Space Science 101 - Plants

Why is Plant Science important to Space Research?

- Plants play a vital role in the Bioregenerative Life Support systems envisioned for extended space exploration
- Plants will form the core of all planetary bases for nutrition, as well as for the recycling of air, water and waste materials
- Plants also make a substantial contribution to the well-being of humans in remote and isolated environments

Why is Space Research important to Plant Science?

- Gravity strongly influences plant growth and development on Earth, and conducting experiments in spaceflight habitats reveals fundamental answers about the metabolic workings of plants that are otherwise masked in Earth's gravity.
- We also need these answers to enable us to successfully grow plants off the surface of the Earth.

Why is Plant Space Research important to Earth?

- Fundamental insights into plant space biology informs all branches of terrestrial plant science, which contributes to innovation in agriculture and renewable energy technology
- Understanding how plants respond to the novel environment of spaceflight also contributes to predicting how plants will respond to novel terrestrial stresses, such as climate change, pollution and encroaching hostile habitats
- The technology and innovation used in optimizing closed plant habitats on the space station and in planetary analogs contributes to innovations in protected agriculture (production greenhouses) that expands our ability to feed populations in remote and hostile environments on Earth

Important Questions – what do we need to know about plants to support space exploration?

Plant tropisms – how do plants "know" how and where to grow without gravity to guide them?

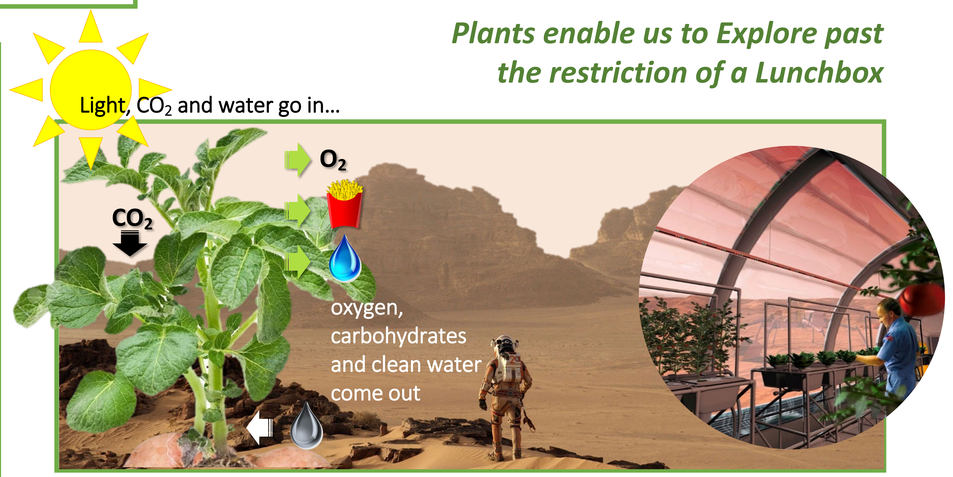
Plant metabolism – what does spaceflight do to basic metabolic processes? Are there impediments to growing plants in space?

Reproduction – is flowering and seed production impacted by the spaceflight environment? How do we deal with pollination in an environment without wind or pollinators?

Gene expression and Genetics – what are the genomic responses to the spaceflight environment? Can we use transcriptome information to engineer plants better adapted to spaceflight environment?

Radiation – How will the radiation environment of deep space, such as on a mission to Mars, affect seeds and the next generation of plants grown at the destination?

Plants enable us to Explore past the restriction of a Lunchbox



Plants enable us to survive in places with limited resources for humans

- Recycle waste water to pure water
- Recycle CO2 (exhaled breath) and generate Oxygen (to breathe)
- Recycle waste organics
- In addition, plants can draw inorganic minerals from the environment, and then make available to humans by converting them into a form that can be metabolized by humans – **Plants are Masters of In Situ Resource Utilization**

What have we learned about plants that could only be revealed in the spaceflight environment?

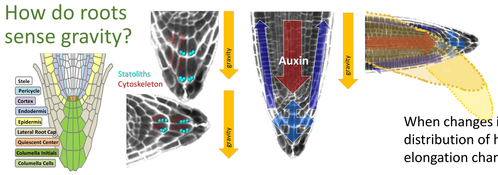
Plant tropisms – In the absence of gravity, plants use light to navigate. Wavelength and intensity gradient of light impacts how a plant grows in the absence of gravity.

Reproduction – gravity is not required for plants to form seed, but plants need help with pollination without wind and insects.

Gene Expression and Genetics – plants change their patterns of gene expression in response to the spaceflight environment:

- genes associated with cell wall remodeling and oxidative stress are important to the adaptive response to spaceflight
- genotype is important, and evidence suggests we can select or engineer genomes to be better adapted to spaceflight
- not all changes in gene expression are due to the lack of gravity, as shown in experiments with on-board centrifuges
- epigenomic changes are induced by spaceflight environment

How do roots sense gravity?



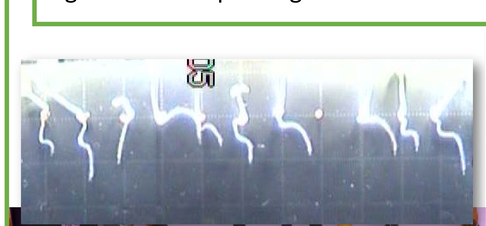
The root has specialized cells called columella that play a role in sensing the gravity environment

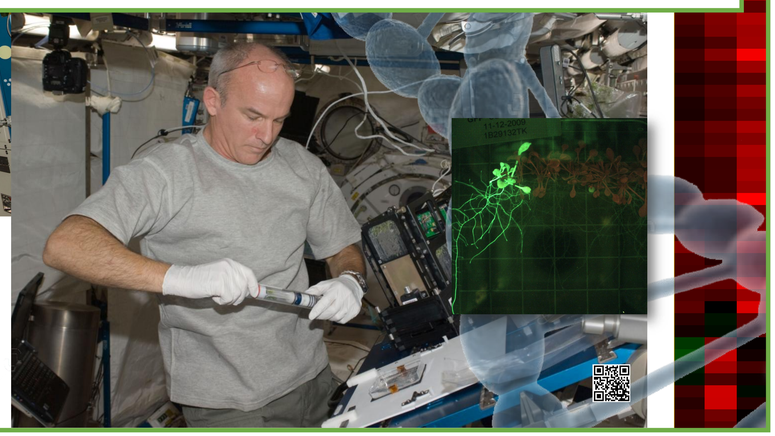
Specialized organelles and structures in these cells sense changes in the gravity vector

It's not the whole story (light plays a role, and so do other cellular factors) But it is a start!

When changes in the gravity vector are sensed, the distribution of hormones that influence cell elongation changes, and some cells get longer.

When cells along one side of the root elongate faster than the cells on the other side, the root grows in a new direction - back towards of gravity





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