



Module 1

Principles of Hydroponics

2026 Greenhouse Hydroponic Tomato Workshop with Dr. Triston Hooks

Outline

1. What is Hydroponics?
2. What is CEA?
3. Why Hydroponics and CEA?



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Principles of Hydroponics

What is Hydroponics?

- Hydroponic means “water working”
- Hydroponics is the method of plant production with a complete nutrient solution and without soil



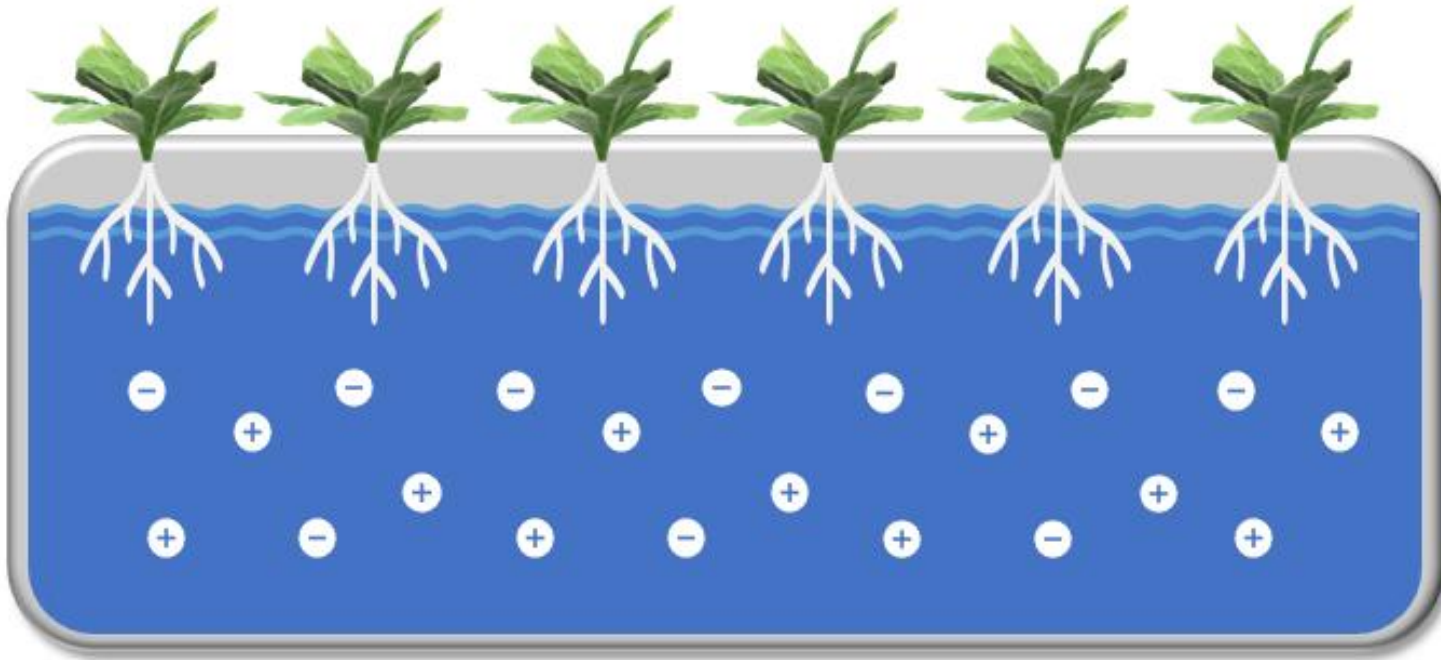
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Principles of Hydroponics

What is Hydroponics?

- Hydroponics uses a complete nutrient solution which contains water and all essential elements
- An essential element is required for a plant to grow and complete its lifecycle



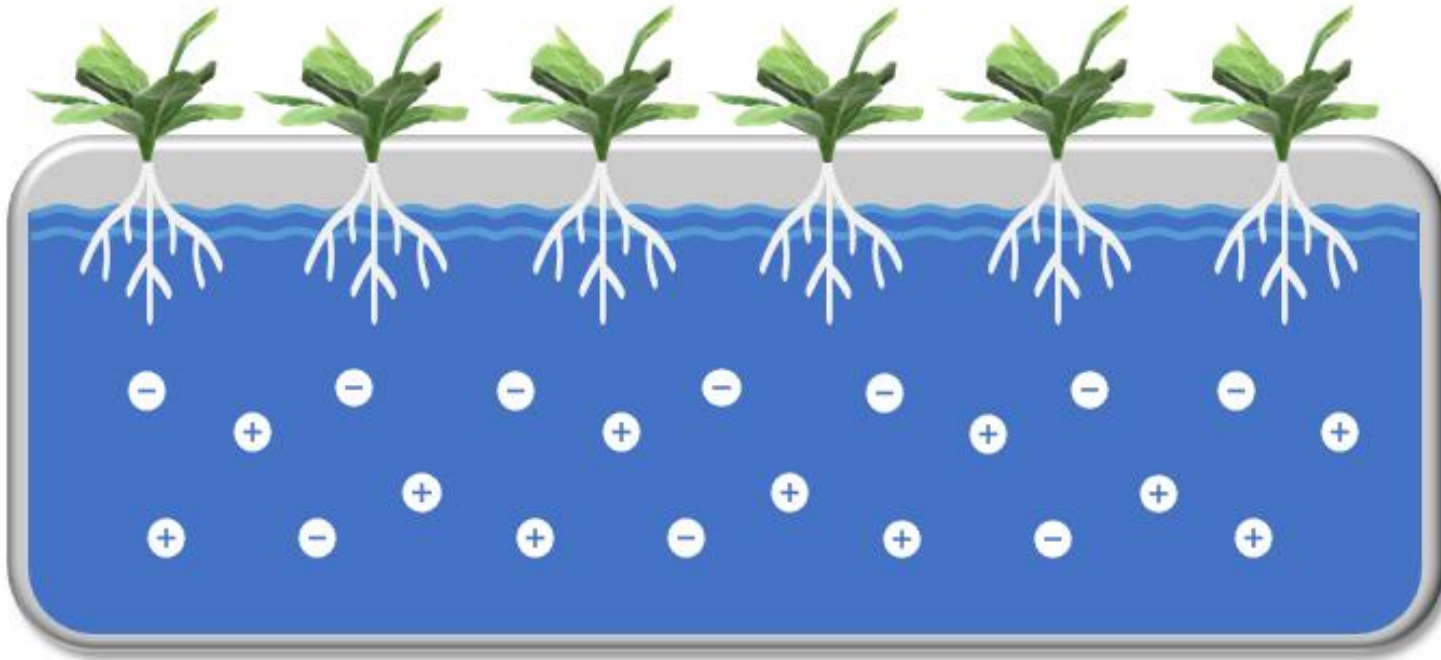
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Principles of Hydroponics

What is Hydroponics?

- 13* essential elements:
 - 6 Macro (N P K Ca Mg S)
 - 7 Micro (Fe Cl B Zn Mn Cu Mo)
- Dissolved in water as inorganic ions for plant roots to uptake



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What is Hydroponics?

- Hydroponics is soilless which means it doesn't rely on soil in the ground for plant production
- However, hydroponics commonly uses a substrate to hold moisture and anchor the plant



Principles of Hydroponics

What is Hydroponics?

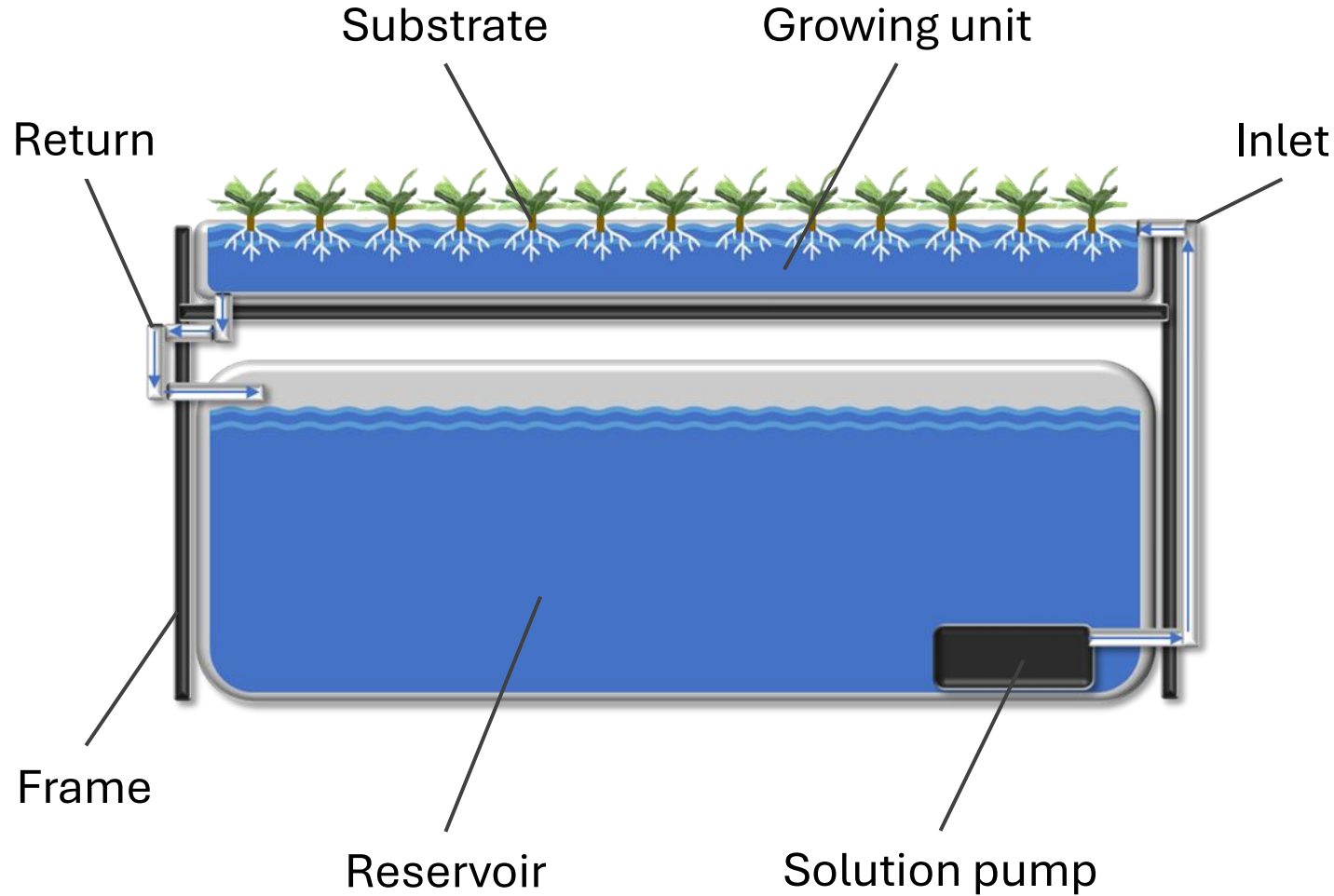
- Therefore, hydroponics enables plant production outside of traditional agricultural constraints
- This allows for unique and limitless methods for growing plants – the future of farming!

Principles of Hydroponics

What is Hydroponics?

Common components of hydroponic systems:

- Reservoir
- Solution pump
- Inlet/Return
- Growing unit
- Substrate
- Frame



Principles of Hydroponics

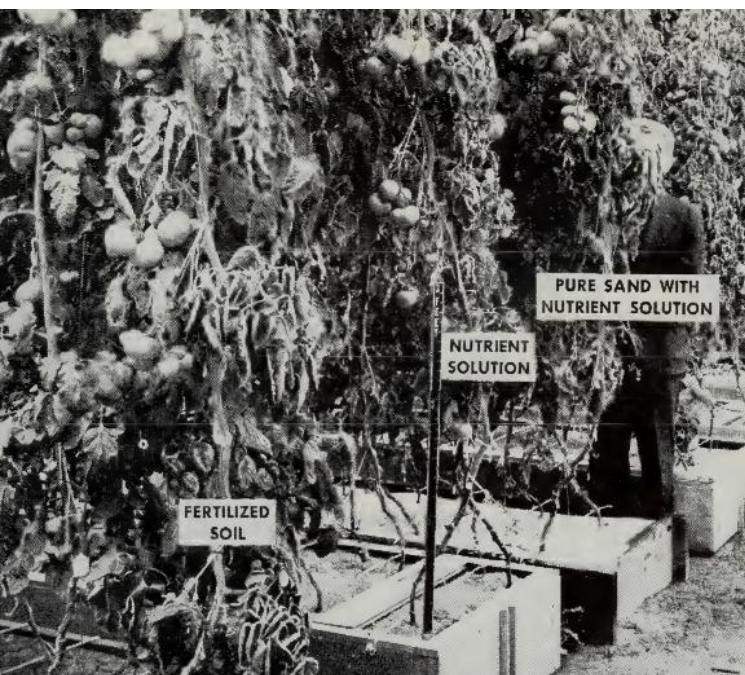
What is Hydroponics?

- Nutrient Film Technique (NFT) systems are the most common and versatile hydroponic systems, globally
- These systems consist of channels with a thin film of solution running through them

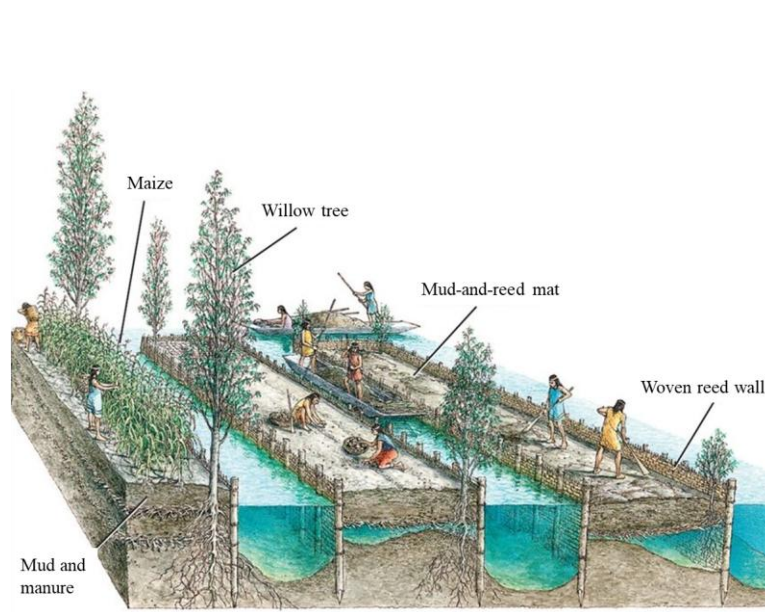


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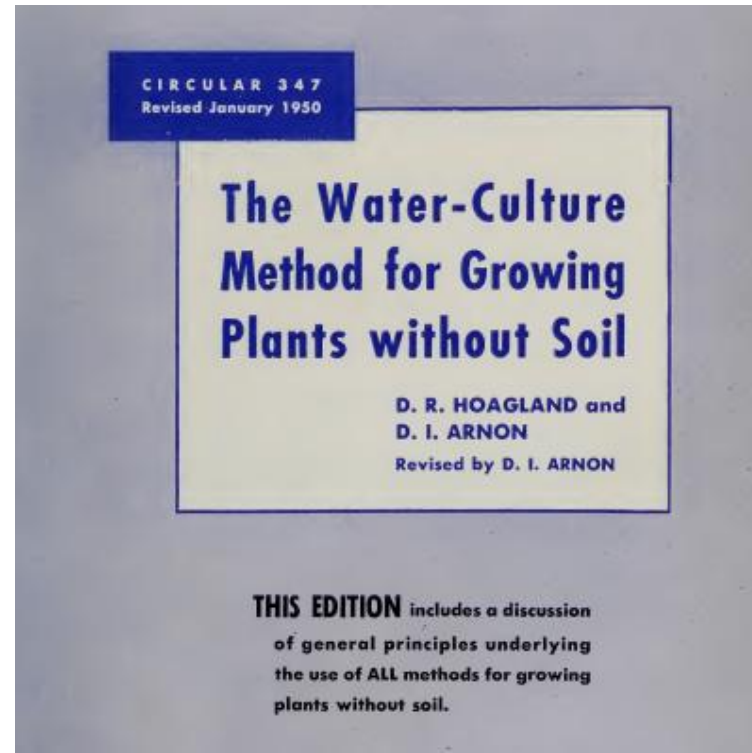
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Hoagland and Arnon 1950



Thearchaeologist.org



Principles of Hydroponics

What is Hydroponics?

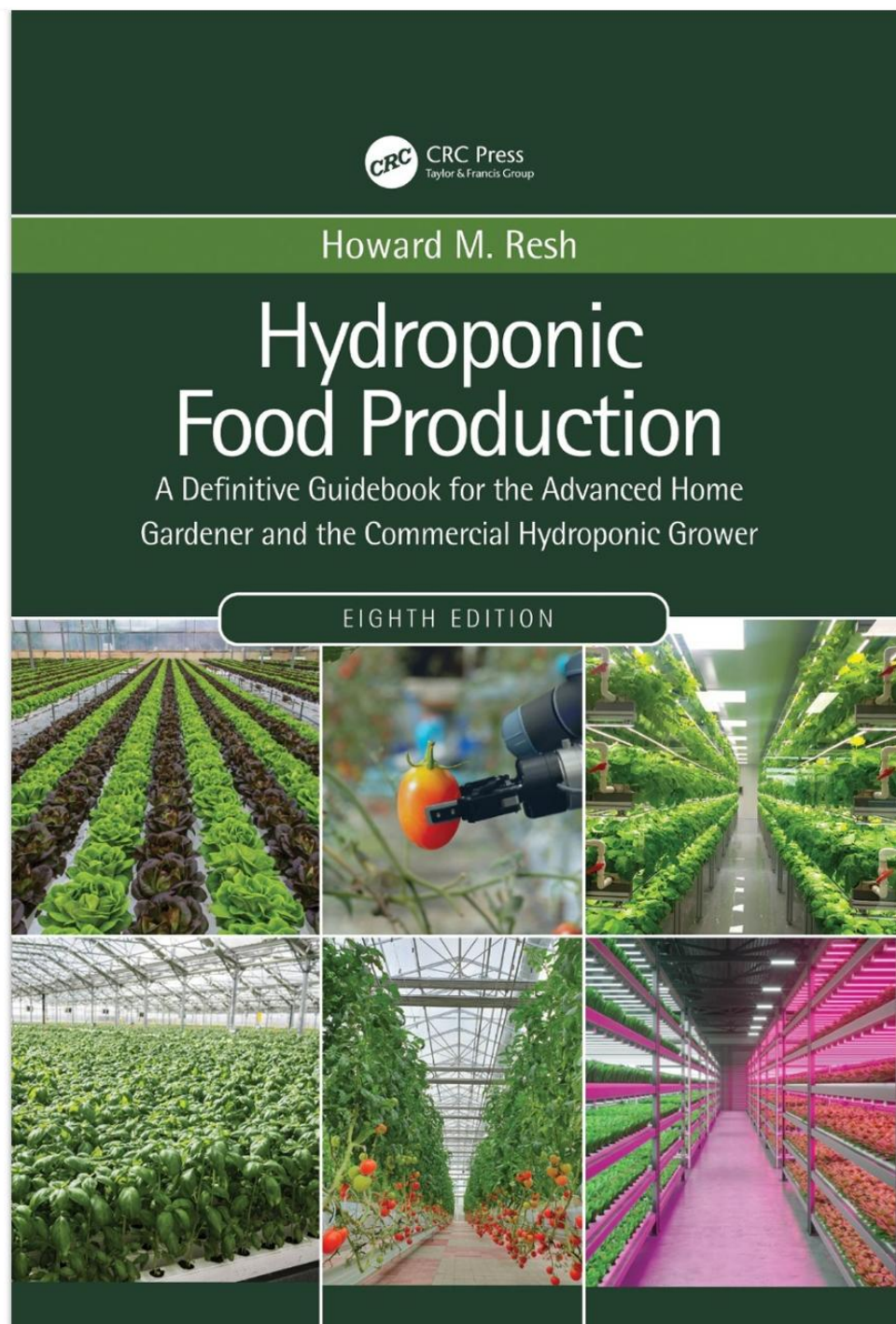
Hydroponics is not new!

- Hanging Gardens of Babylon
- ‘Chinampas’ Aztec floating gardens
- ‘Nutriculture’, ‘Water-Culture’, and finally ‘Hydroponics’ by Dr. William Gericke in the 1930s



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What is Hydroponics?

- Today, hydroponics is used worldwide to grow many different crops and compliment/supplement traditional agriculture
- Hydroponics is commonly used in Controlled Environment Agriculture (CEA)



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Principles of Hydroponics

What is CEA?

- Controlled Environment Agriculture (CEA) is an integrated science and engineering-based approach to provide specific environments for plant production



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What is CEA?

To provide a specific environment for plant production, CEA can control:

- Air temperature
- Humidity
- Air flow
- Light
- CO₂
- and more...



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What is CEA?

- CEA is made possible primarily by a structure that enables environmental control
- The structure can be equipped with more or less technology to enhance the level of environmental control



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What is CEA?

High-tunnel (low-tech)

- Simple but effective structure that can enable season extension
- Benefits include low cost, energy, and maintenance
- Suitable for small scale rural, urban, or off-grid agriculture

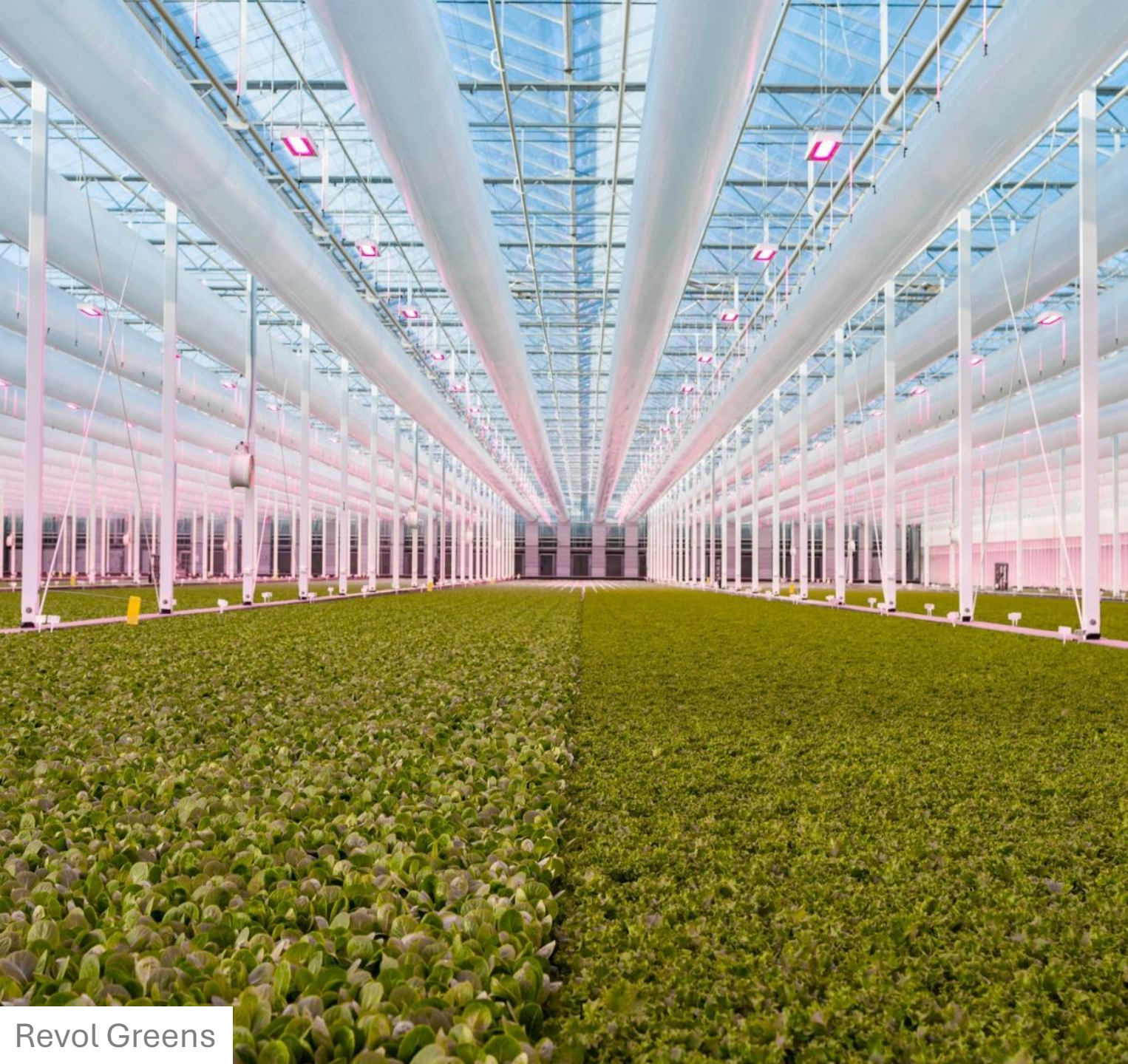


Johnny's Select Seeds



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What is CEA?

Greenhouse (medium-tech)

- The most common CEA structure for year-round production
- Offers a balance between environmental control and cost/energy
- The most scalable and versatile form of CEA!



Principles of Hydroponics

What is CEA?

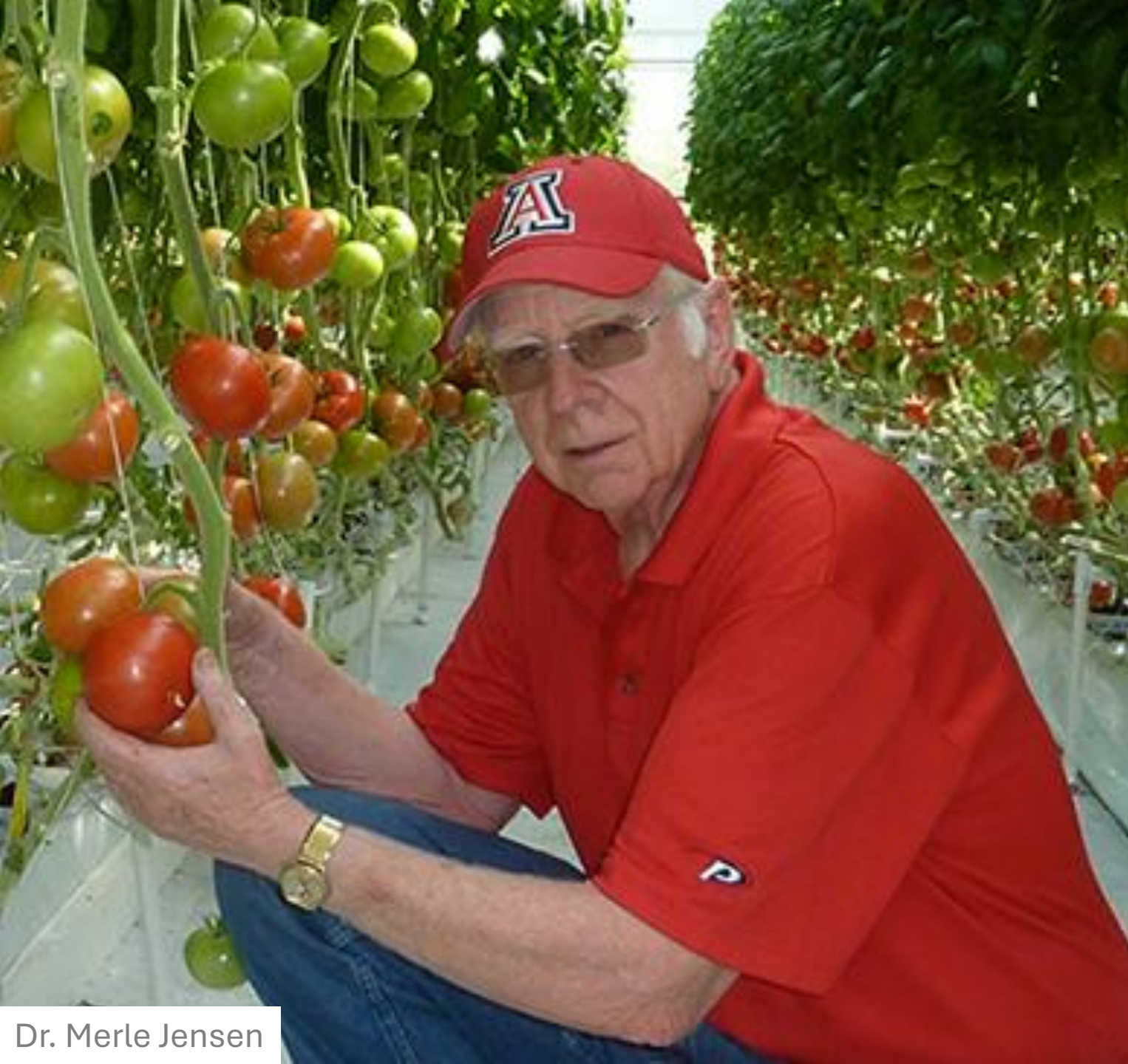
Indoor farm (high-tech)

- The apex of environmental control at the expense of cost/energy
- Most suitable for densely populated urban areas or unique/extreme environments (e.g. Antarctica, the ISS, or the moon!)



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What is CEA?

- Technically, environmental control is not new and has been applied in nursery and potted plant production for a long time
- However, the combination of hydroponics and CEA for crop production is a relatively new and exciting method of agriculture – the future of farming!

Dr. Merle Jensen



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Why Hydroponics and CEA?

- Create an optimal growing environment for consistent, fast, and high-quality yield
- Extended or year-round production that is protected from adverse climate or soil conditions



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Village Farms

Principles of Hydroponics

Why Hydroponics and CEA?

- Up to 7x plant density and up to 20x greater yield per unit area compared to traditional agriculture
 - Tomato yield = 6x
 - Peppers = 9x
 - Lettuce = 11x
 - Cucumbers = 20x



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Why Hydroponics and CEA?

- Less water, fertilizer waste, and pesticides due to closed, precise, and recirculating systems
 - 20% - 95% less water
 - Zero fertilizer waste from leaching or runoff
 - Minimal pesticide use with IPM*



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Why Hydroponics and CEA?

- New crops, such as peppers, melons, eggplant, beans and peas, berries, edible flowers, and more!
- New nutrient solution recipes, environmental setpoints, and plant production methods!



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Aluutiq Grown, Alaska

Principles of Hydroponics

Why Hydroponics and CEA?

- Food travels an average of 1500 miles from farm to table in the US
- Hydroponics and CEA can reduce food miles by 96% or more!
- Sustainable food systems that can strengthen food security



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THE ROOFTOP GREENHOUSE

In Collaboration with the Student Union, Campus Pantry, and Biosystems Engineering Department



Our mission is student-grown hydroponic produce delivered weekly to the Campus Pantry to strengthen food security on Main Campus!

Follow us on Instagram @ua_rooftopgreenhouse

Contact Dr. Hooks for more information!
tristonh@arizona.edu

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Why Hydroponics and CEA?

- Food security is the availability and accessibility of safe and nutritious food
- Impacts ~800 million worldwide, including the U.S.
- Hydroponics and CEA can provide fresh food in urban and rural food deserts!



Principles of Hydroponics

Why Hydroponics and CEA?

- Lots of challenges, lots of unknowns, but lots of opportunities!
 - Energy (up to 100x more!)
 - Cost of technology
 - Cost of labor



Eden Green Tech

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Why Hydroponics and CEA?

- Conclusion...
 - Hydroponics and CEA offer unique and sustainable food production systems that can strengthen food security, complement traditional agriculture, and help grow a better future!



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References

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- *Resh, 2022, Hydroponic Food Production*
- *Jensen, 1997*
- *Barbosa et al., 2015*
- *Maureira et al., 2022*
- *Hooks, 2023-2024, UA-CEAC Teaching Greenhouse and NFT Greenhouse unpublished data*
- *EPA.gov and WRI.org*
- *Food, Fuel, and Freeways*



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