Plants as Enablers for Living and Thriving in Space

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NASA

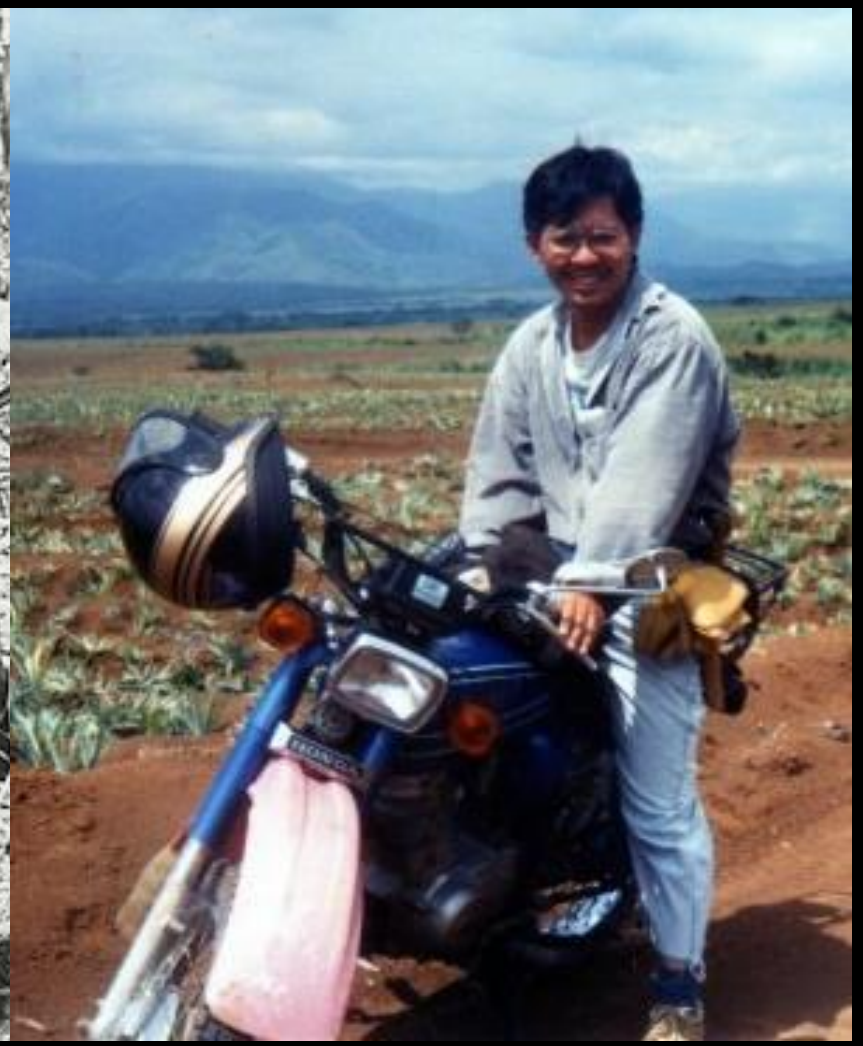
BPS

Biological & **P**hysical **S**ciences

My Journey to NASA and working with plants started in the Philippines







Then onto the USA to learn more about why plants do what they do

UNIVERSITY OF LOUISIANA Lafayette

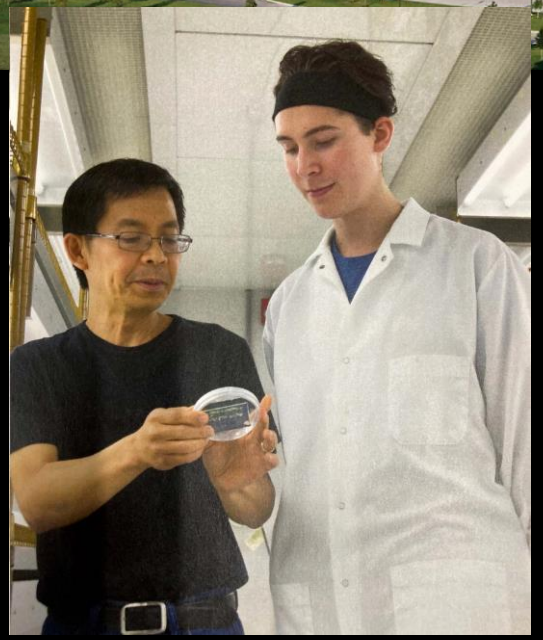
PENNSTATE



1855

NOBLE RESEARCH INSTITUTE



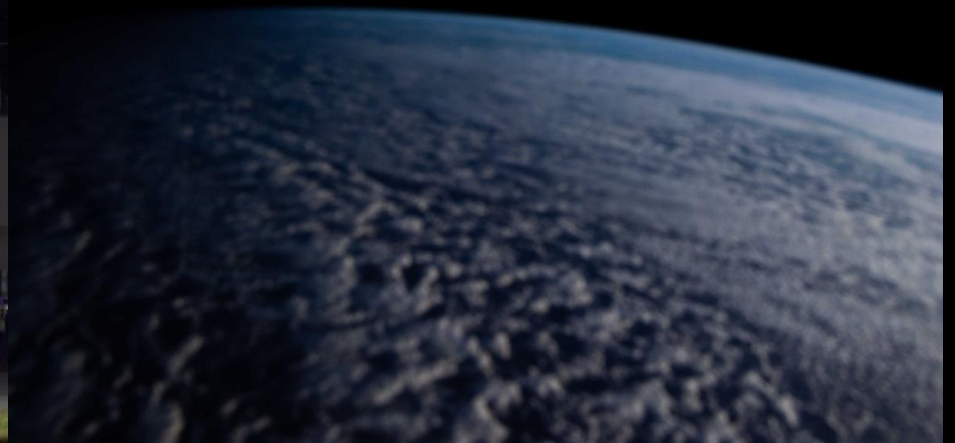




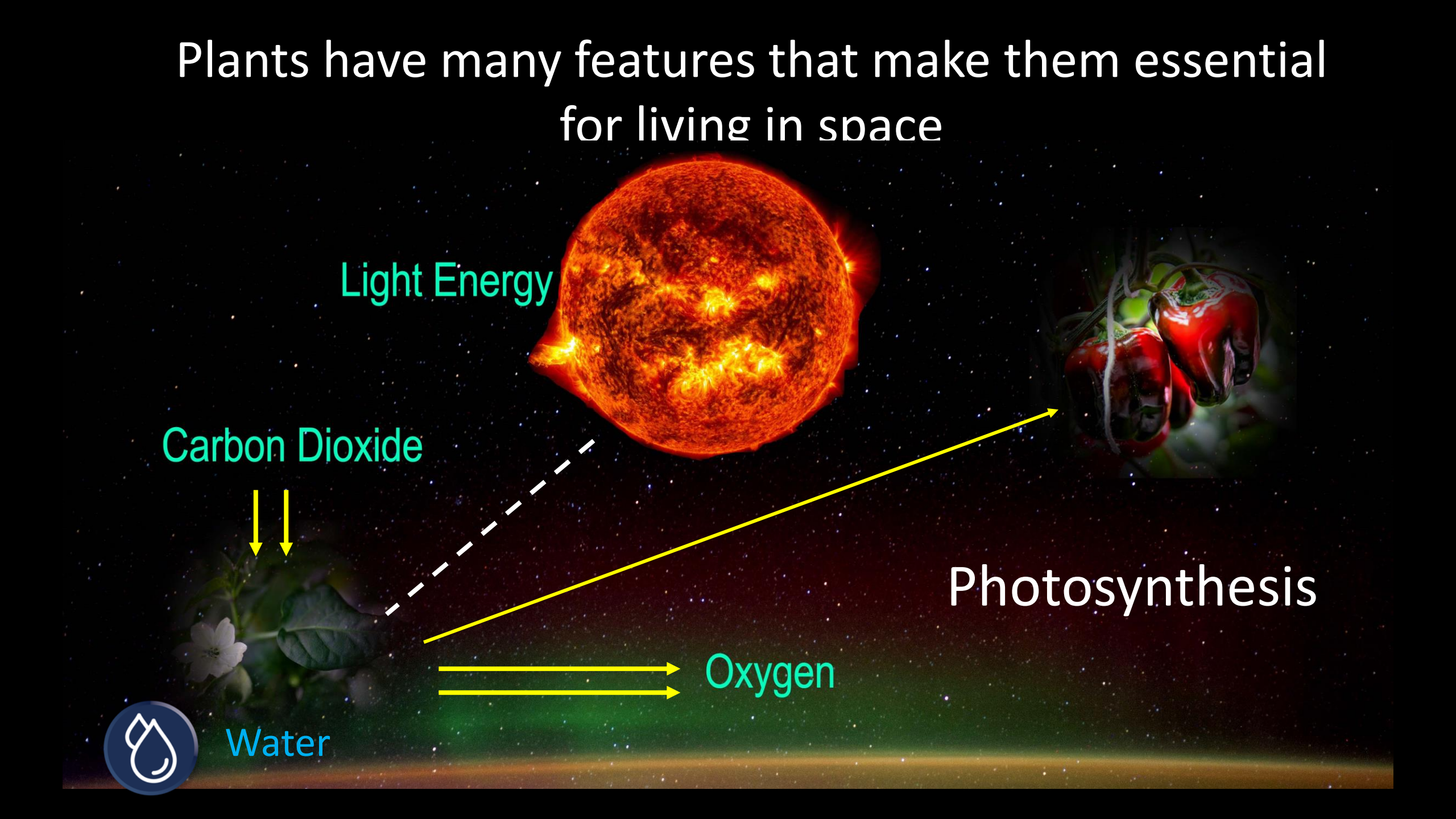
Currently at the NASA Kennedy Space Center to learn how plants can best be used to enable humans to live in space







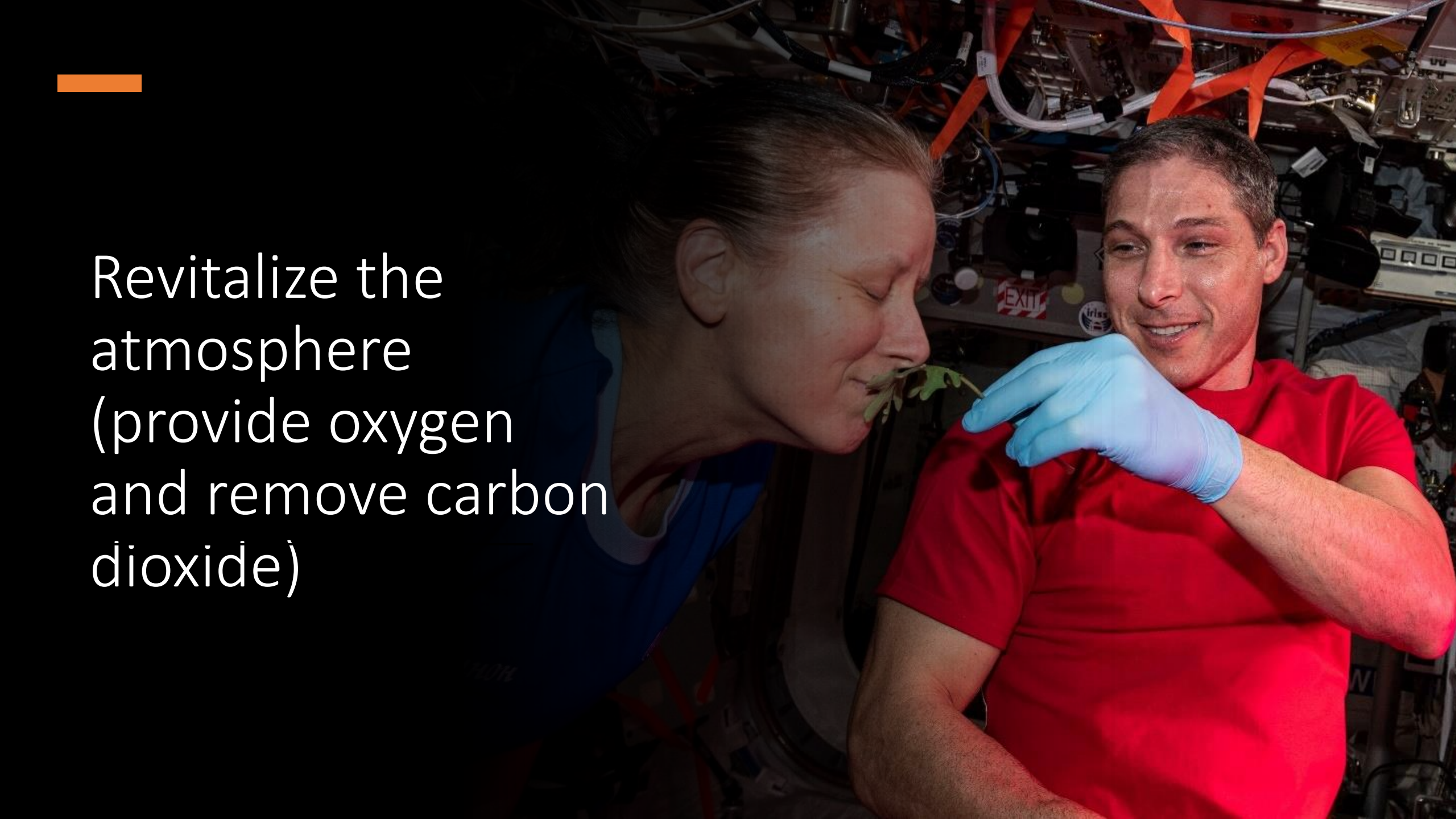
Plants have many features that make them essential for living in space



Source of Fresh Food for Astronauts



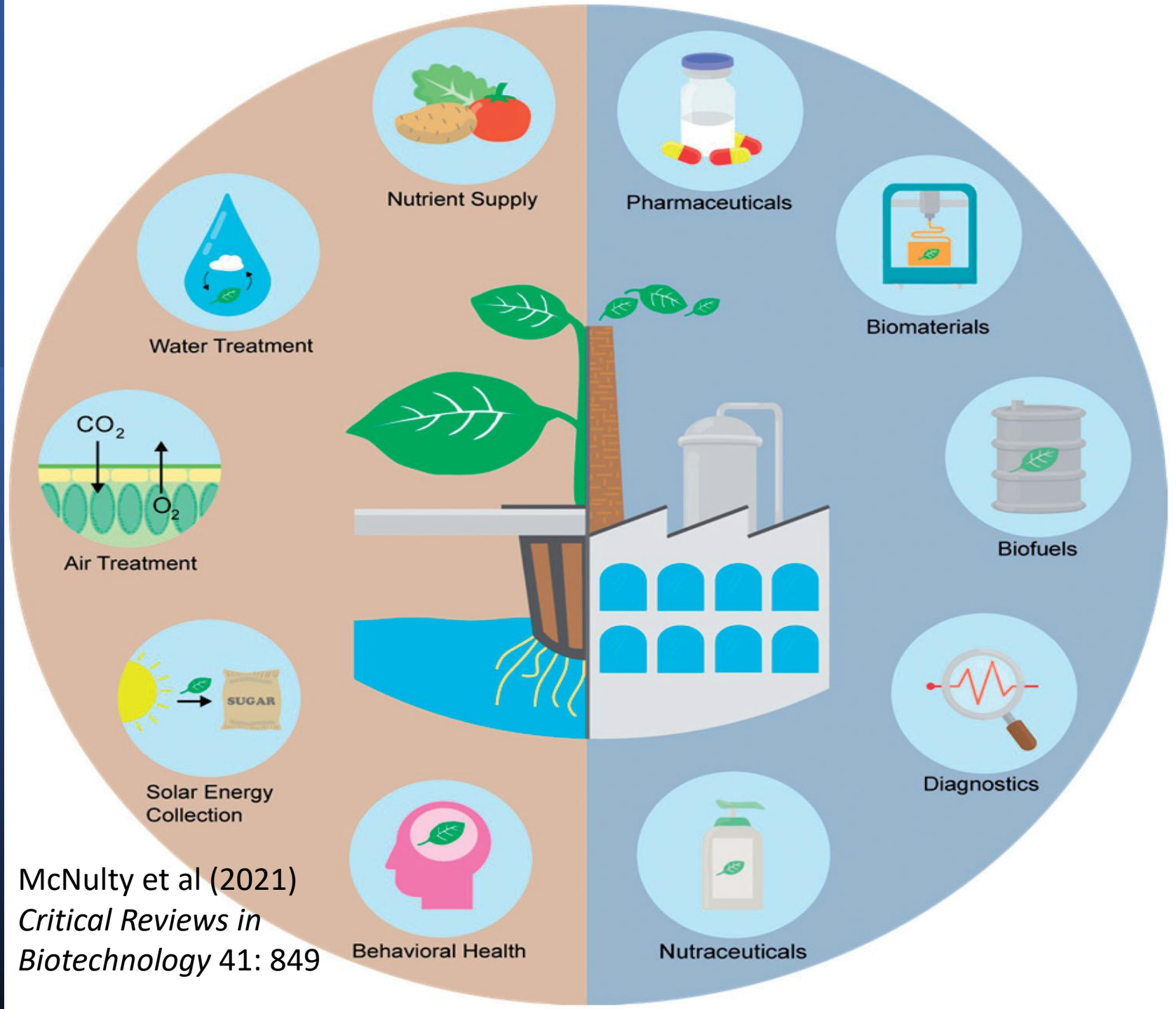
Revitalize the atmosphere (provide oxygen and remove carbon dioxide)



For Mental Well-Being of Astronauts



Plants can be used for things other than food



McNulty et al (2021) *Critical Reviews in Biotechnology* 41: 849



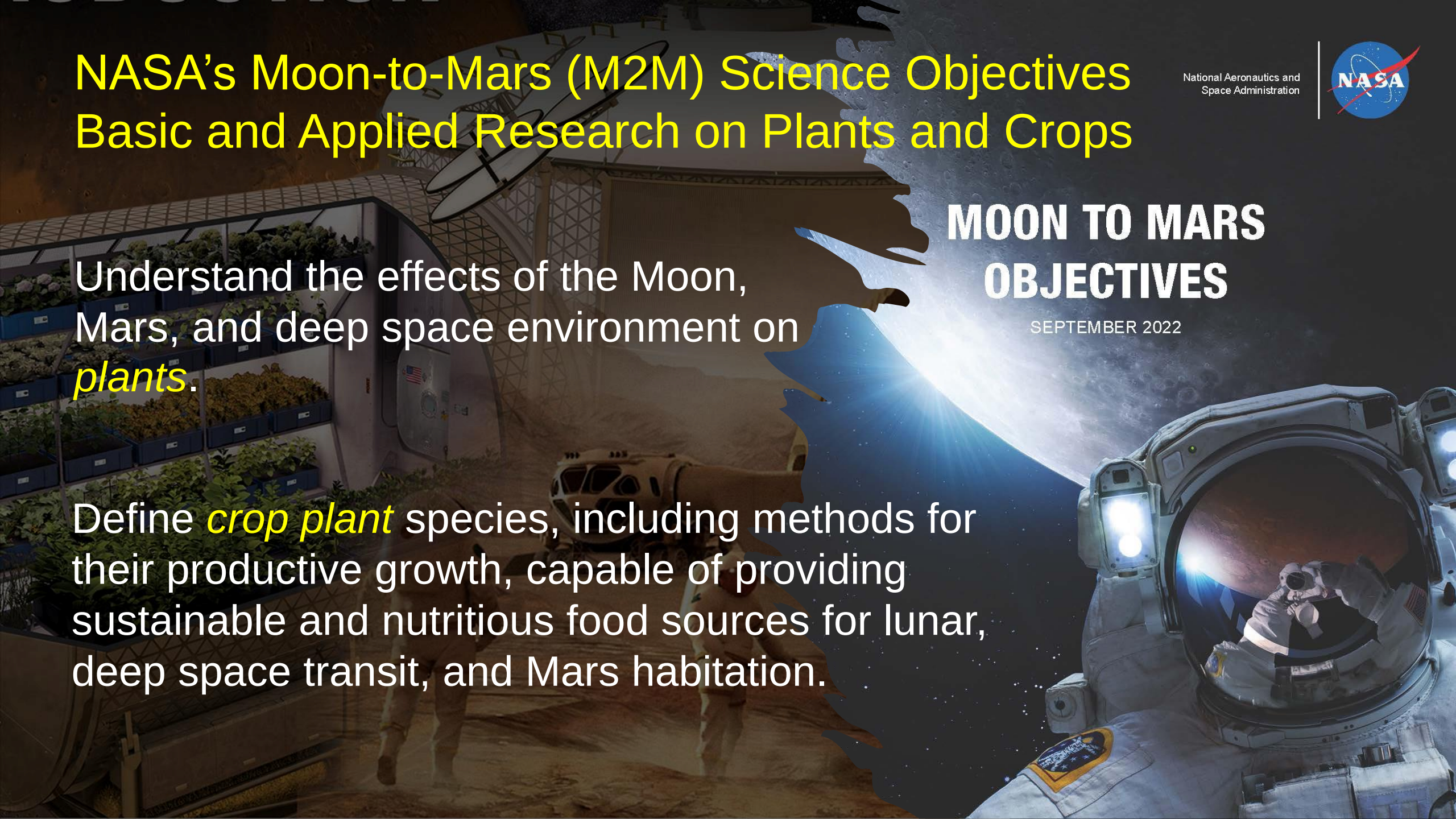
Before we can use plants effectively for space travel we need to understand:

- How they respond to the space environment.
- Use the knowledge gained from answering the question above to guide us on how to grow plants in space.

NASA's Moon-to-Mars (M2M) Science Objectives
Basic and Applied Research on Plants and Crops

National Aeronautics and Space Administration

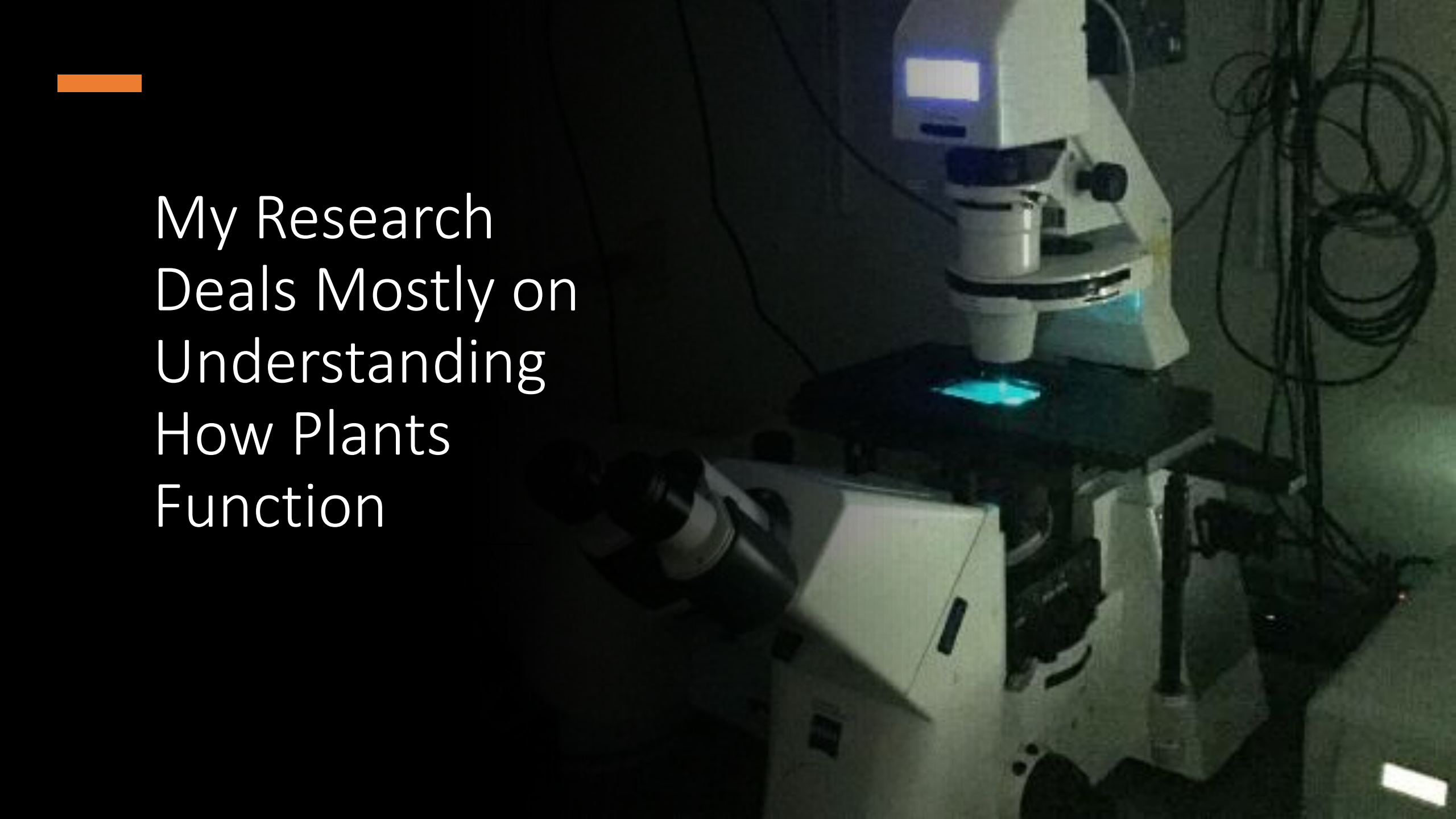
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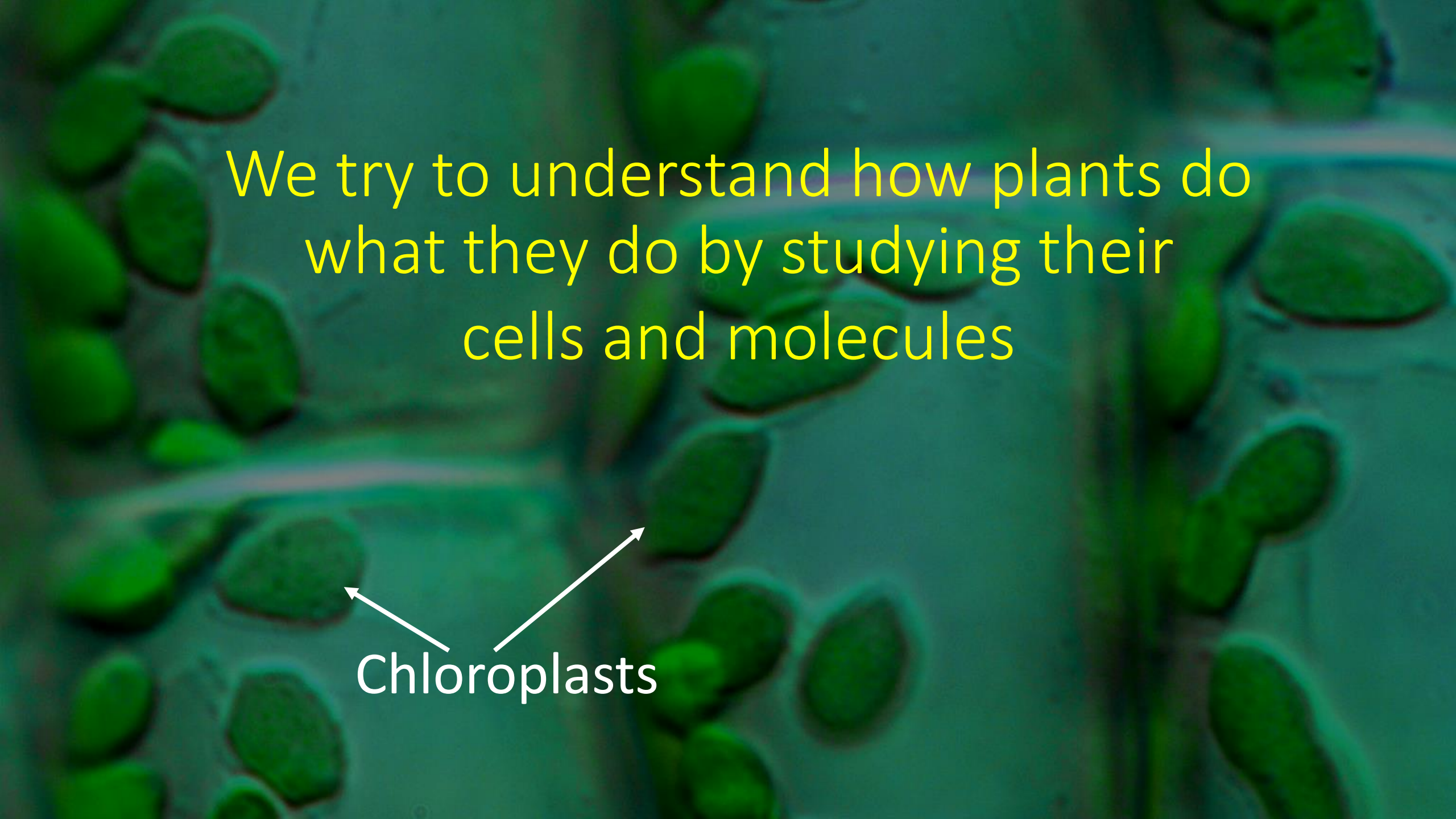


Understand the effects of the Moon, Mars, and deep space environment on *plants*.

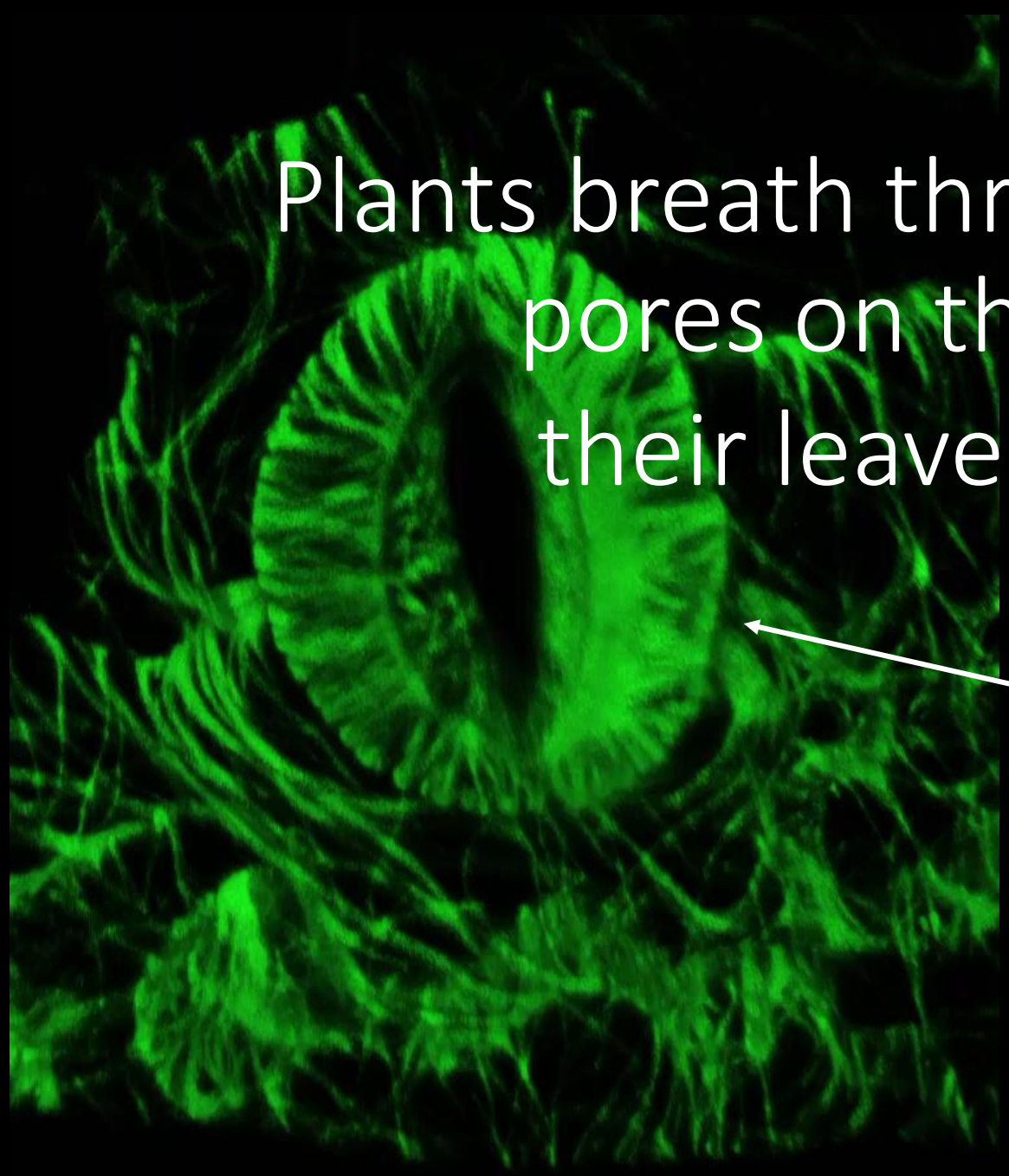
Define *crop plant* species, including methods for their productive growth, capable of providing sustainable and nutritious food sources for lunar, deep space transit, and Mars habitation.

My Research Deals Mostly on Understanding How Plants Function



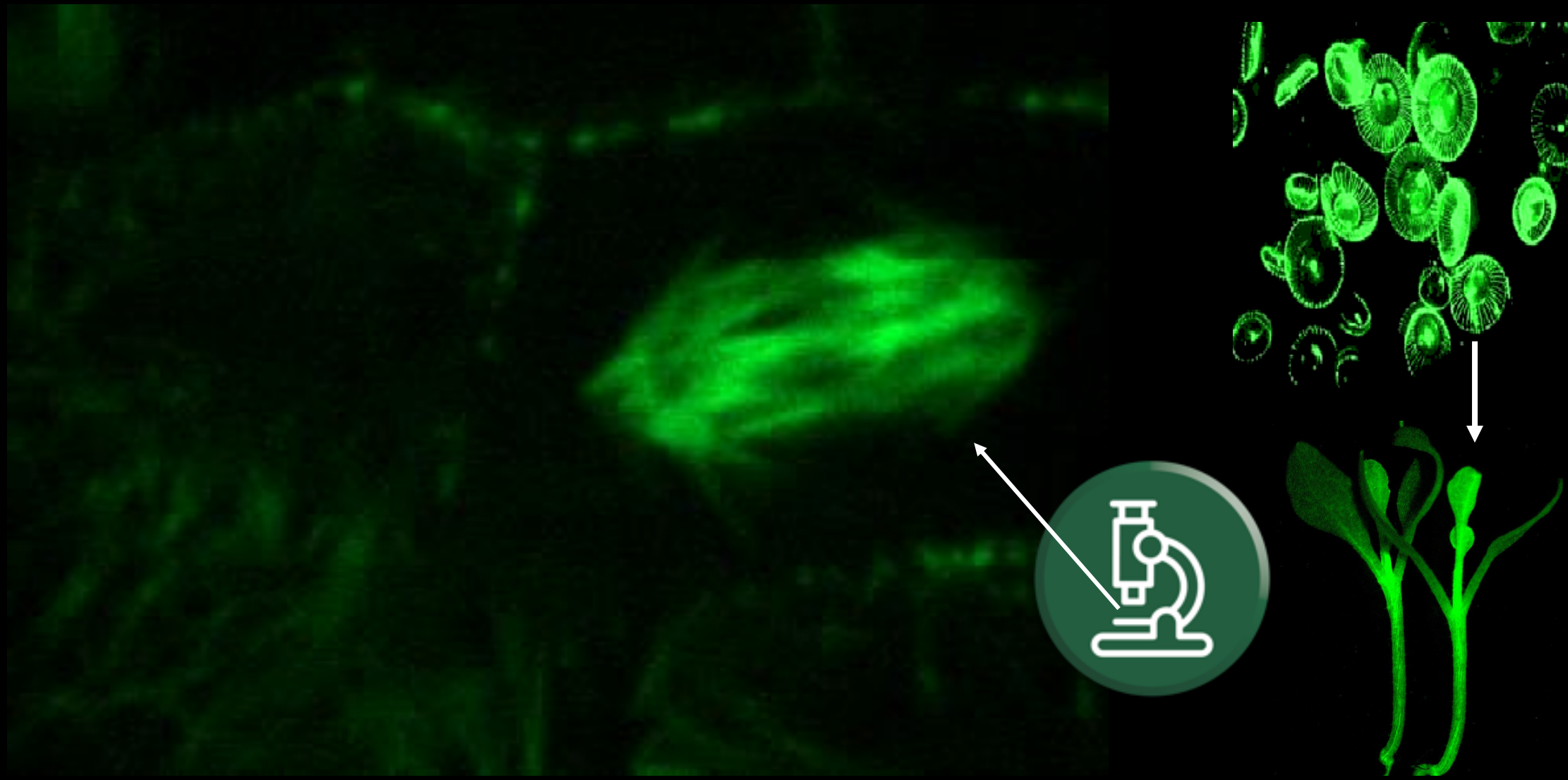

We try to understand how plants do what they do by studying their cells and molecules
Chloroplasts

Plants breath through microscopic pores on the surface of their leaves and stems





We use fluorescent molecules to tag parts of the cell and study them under the microscope

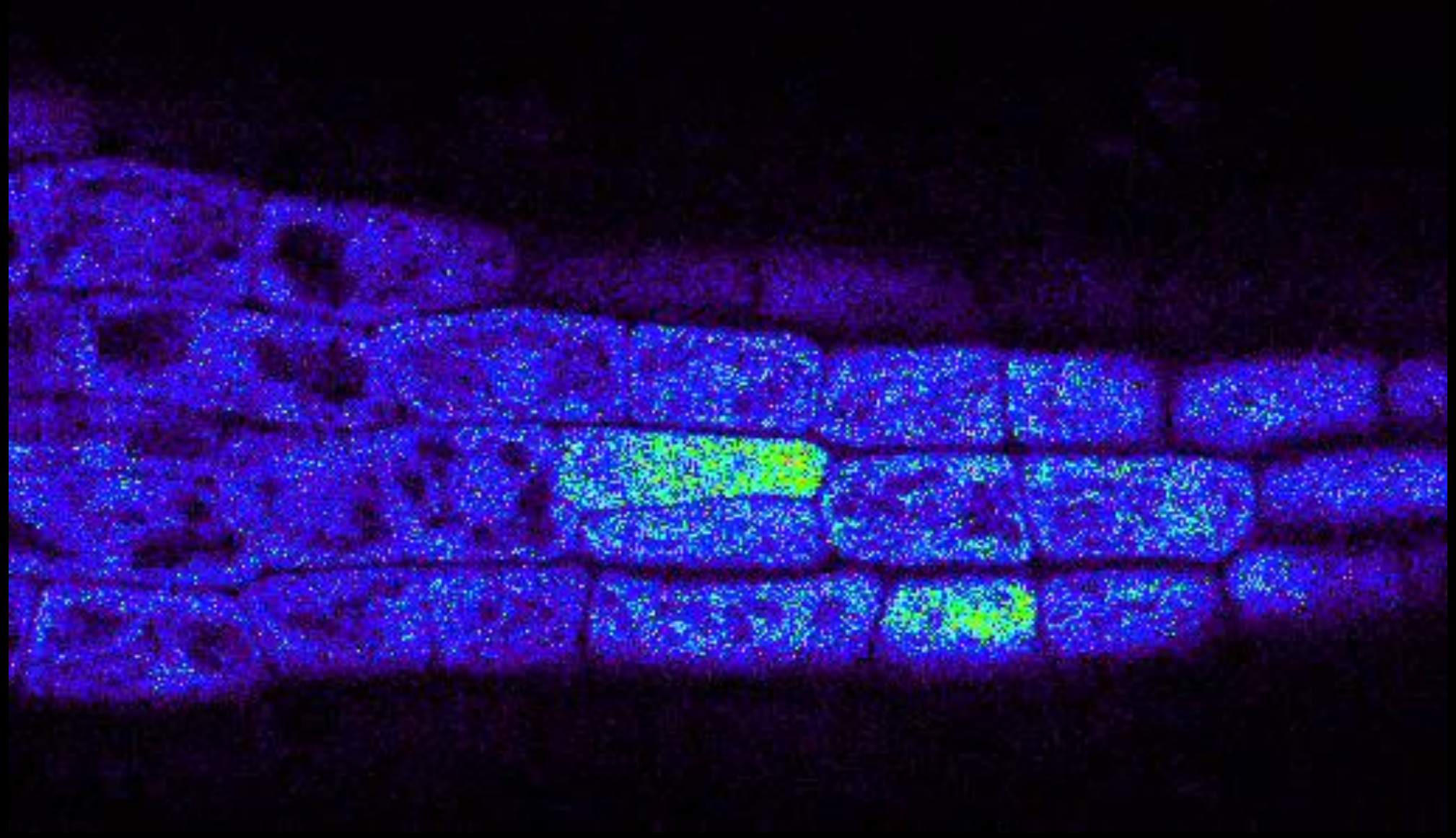


How do plants sense changes in their environment?

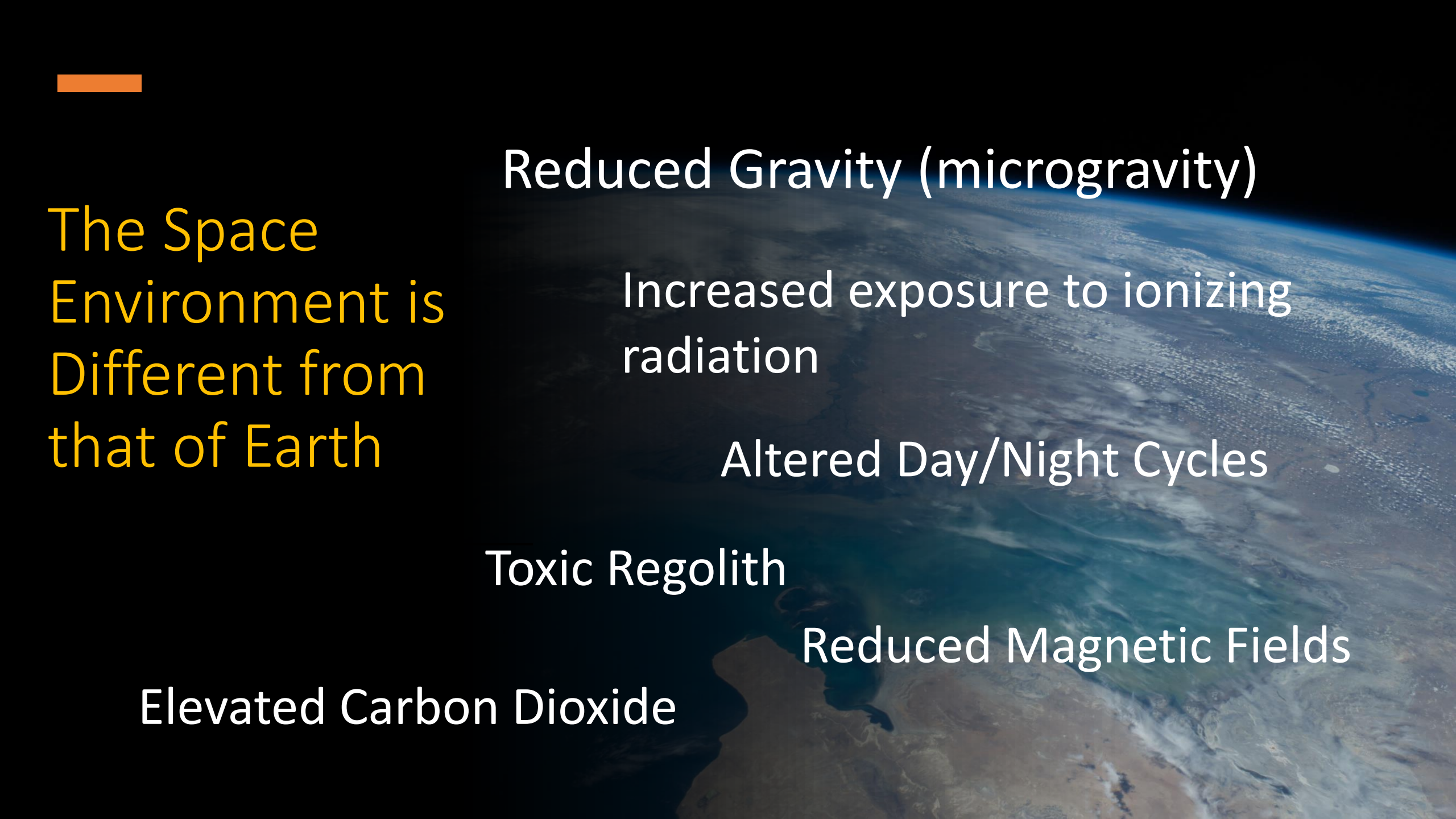


Plants responding to touch by rapidly changing calcium concentrations in their cells

A growing plant root as it is treated with a chemical called glutamate



The Space Environment is Different from that of Earth

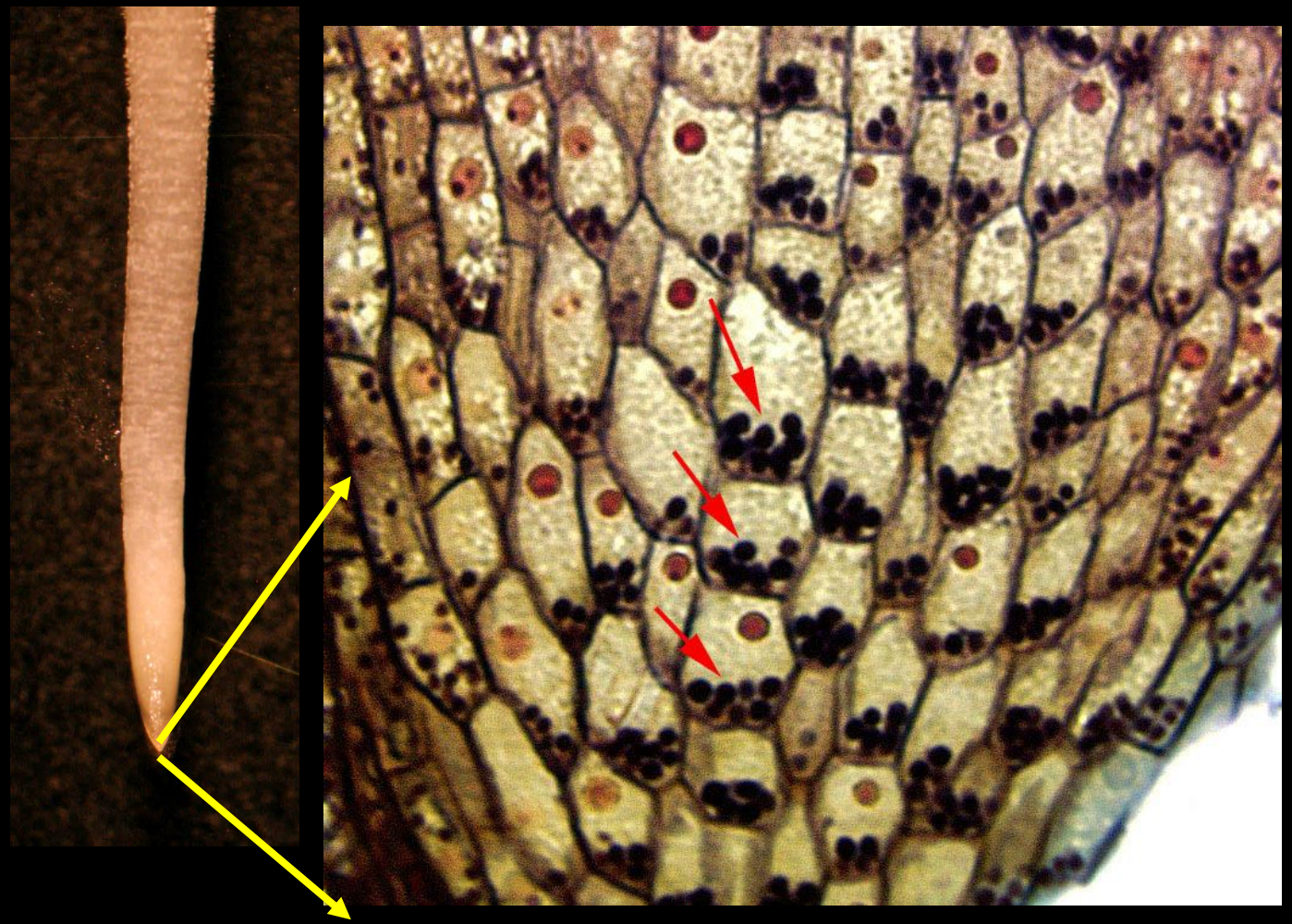


Gravity is a major environmental factor that affects plant development



How do plants know up from down?

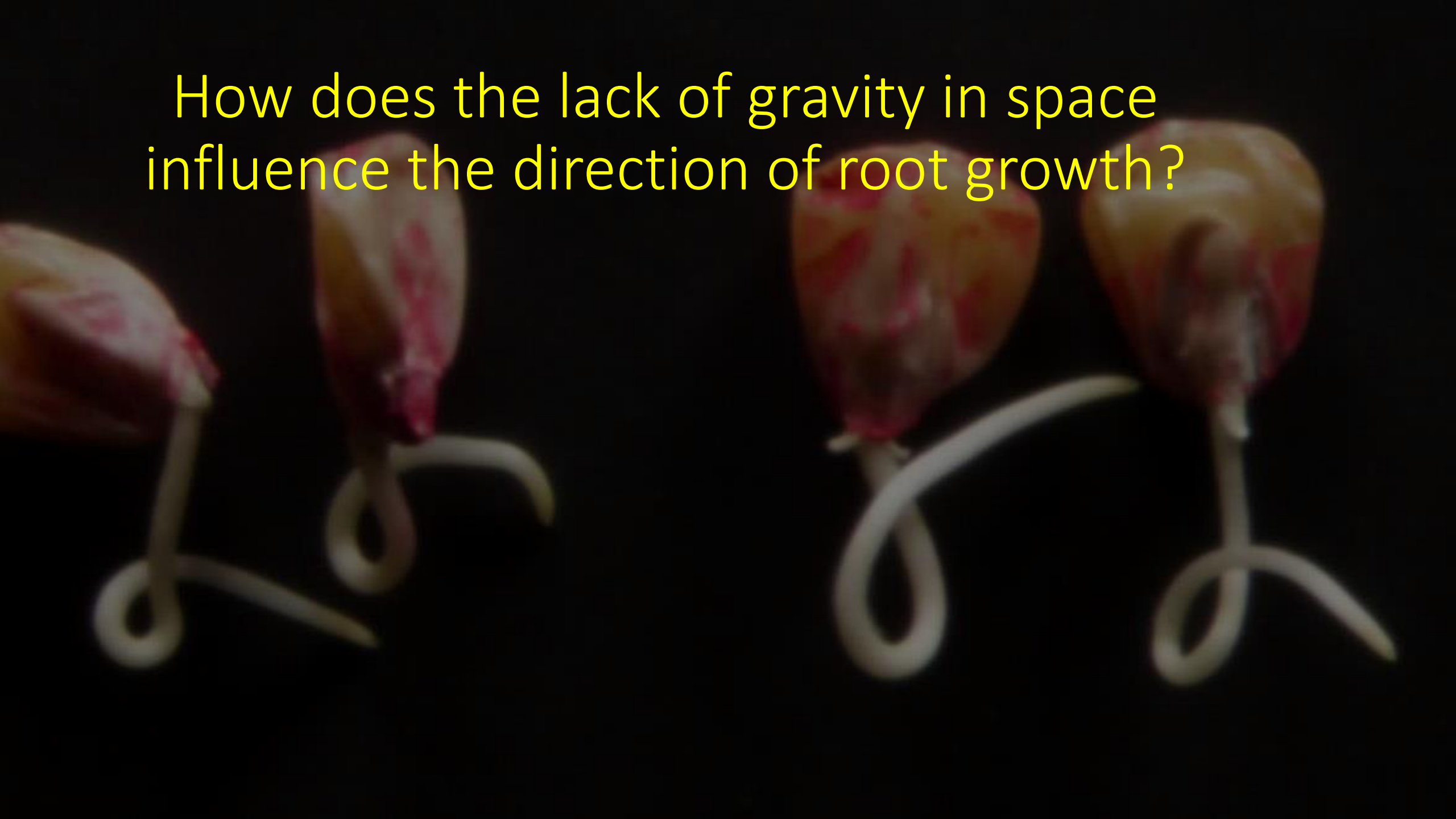
Vertical root



COLUMELLA CELLS

Gravitropism

How does the lack of gravity in space influence the direction of root growth?



What else does low gravity do that can affect how plants perform in space?



Challenges of growing plants/crops in space

Non-Edible Plant Parts

Food safety

Too much or too little water

Plant diseases

Crop nutrient content



Challenges of Growing Plants in Space Comes Down to Biology and Engineering



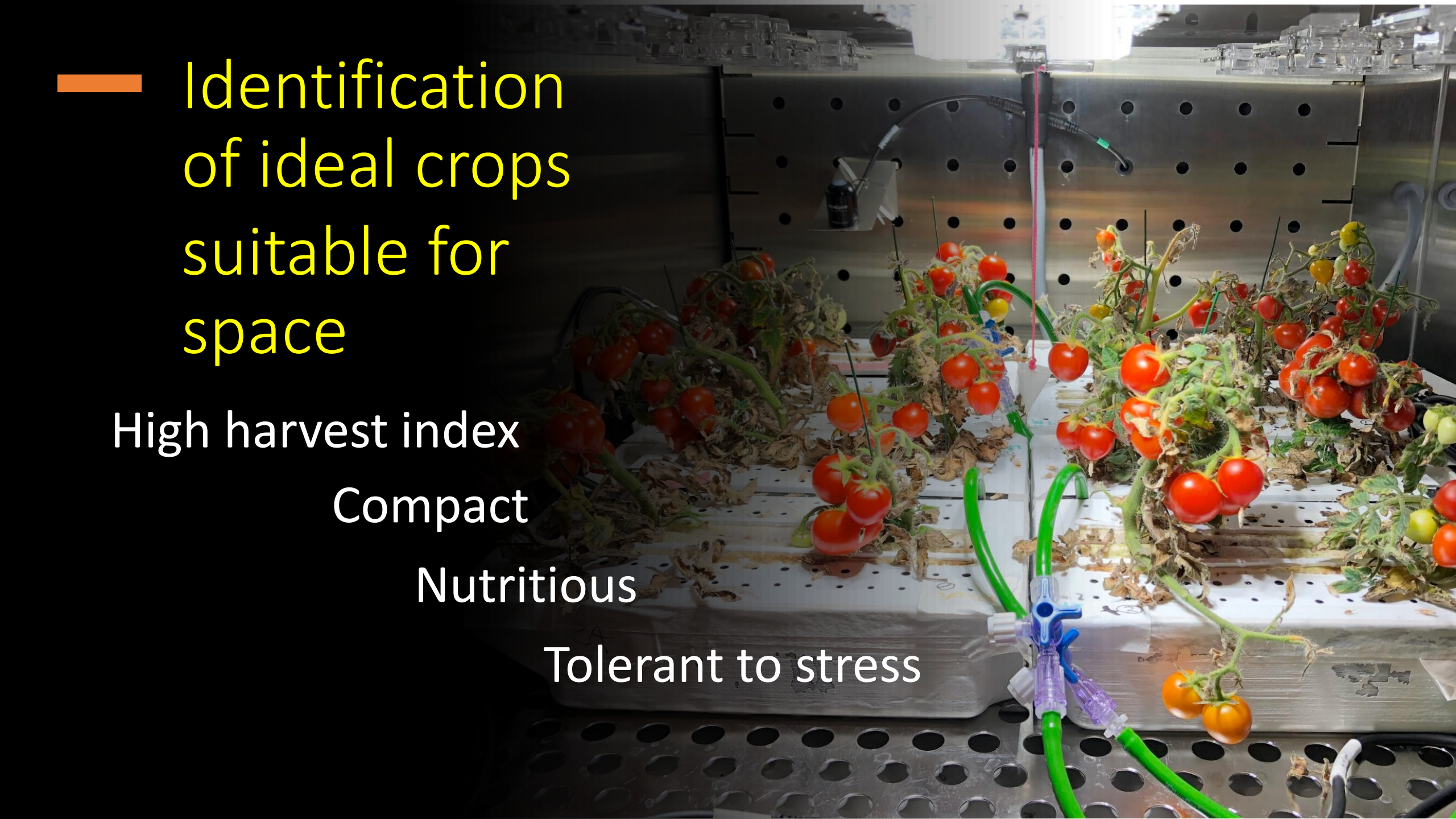
Identification of ideal crops suitable for space

High harvest index

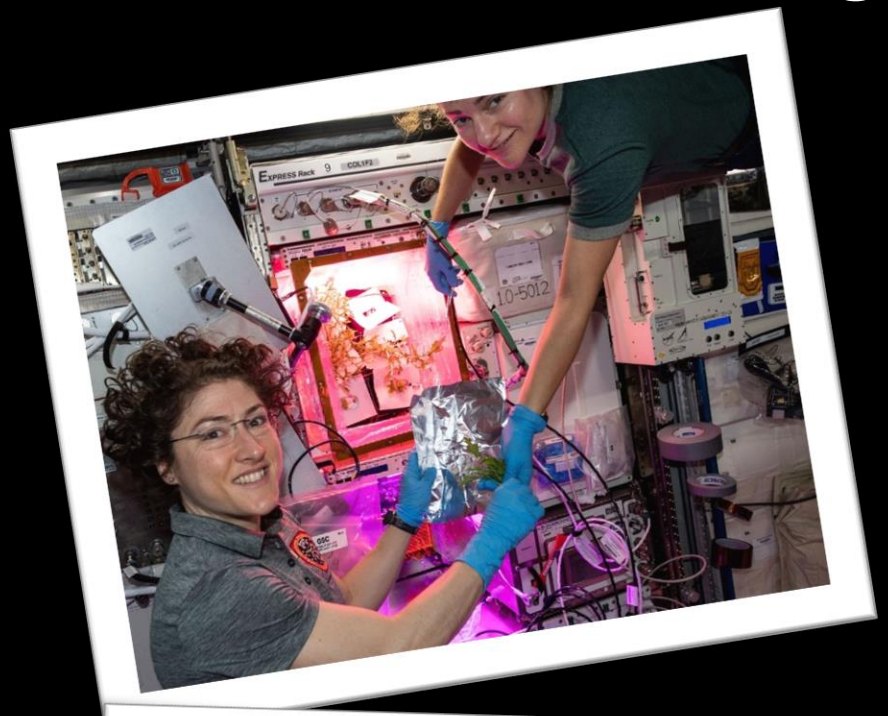
Compact

Nutritious

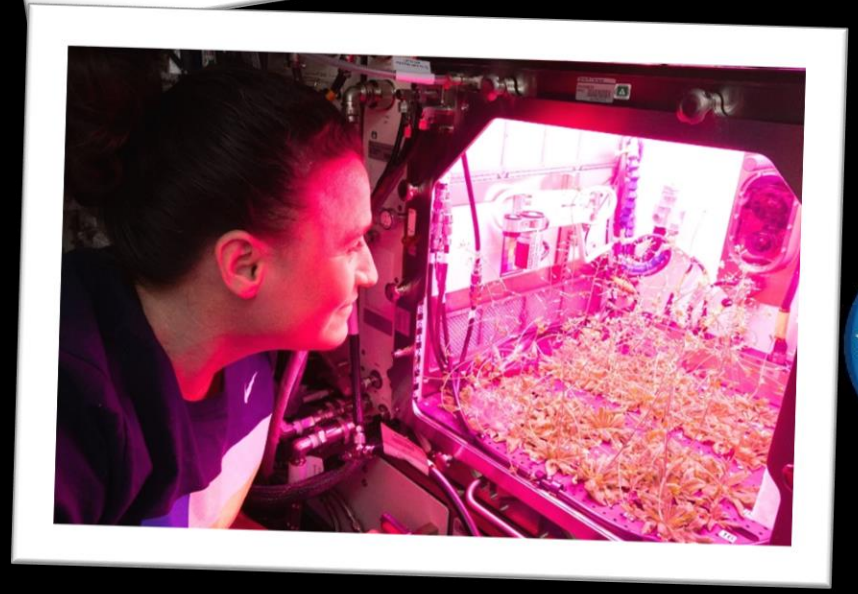
Tolerant to stress



Current NASA Large Plant Research Capabilities On ISS









Challenge Questions

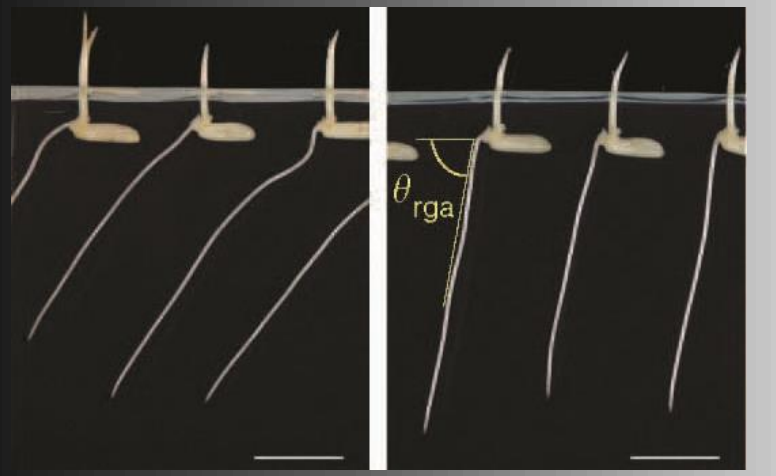
- How do we adapt plants for space travel?
- How can scientists and engineers work together to create sustainable closed systems to support human life in space?



How Work on Plants in Space Benefits Life on Earth



Studies on gravitropism led to the discovery of genes that can used to develop crops with steep and deep roots







Uga et. al. (2013) *Nature Genetics* 45: 1097

New crops for small spaces



Kwon et al (2019)
Nature Biotechnology
38:182

Effectively using plants to enable humans to live in space will overcoming biology and engineering challenges

