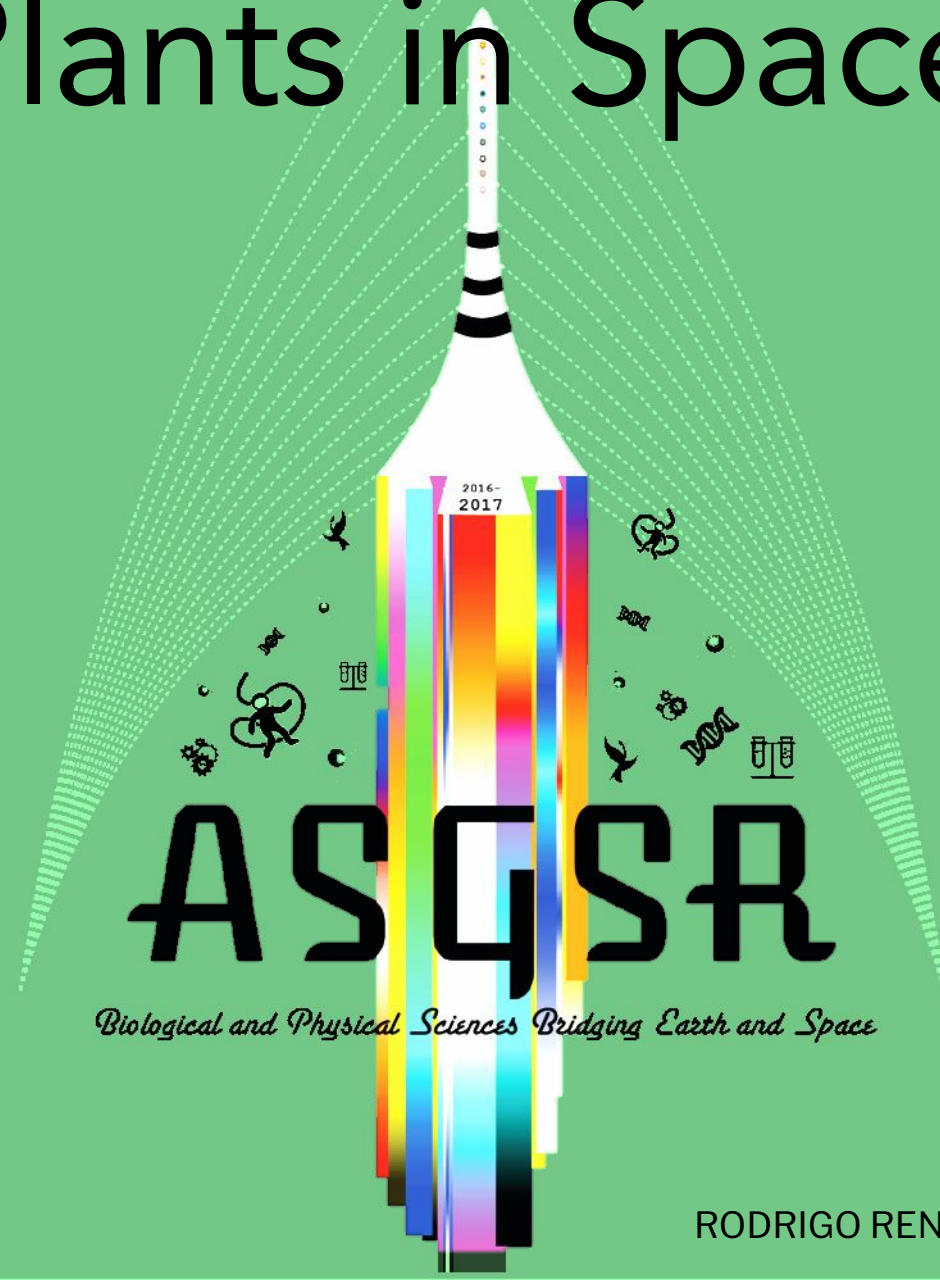


# Plants in Space



SLIDES BY:

RODRIGO RENE RAI MUNOZ ABUJDER

# WHAT ARE PLANTS?



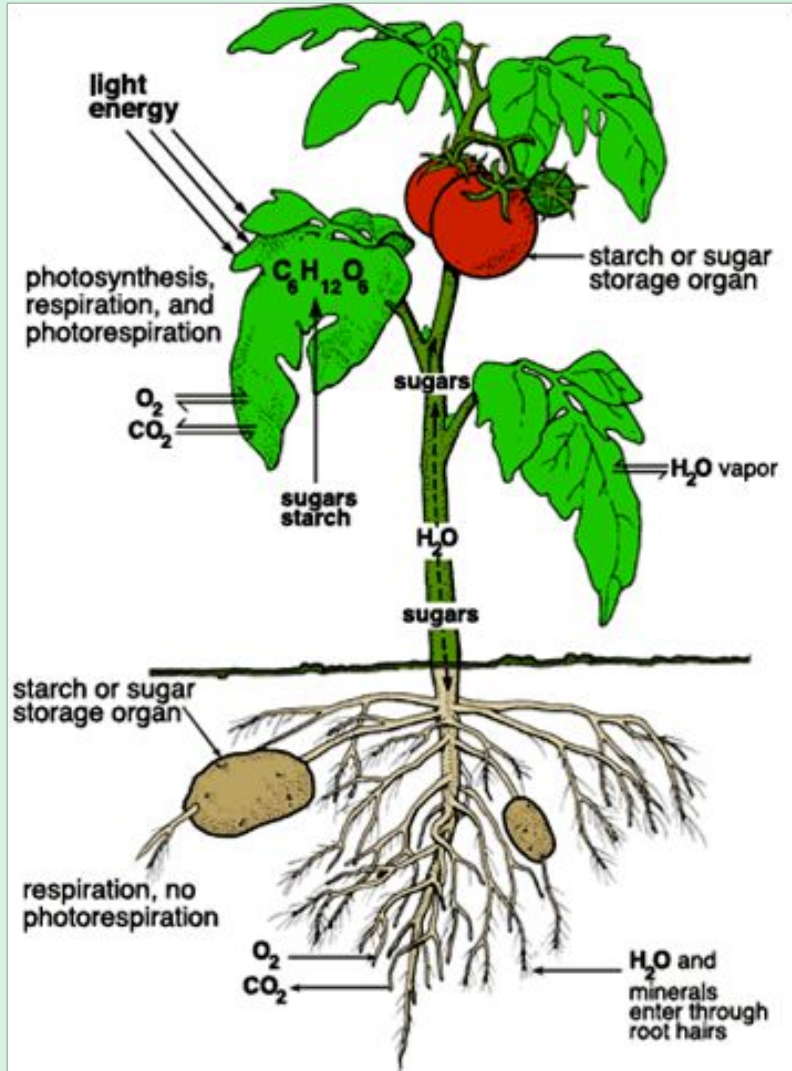
**Plants** are living organisms with many different species including shrubs, herbs, trees, and flowers.

## Plants:

- Grow almost anywhere on Earth
- Absorb water and inorganic substances through its roots
- Mix nutrients in its leaves via photosynthesis (or light) and carbon dioxide



Most importantly, plants create oxygen for us to breathe and different types of food for us to eat!



## What is the function of Roots

Roots take nutrients and water from soil and transport them to the plant to allow it to grow

## Leaves

Leaves perform photosynthesis, meaning they take light energy to create sugars

## Fruit

Fruits allow plants to spread their seeds and reproduce

# WHAT DO PLANTS HAVE TO DO WITH SPACE?



Plants provide both **food** and **oxygen**.

This is especially **critical** for astronauts living in the space station a long durations and eventually **life in space!**

Currently, several plants such as Arabidopsis, rice seeds, red lettuce, cabbage have been grown.

Video: Plants grown in space  
<https://youtu.be/CN5PA3Mq-SE>



NASA Veggie System growing Red Lettuce



NASA European Modular Cultivation System



# WHAT DO WE OBSERVE ABOUT SPACE PLANTS?



Research on the space station has shown that microgravity has a **weird** effect on plants! Can you guess what these influences might be?

- ***Photosynthesis***

So far, no studies have shown a difference in photosynthesis in space

- ***Root growth***

Usually, plant roots grow downward into soil. In microgravity, they don't know which way to grow!

- ***Leaf growth***

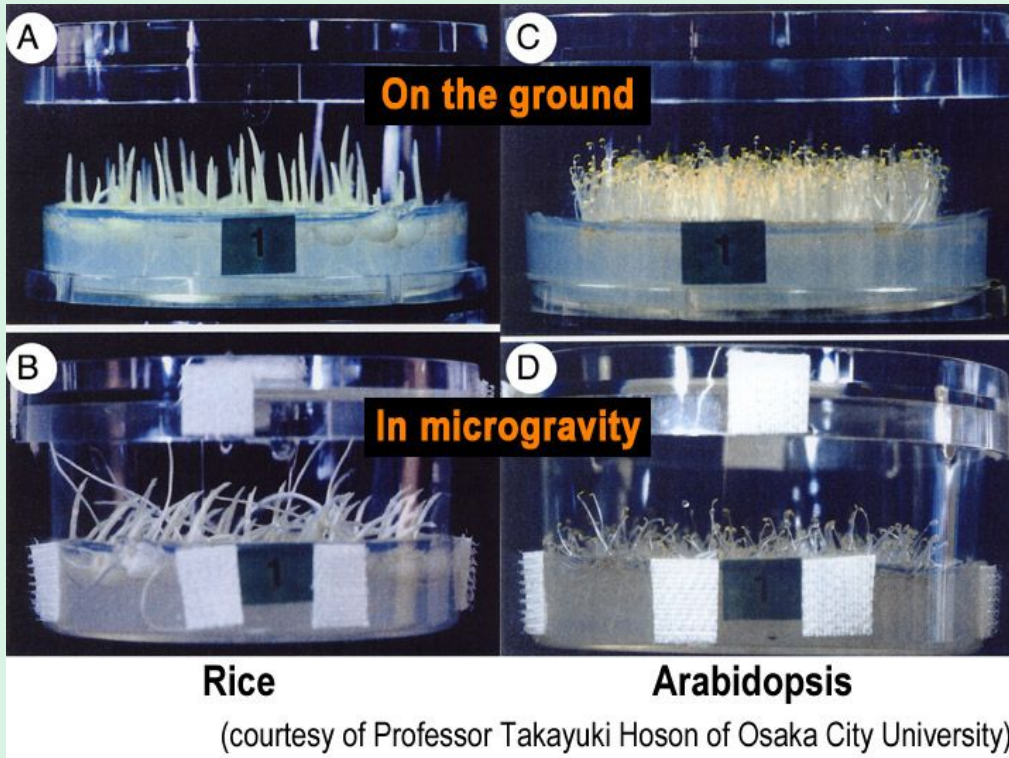
In space, leaves tend to droop. This is called leaf **epinasty**.

- ***Nutrient transport***

Nutrient transport is disrupted in microgravity, and plants suffer from **hypoxia**: a lack of oxygen in the tissues



**Gravitropism:** The behavior of plants where roots grow downwards and stems grow upwards



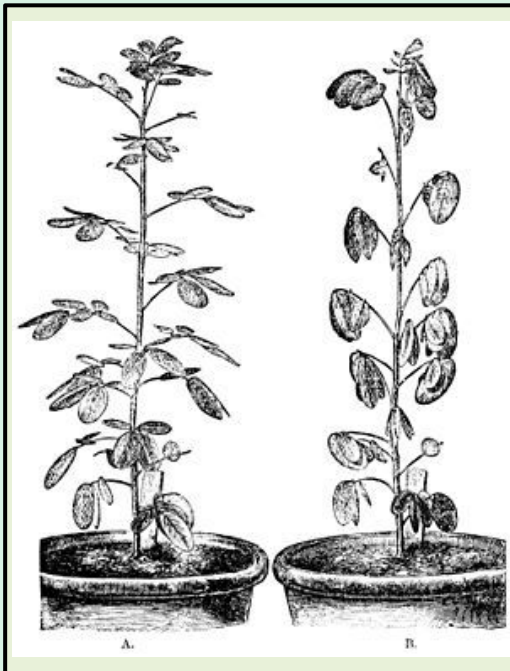
**How do plants sense gravity?**

Scientists think the tips of roots have special cells containing starch. The starch flows in the direction of gravity, providing a signal to the plant which direction is down

# EXTERNAL EFFECTS ON PLANTS



- Many of the effects on plants in microgravity are actually not caused by the plants themselves, but to differences in how the air, water, and soil behaves in microgravity.



## Plant Epinasty

Does microgravity cause leaves/stems to grow incorrectly? Or, does it occur because ethylene (a contaminant found in spacecraft) is elevated in

## Nutrient Transport

Does microgravity cause lypoxia? Or is difficult for plants to get nutrients because of how water behaves in space?



These **external effects** can make it difficult to separate out which behaviors of plants are due to microgravity

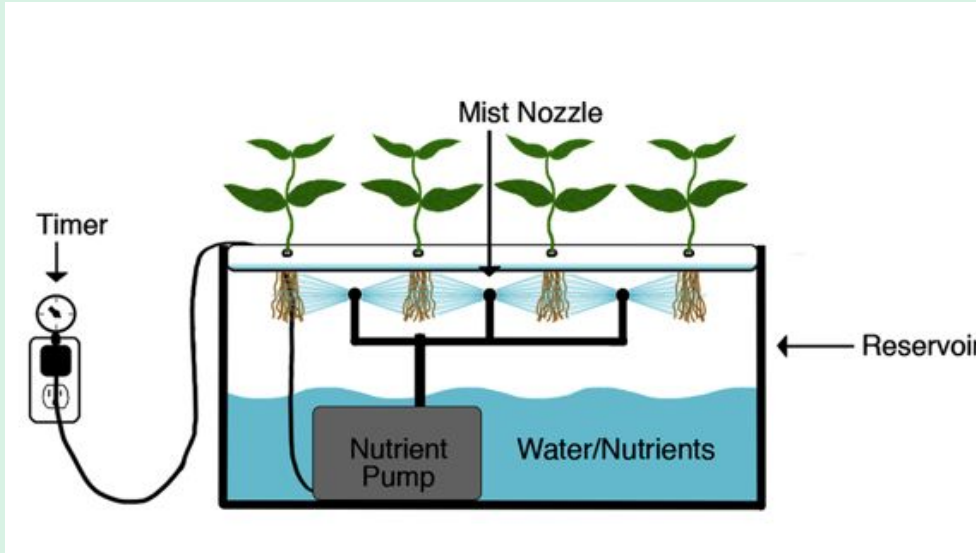
# CLASS EXERCISE (20 MINS)



1. Split into groups of 4
2. Pick a plant (arabidopsis, ginger, potatoes, etc.) that you think will be important for space travel
3. What does this plant need to grow? How would you design a space experiment that eliminates external effects and lets you study the effect of microgravity?
4. Draw a picture or diagram explaining your idea

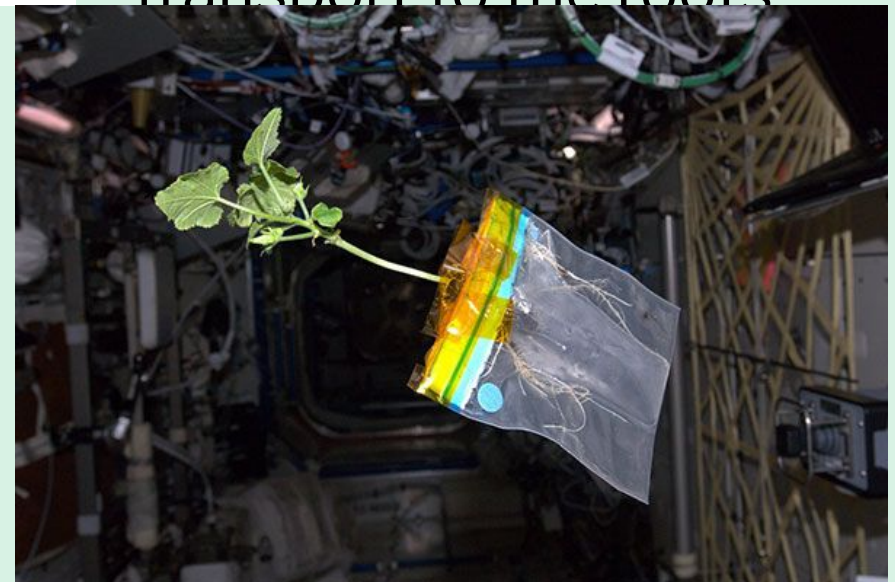


# MICROGRAVITY PLANT GROWTH



A microgravity horticulture design to spray nutrients and water directly onto plant roots, and therefore eliminate problems with transport to the roots

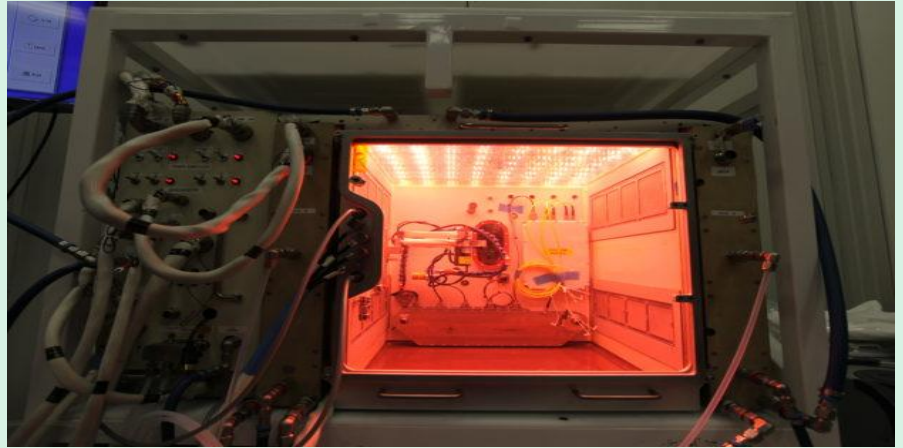
Plants don't need a pot in space, a plastic baggy is enough to contain their roots, water, and nutrients!



# THE FUTURE OF PLANTS IN SPACE



***Advanced Plant habitat***, largest plant chamber made, which will be sent to the ISS in 2018



***NASA Future Martian space farm***, These photos are showing future designs of building a space farm on Mars



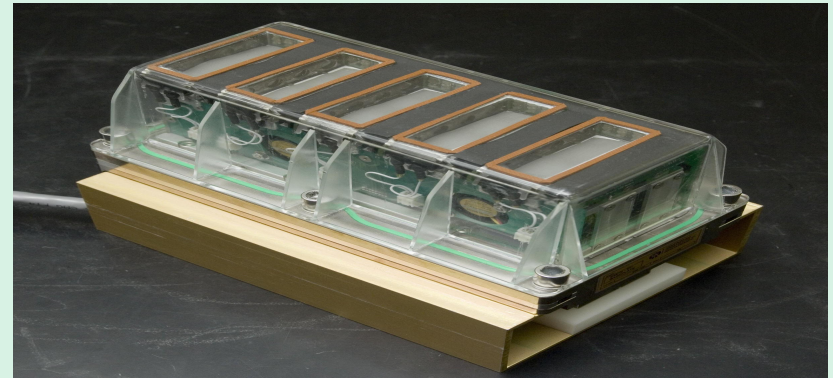
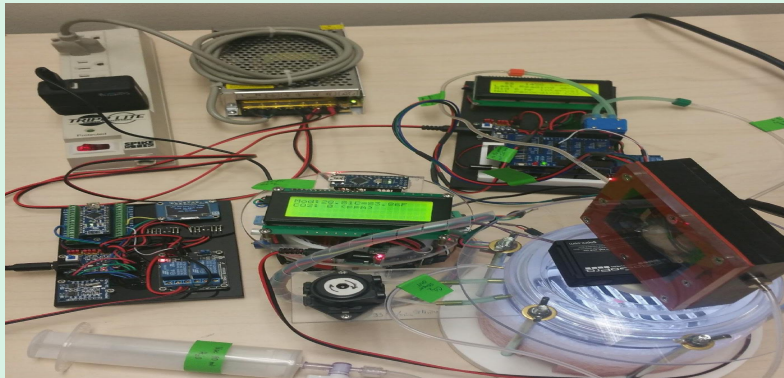
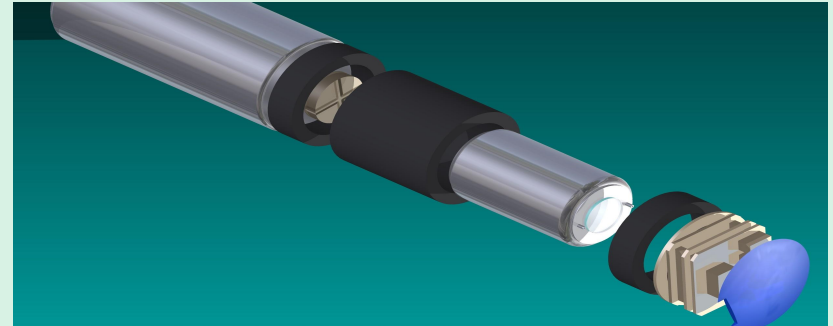
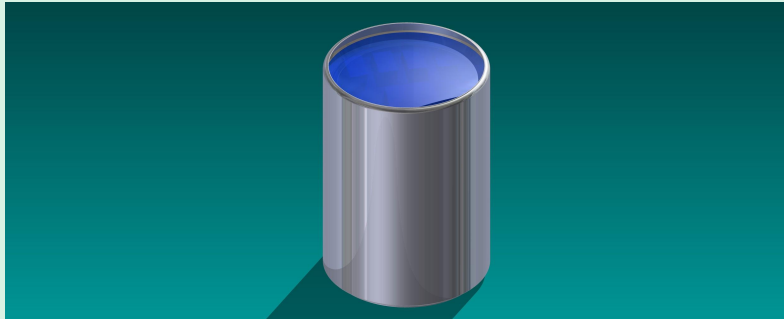
# REFERENCES AND RESOURCES



- Scientific investigations with plants in space:
  - ***Tropi (2006)***, used Arabidopsis plants to investigate how roots respond to different levels of light and gravity.
  - ***Plant Signaling Space Experiment (2013)***, used genetically modified Thale cress plants to study how they grow in 1g and microgravity
  - ***Biomass Production System (BPS, 2001)*** is a system capable of keeping plants growing for more than 90 days.
- A researcher's guide to Plant Science on the ISS, pdf:  
[https://www.nasa.gov/sites/default/files/atoms/files/np-2016-06-016-jsc\\_plant\\_research\\_mini\\_book508c.pdf](https://www.nasa.gov/sites/default/files/atoms/files/np-2016-06-016-jsc_plant_research_mini_book508c.pdf)



## *Conceptual Design of Autonomous Germination Habitat*

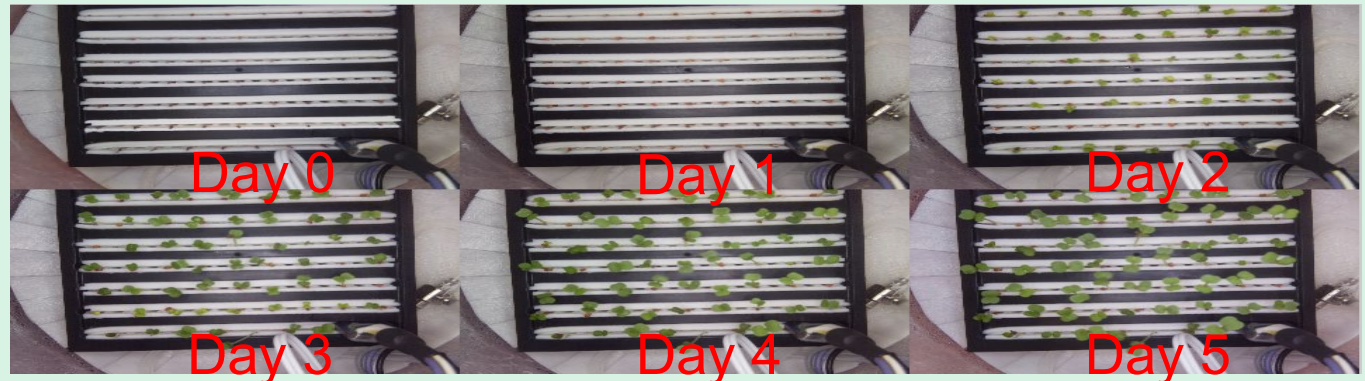




# ARABIDOPSIS PLANT GERMINATION/PLANT GROWTH



*Camera  
Images*



*Light  
Absorbed  
Plants*

