Unit 5.2

Plant Biology

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Vocabulary:

• Autotrophic
• Circumnutations
• Embryogenesis
• Gametophyte
• Gravitropism
• Meristems
• Nastic
• Nictinasty
• Phototropism
• Thigmotropism

Purpose:

This course section is intended to give you a brief introduction into the structure of plants used in space research. Plants possess unique growth attributes that make their growth and differentiation very different from animals. By understanding the unique attributes of plants, you will better understand the importance of plant research performed in space.

Objectives:

The following are merely some of the questions asked about plants in space. In order to answer these questions, we need a basic understanding of how plants are structured and how they grow.

a) What is a plant?

b) How do plants grow, and why is this relevant to spaceflight research?

c) From an evolutionary perspective, are plants primitive or advanced?
   1. If plants are advanced, why don’t they possess complex structures like brains or hearts?
   2. Without brains, how do plant parts talk to each other?

d) What aspects of plant biology do researchers want to study in space?

e) What are some of the more useful attributes of plants that make them amenable to space research?
How Plants Grow

- Photosynthesis and the autotrophic habit: Plants are the source for acquired energy in all living systems.

- Life as a non-moving sessile organism: Fight or flight is not an option.

- Plants as “copers” in a hostile environment: Consequences of being stuck in the ground.

- Plant cell walls as a means of dealing with mechanical and environmental stresses.

- Cell division and cell differentiation: Meristems as localized centers of cell division. The formation of functional plant tissues from specialized plant structures.

- The overall plant body as a polarized system of shoots and roots: The predominant role of gravity in defining the orientation of plant organs.

- Control of growth and differentiation in an organism without a neural system: How do plant cells talk to each other?

Photosynthesis

Overview of photosynthetic processes as they occur in plants, algae, and cyanobacteria.
Durability of Plants

- Ability to tolerate extreme temperature ranges
- Mineral absorption and food storage
- Long term capacity to store labile chemical molecules
- DNA and RNA repair mechanisms
- Seeds as resting stages of plants: The durability of seeds
- The direct impact of plant durability on spaceflight experiments

How Plants Respond to a Hostile Environment

- Tropisms, a sessile plant’s response to a hostile world
  - Phototropism
  - Gravitropism
  - Thigmotropism
- Other movements of plants: Why do they move? How do they move?
  - Quick animal-like movement in plants
  - Nictinasty and circumnutations
- Plant Defense Mechanisms
  - Does gravity influence how they work?
  - Are they relevant to space biology?

Plant Reproduction

- Unique attributes of sexual reproduction in plants
- Plants as a model for sexual reproduction in all organisms
- What is a gametophyte, and why do plant biologists like to study them?
  - The life cycle of a fern as a model for all organisms
  - Alternation of generations
Model Plant Organisms

*Arabidopsis - one word says it all*

Other plants:
- Wheat
- Brassica
- Fern gametophytes
- Tomato, tobacco, petunia,
- Pea, soybean, carrot, pines
- Plant cells and explants

Future Spaceflight Experiments

Specifically, what do plant biologists want to study in space?

- Control of growth and differentiation
- Signal transduction: long and short distance communication
- Genetic control vs. environmental influence (especially gravity)
- Investigation of “pure” mechanisms
- Transgenics, especially knockout mutants
- Regulation of gene activity without the complications of gravity
- What genes regulate gravity perception?
- How is gravity perceived outside the root cap?
- How is (gravity) perception translated into control of differentiation?
- Sensitivity of plants to very low levels of environmental pollutants
- Disruption of “normal” differentiation, somatic embryogenesis
- Gravity influence on secondary metabolites

Other interesting experiments:

- Biomass production
- Energy and carbon cycling, advanced life support
- Other spin-off studies, green light, impact of organic volatiles (ethylene)
- Plants as sensitive bioassays for environmental pollutants
- How to grow plants in a little box
- How to grow all organisms in a little box
Notes: