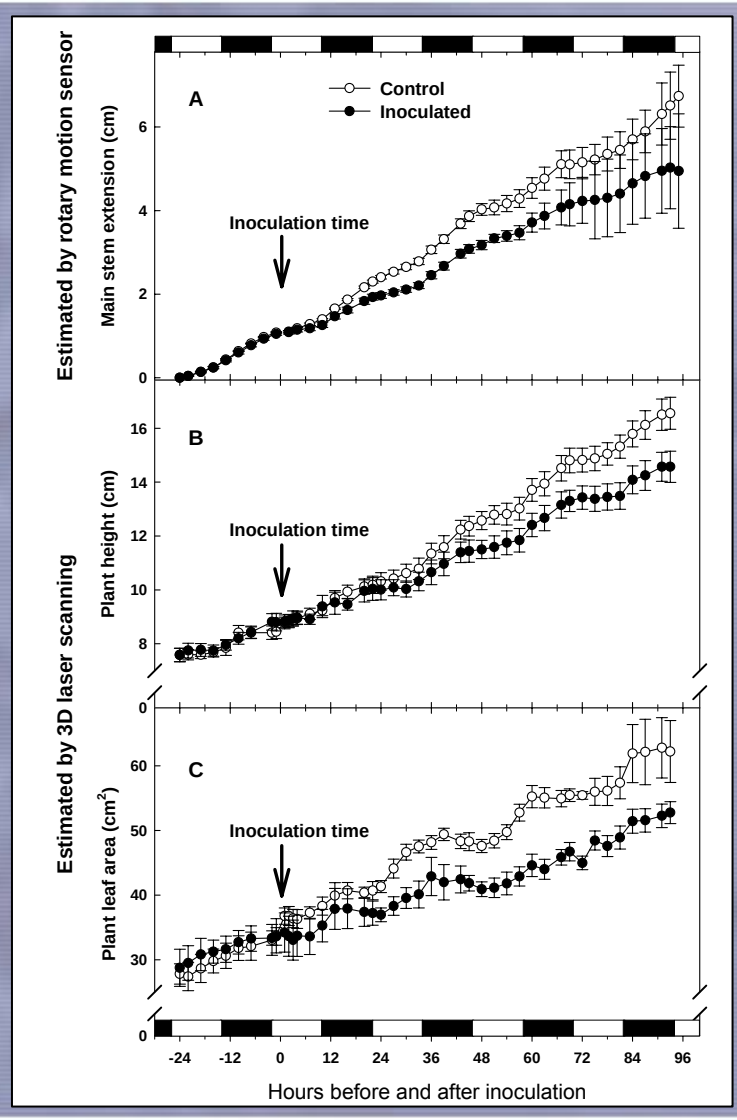
neptec.com



Correlation with Linear Transducers

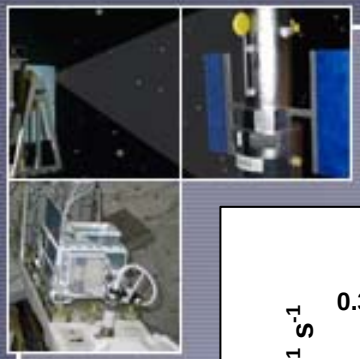
- Very good correlation with the transducer set
- No need to adjust strings (no handling required)

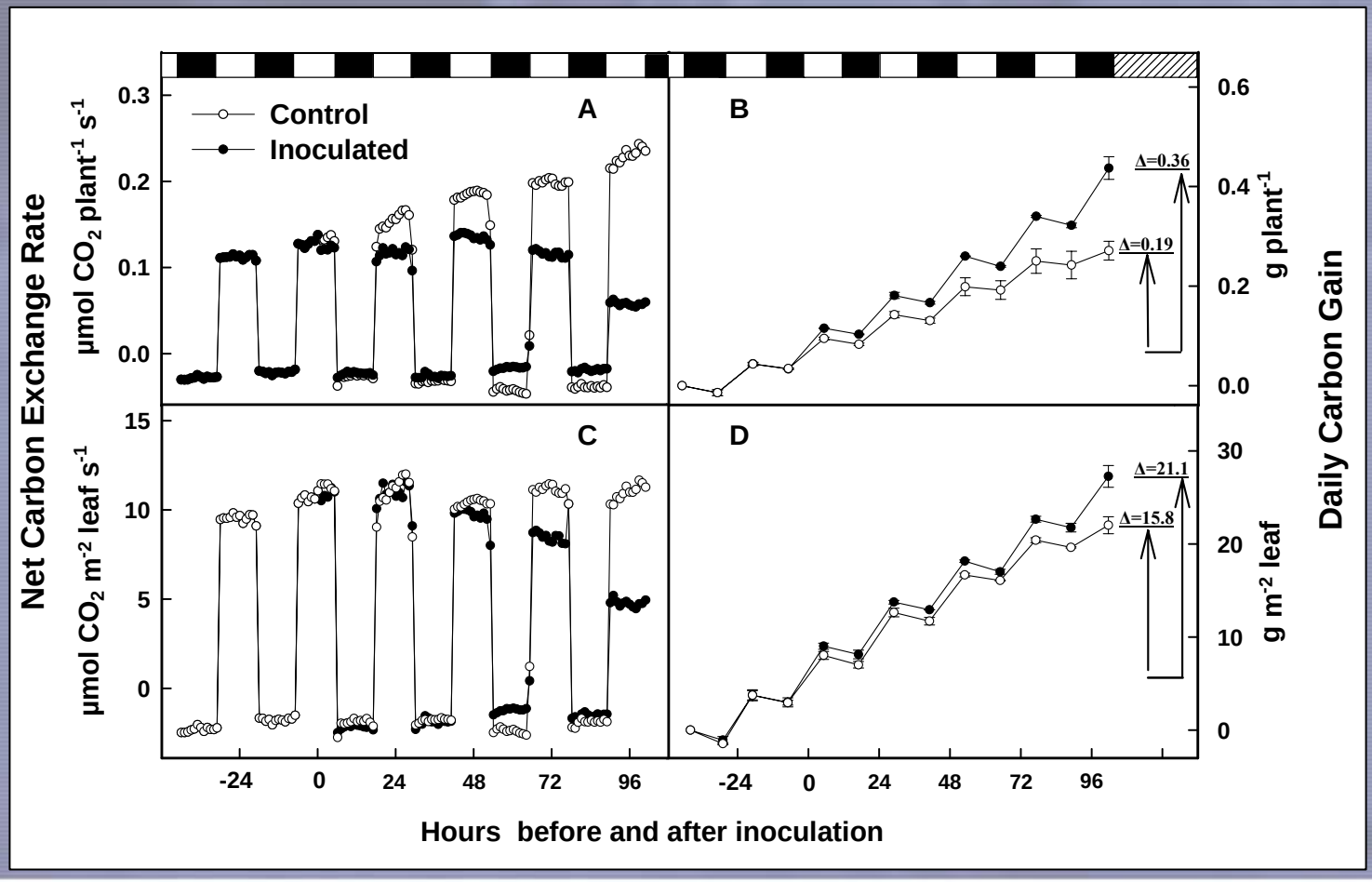
- Leaf area measurements have been corrected with std. Curve.



Correlation

neptec.com





Enabling Metrics

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CES and Research Levels

- Canopy/Ecosystem
- Organism (autotrophic, heterotrophic organs)
- **Organ (source leaf)**
- Tissue
- Cell
- Sub-cellular
- Molecular

Acknowledgement:

Bernard Grodzinski's Lab

- Demos Leonardos
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- Maria Emilia
- Renuka Subasinghe
- Lin Tian
- Shezad Rauf

- Jorge Gutierrez
- Melanie Johnstone
- Noe Ortiz
- Jason Deveau
- Jamie Doran

Barry and Malgre Micallef
Mary Ruth MacDonald

John Sutton (EVB)
Mike Dixon (EVB)
Chris Hall (EVB)
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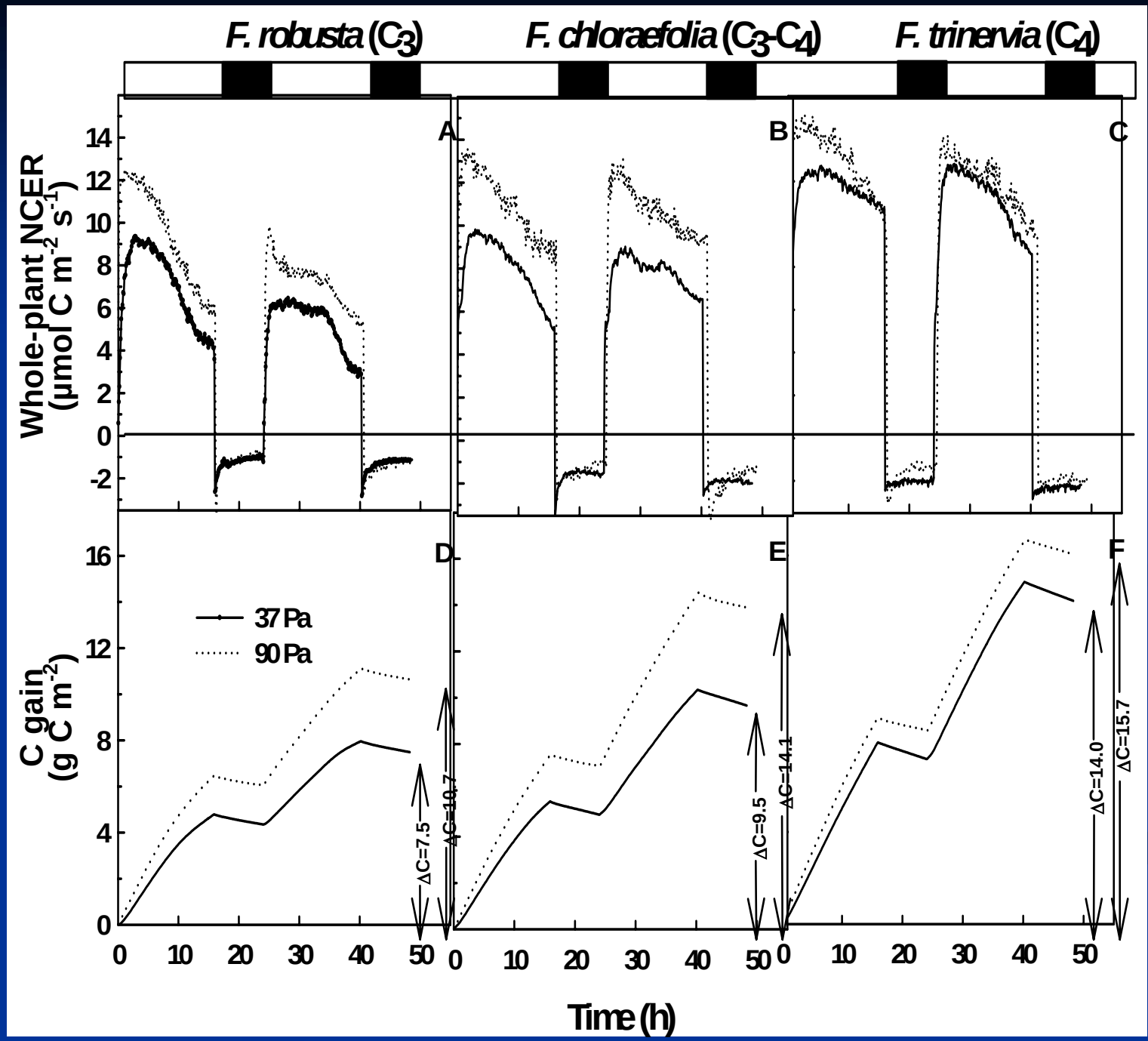
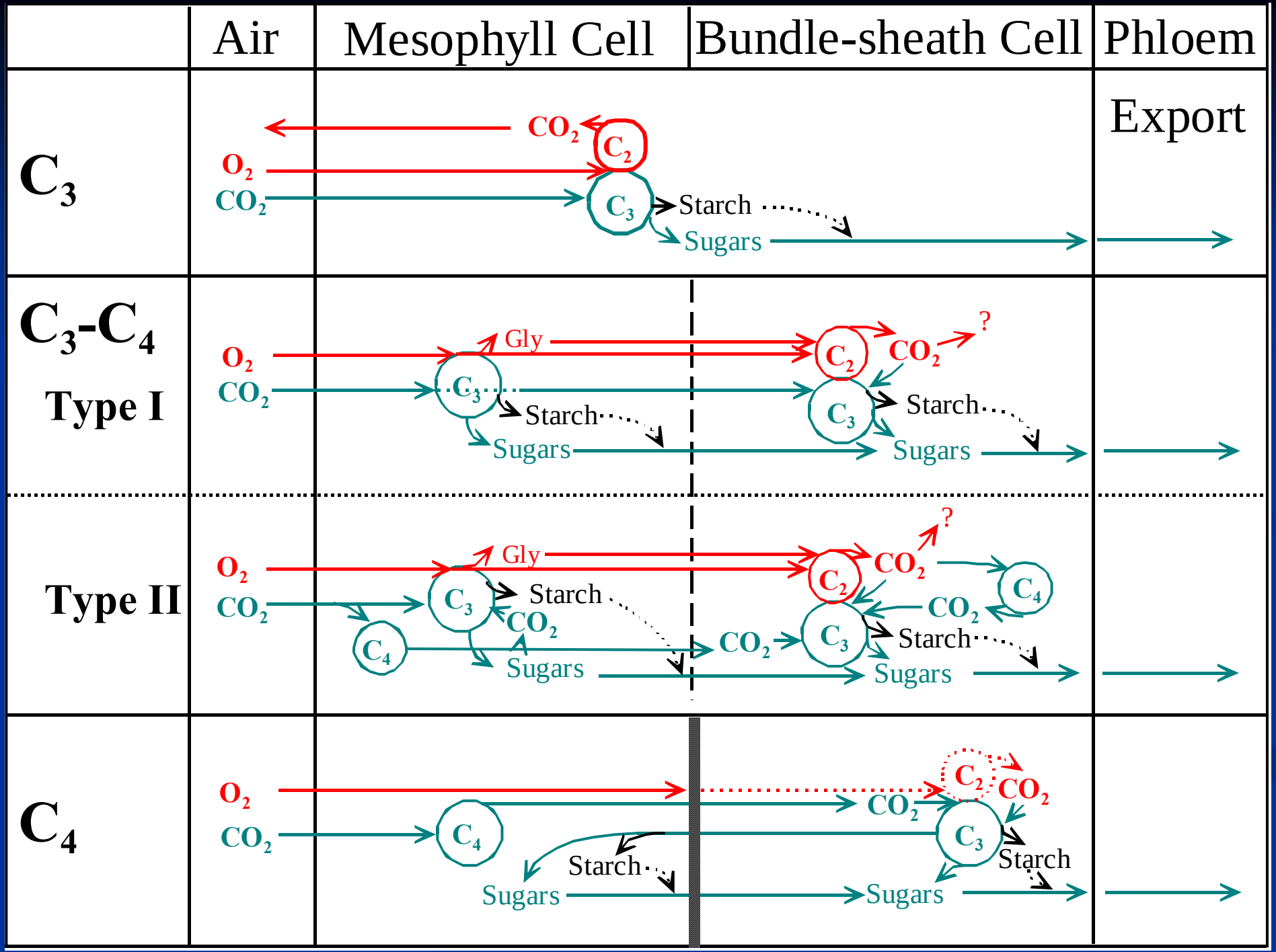
THANK YOU

Flaveria species

C_3	C_3-C_4	C_4

biotron
experimental climate change research




Air
Mesophyll Cell
Bundle-sheath Cell
Phloem
C3
CO2
C2
O2
CO2
C3
Starch
Sugars
Export
C3-C4
Type I
Gly
O2
CO2
C3
Starch
Sugars
C2
CO2
?
C3
Starch
Sugars
Type II
Gly
O2
CO2
C3
Starch
CO2
C4
Sugars
C2
CO2
?
C4
CO2
CO2
C3
Starch
Sugars
C4
O2
CO2
C4
Starch
Sugars
C2
CO2
CO2
C3
Starch
Sugars