NASA Institute for Advanced Concepts

A PLANT GENETIC ASSESSMENT AND CONTROL SYSTEM FOR SPACE ENVIRONMENTS

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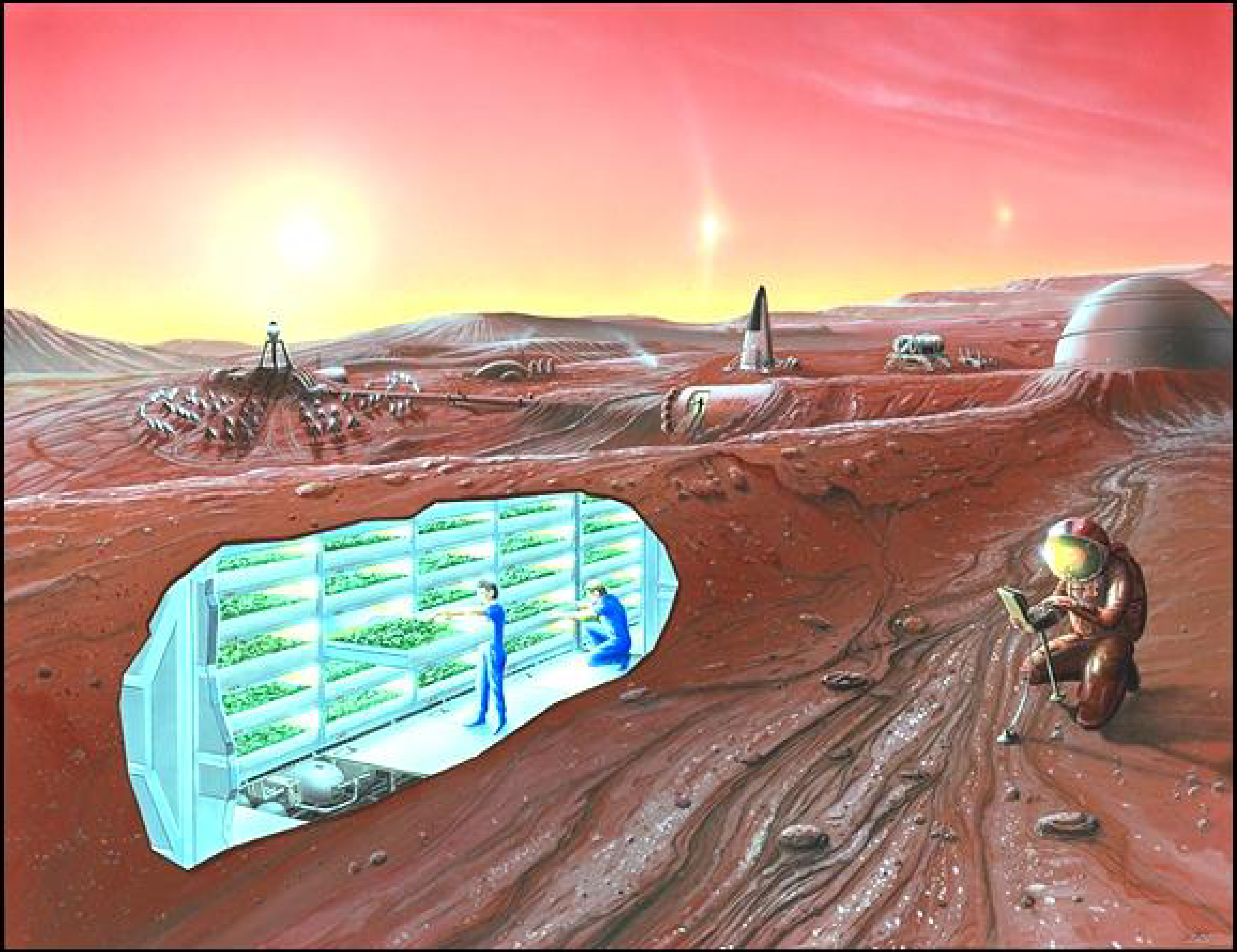
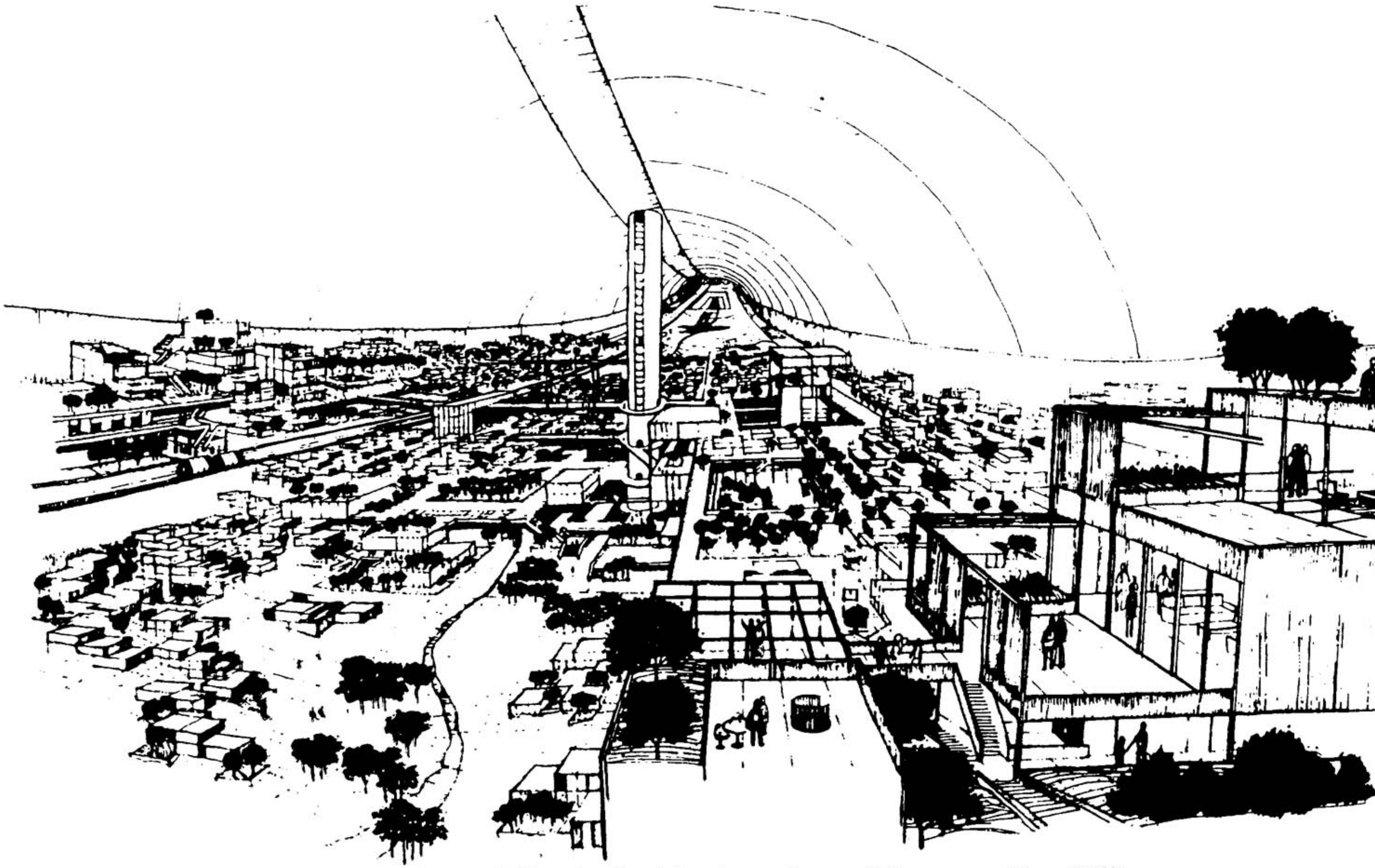
Plants will play an important role in any long-term space exploration

....colonization.....



…..or habitation



Residential district inside the colony. (Courtesy Pat Hill)

Challenges for Plants in Space:

Microgravity

Cosmic Radiation

Low Atmospheric Pressure

High CO_2

Temperature

????

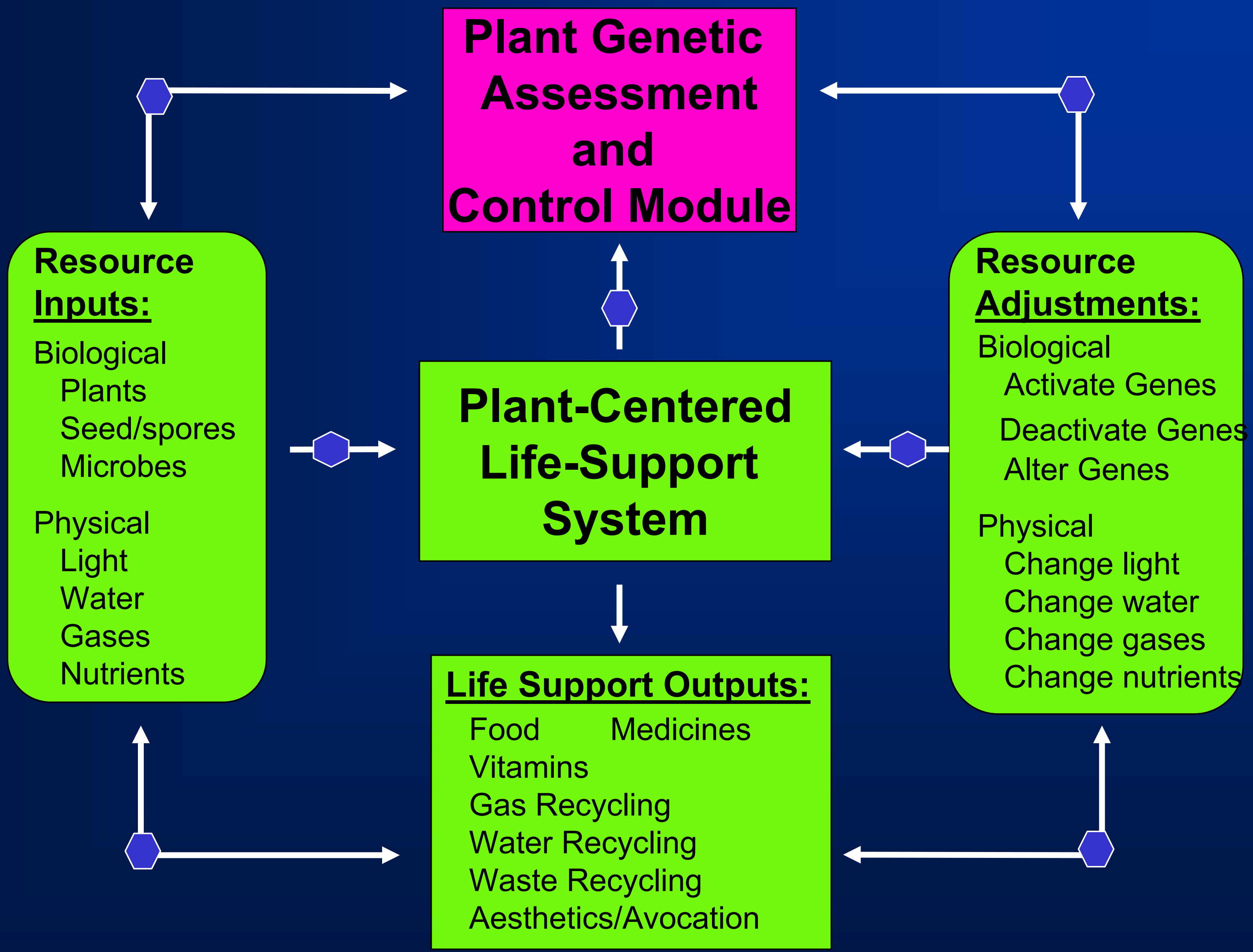
The Solution:

Plant Genomics in Space Environments

Adaptable system to measure and optimize the response of plants to any unique space condition

↓

Plant Genetic Assessment and Control Module


Plant Genetic Assessment and Control Module
Resource Inputs:
Biological
Plants
Seed/spores
Microbes
Physical
Light
Water
Gases
Nutrients
Plant-Centered Life-Support System
Resource Adjustments:
Biological
Activate Genes
Deactivate Genes
Alter Genes
Physical
Change light
Change water
Change gases
Change nutrients
Life Support Outputs:
Food
Medicines
Vitamins
Gas Recycling
Water Recycling
Waste Recycling
Aesthetics/Avocation

Plant Genetic Assessment <u>and Control Module</u>

Plants respond to their environment by changing gene expression

e.g. high CO_2

↓

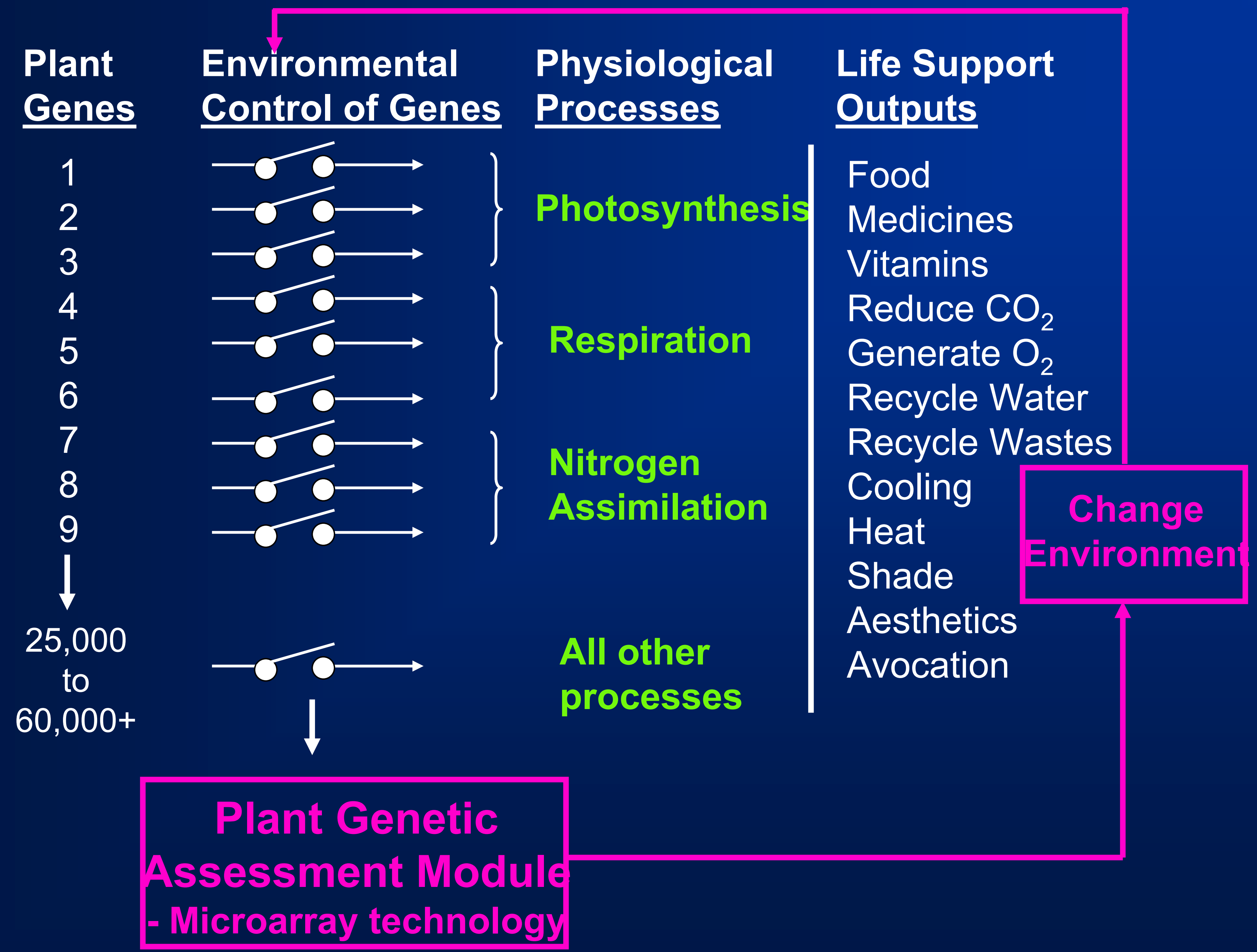
mRNA transcription from the Rubisco gene

↓

Increased Rubisco protein

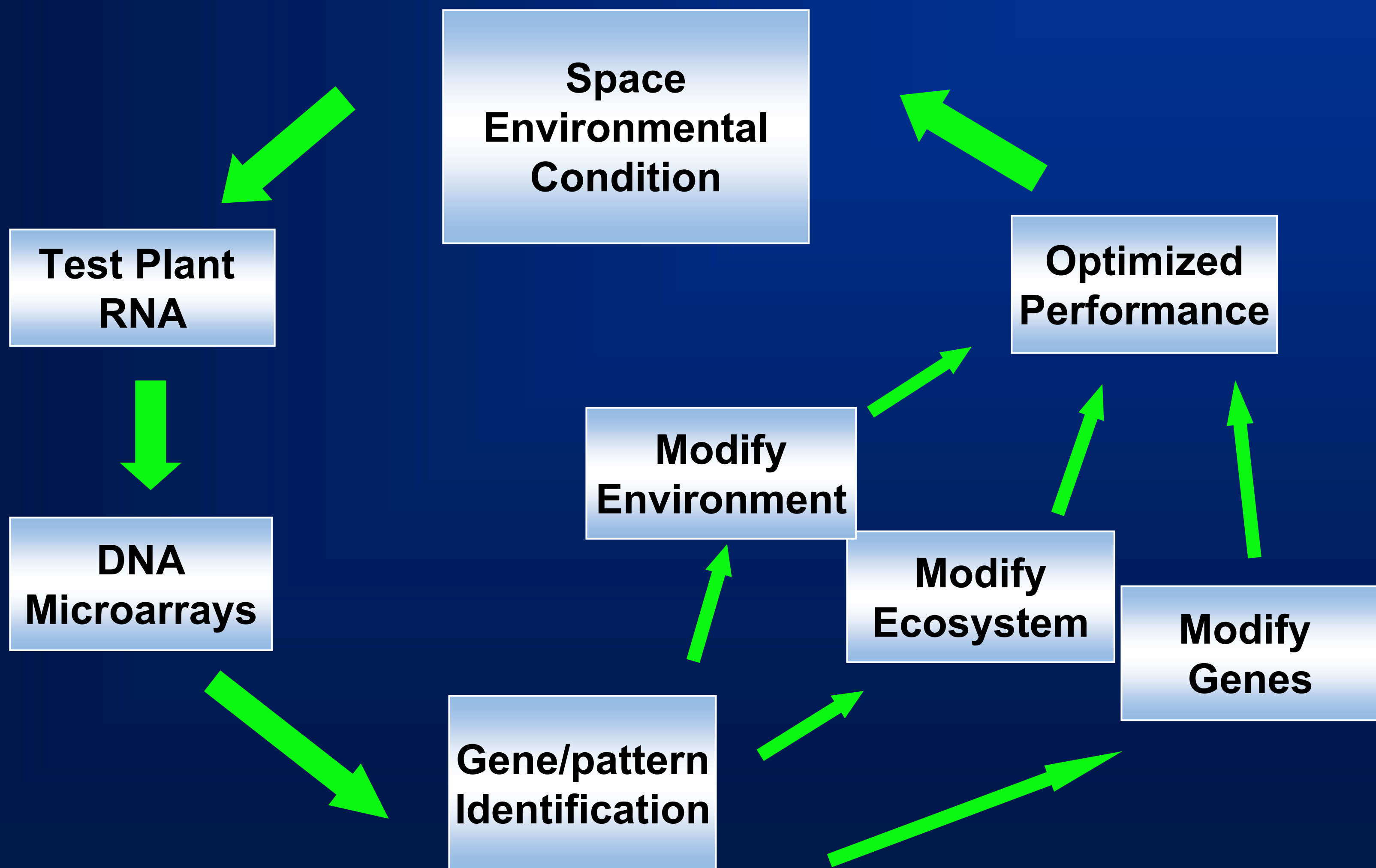
↓

Increased photosynthesis → outputs

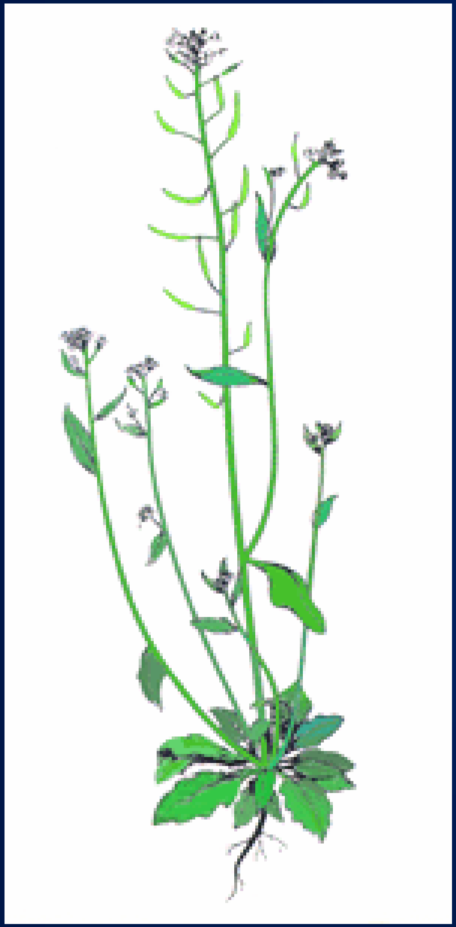


Plant Genes
Environmental Control of Genes
Physiological Processes
Life Support Outputs
1
2
3
4
5
6
7
8
9
25,000 to 60,000+
Photosynthesis
Respiration
Nitrogen Assimilation
All other processes
Food
Medicines
Vitamins
Reduce CO_2
Generate O_2
Recycle Water
Recycle Wastes
Cooling
Heat
Shade
Aesthetics
Avocation
Change Environment
Plant Genetic Assessment Module
- Microarray technology

Basic Architecture for Plant Genomics in Space Environments

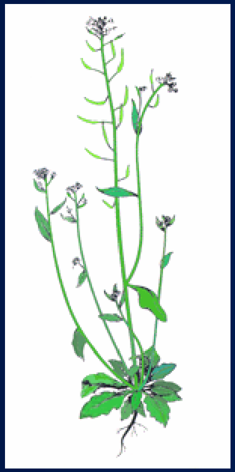


Arabidopsis thaliana:



- model plant system
  2010 Project
- defined gravitropic response
- genome sequence complete
- small size
- rapid generation time
- space-flown

Basic Architecture for Plant Genomics in Space



Space Environmental Condition

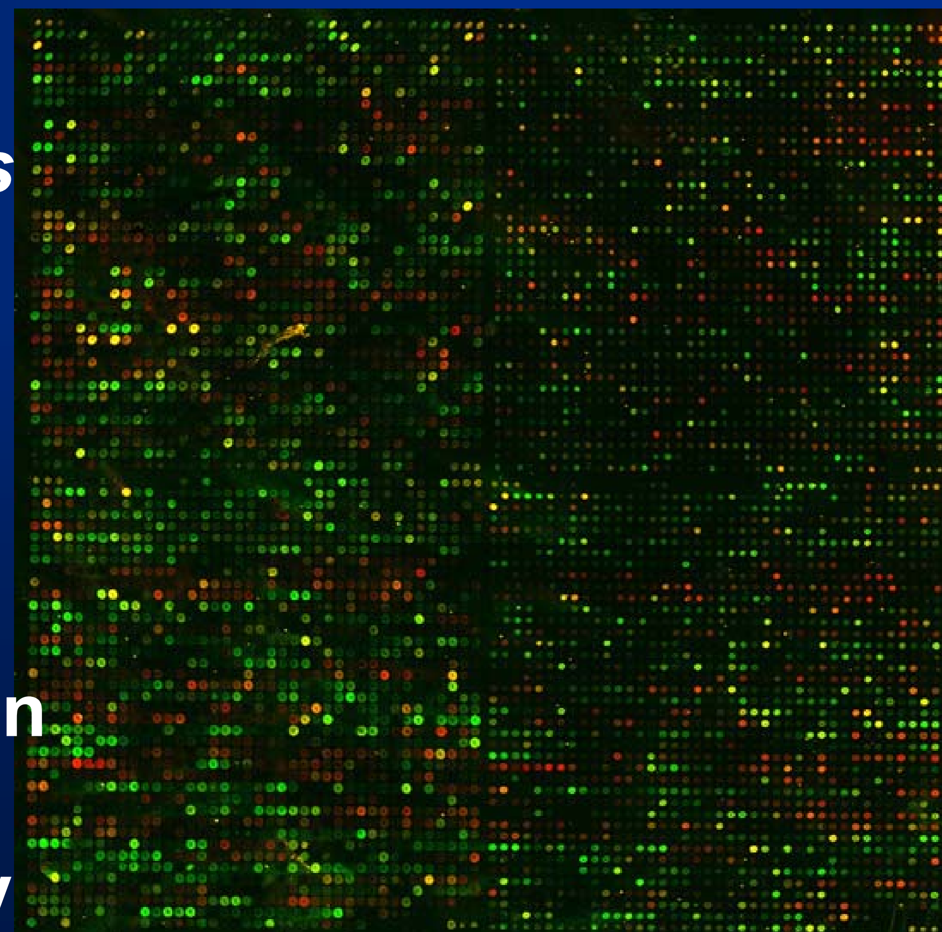
Test Plant RNA

DNA Microarrays

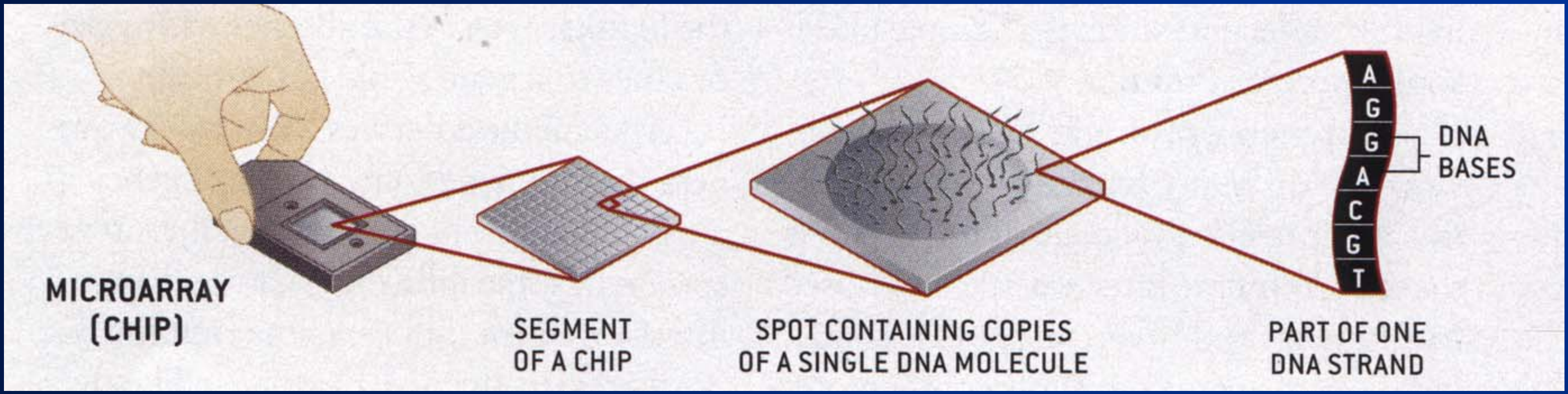
Plant Genomics in Space Environments

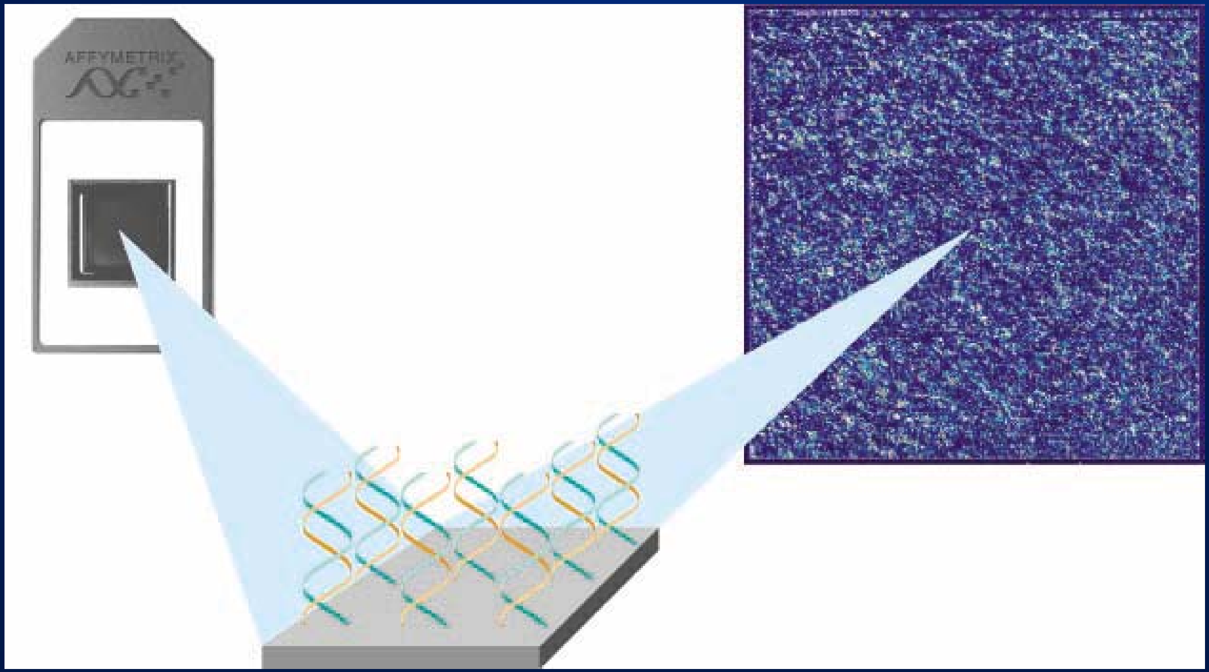
Microarray Technolog

- temporal and spatial gene expression
- Affymetrix *Arabidopsis* gene chips with over 8200 genes
  - next generation chip w/entire genome due this summer
- provides information on gene involvement in a process or pathway

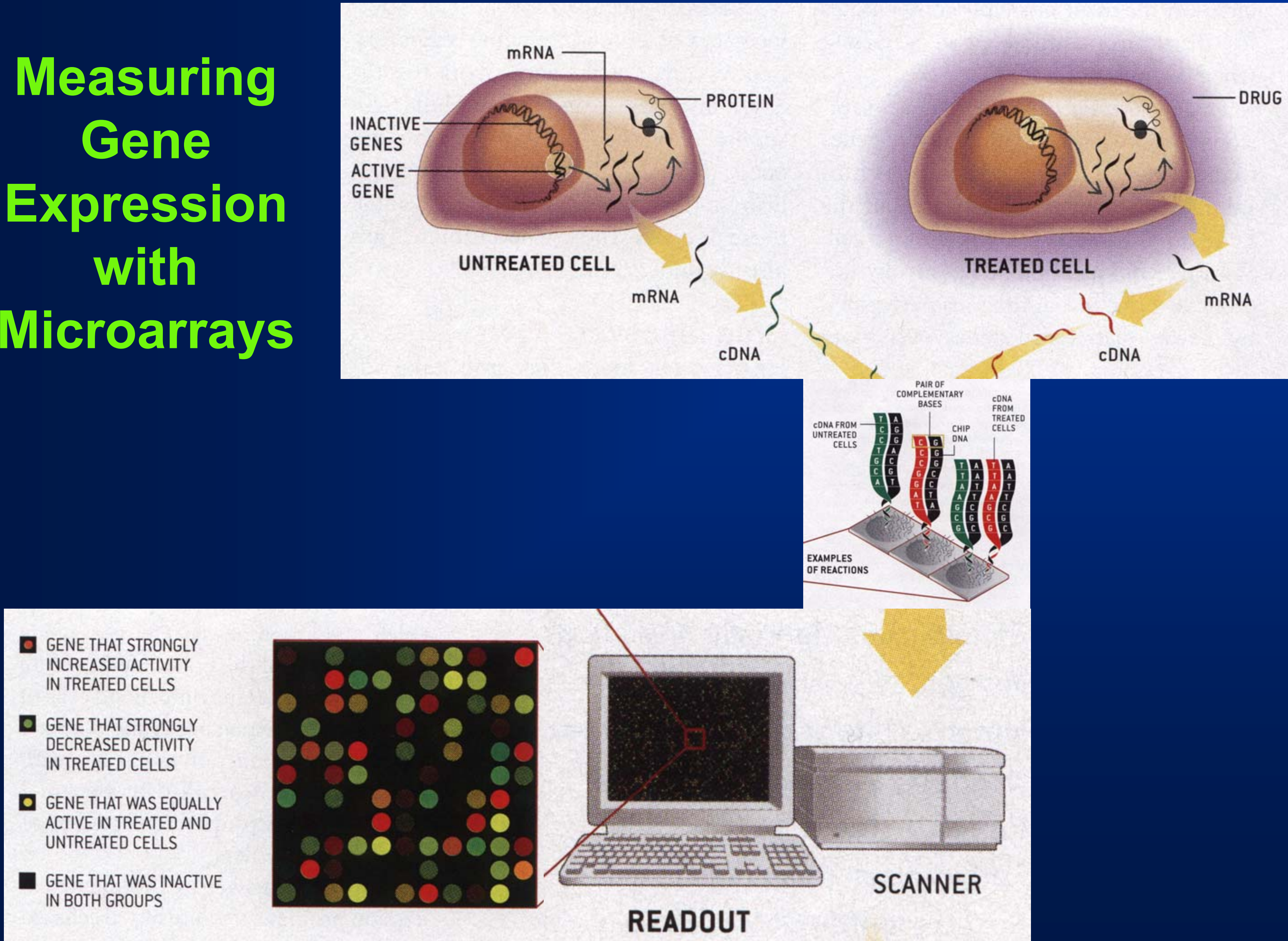


Microarrays carry DNA representing 10,000s of gene

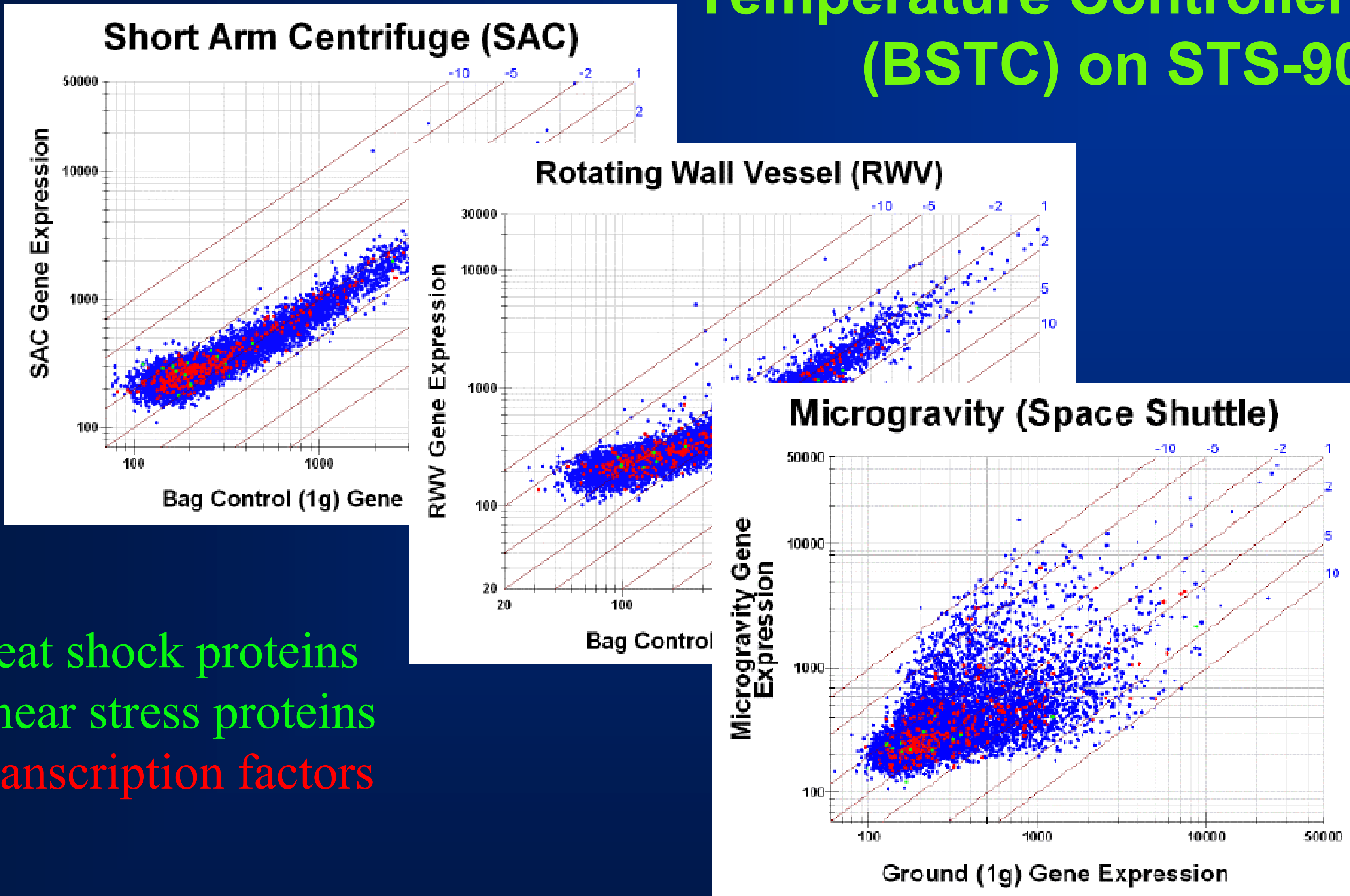




Measuring Gene Expression with Microarrays



Rat kidney cell cultures in the Biological Specimen Temperature Controller (BSTC) on STS-90



heat shock proteins
shear stress proteins
transcription factors

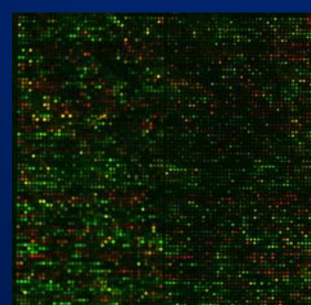
Courtesy Tulane Environmental Astrobiology Center

Basic Architecture for Plant Functional Genomics

Space Environmental Condition

Test Plant RNA

DNA Microarrays



Gene Identification

Data Mining:
Plant Genome Sequence Databases

The Arabidopsis Information Resource

tair

TIGR

THE INSTITUTE FOR GENOMIC RESEARCH

Phase I - Issues & Accomplishments

Arabidopsis

√ Test plant *Arabidopsis thaliana* as model system to identify genes involved in the gravitropic response

Arabidopsis
RNA

√ Optimize sample preparation for differential expression analysis

DNA Microarrays

√ Affymetrix Microarray analysis

Arabidopsis
Database

√ Identify genes whose expression increases

Phase II - Plant Genetic Assessment and Control System

Based on unique combination of systems:

- Rapid advances in plant genomics
- Microarray technology to measure gene expression
- Bioinformatics
- Physiological monitoring

Plant Genomics in Space Environment

Phase II:

- Continue testing feasibility of microarray analysis

- Introduce additional environmental condit

  - space-flown plant material

  - high CO_2

OSU Controlled Environment Chamb

Plant Genomics in Space Environment

Phase II:

- Continue testing feasibility of microarray analysis
- Introduce additional environmental conditions
  - space-flown plant material
  - high CO_2
- Assess the key technology issues for developin a Plant Genetic Assessment and Control Module

Plant Genomics in Space Environments

Key Technology Issue - Size:

The Future: 2002-2020

- Expand collaborations with NASA, Affymetrix, and AVI Biopharma (gene knockouts) to develop remote technologies
- Work with engineers to optimize module for space flight/habitat
- Adapt approach to additional plant systems as data and technologies evolve

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