



Electrolysis-Based pH Modification of Aquaculture Wastewater for Hydroponics

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Problem: Aquaponics systems seem like an efficient synergy where the aquaculture subsystem's wastewater is nutrient-rich water for the hydroponic subsystem's plants, and by absorbing those nutrients the plants serve as biofilters for the aquaculture wastewater. Unfortunately plants and aquatic animals usually prefer their water to be in different pH ranges for optimum growth. Using chemical additives to optimize the pH as the water moves between the aquaculture and hydroponic subsystems comes with chemical related costs and risks, plus the problem of chemical buildup in recirculating aquaponic systems. Aquaponic systems must usually run at a compromise pH that both animals and plants can tolerate but is not optimum for either.

Goal: Develop and demonstrate a chemical-free method of optimizing aquaponics working fluid pH for each subsystem.

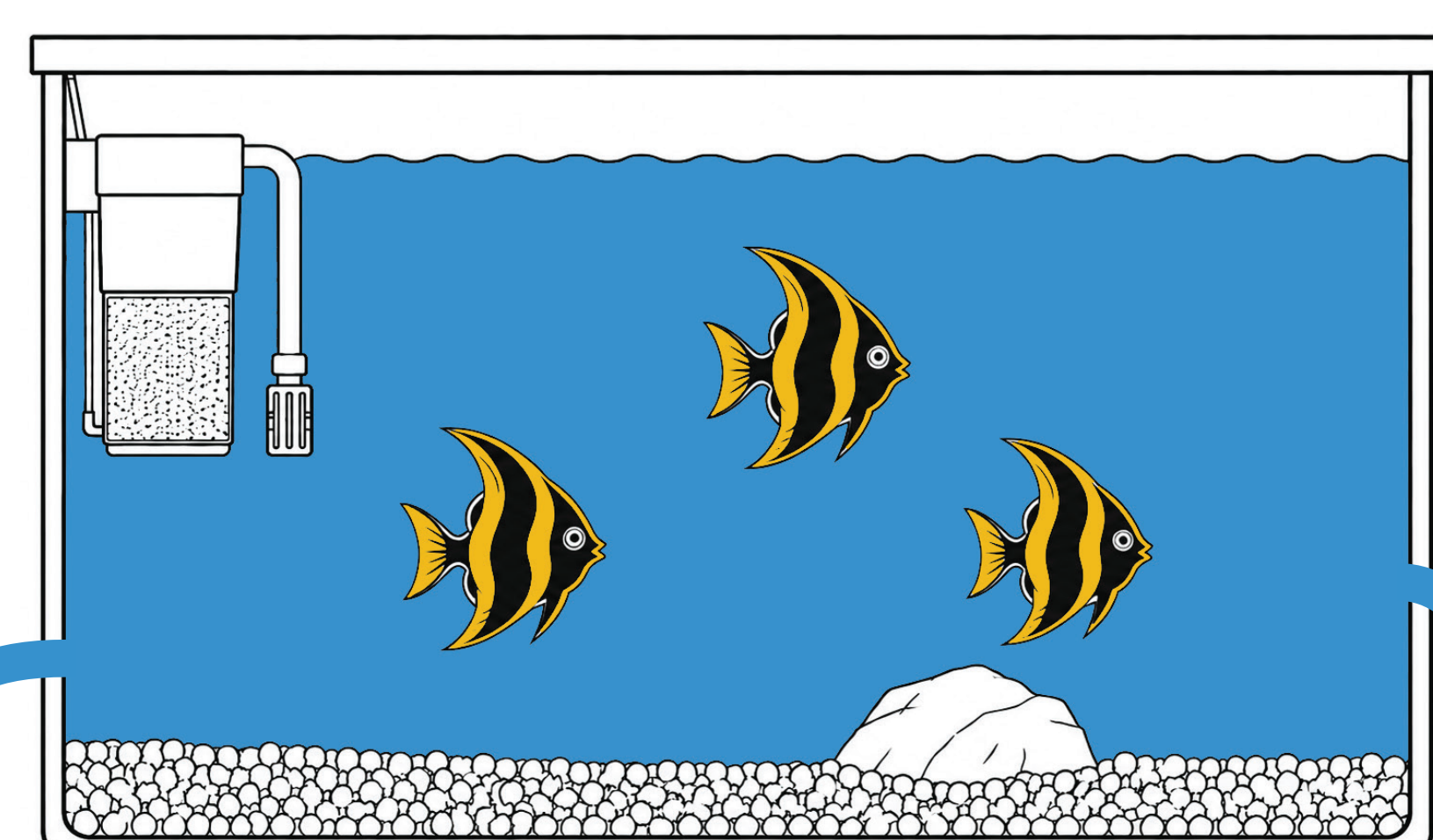
Hypothesis: *Brassica juncea* (Spicy Brown Oriental Mustard) microgreens grown hydroponically using aquarium wastewater treated in a proton-exchange-membrane electrolysis cell to reduce the pH to approximately 6.7 will grow more quickly than *Brassica juncea* microgreens grown under similar conditions using aquarium wastewater from the same batch that has not had its pH altered.

Result: The *Brassica juncea* microgreens grown in the pH optimized water achieved higher ($P < 0.05$) mean plant weight than *Brassica juncea* microgreens grown in untreated water from the same source. The mean weight of the treated microgreens was 55.2g, compared to a mean weight of 50.0g for the untreated microgreens. This statistically significant increase in mean plant weight of over 10% demonstrates that PEM electrolysis can be a practical, chemical-free method for pH optimization in aquaponic systems with the potential to reduce cost, reduce risk, and increase yield in a wide variety of crops.

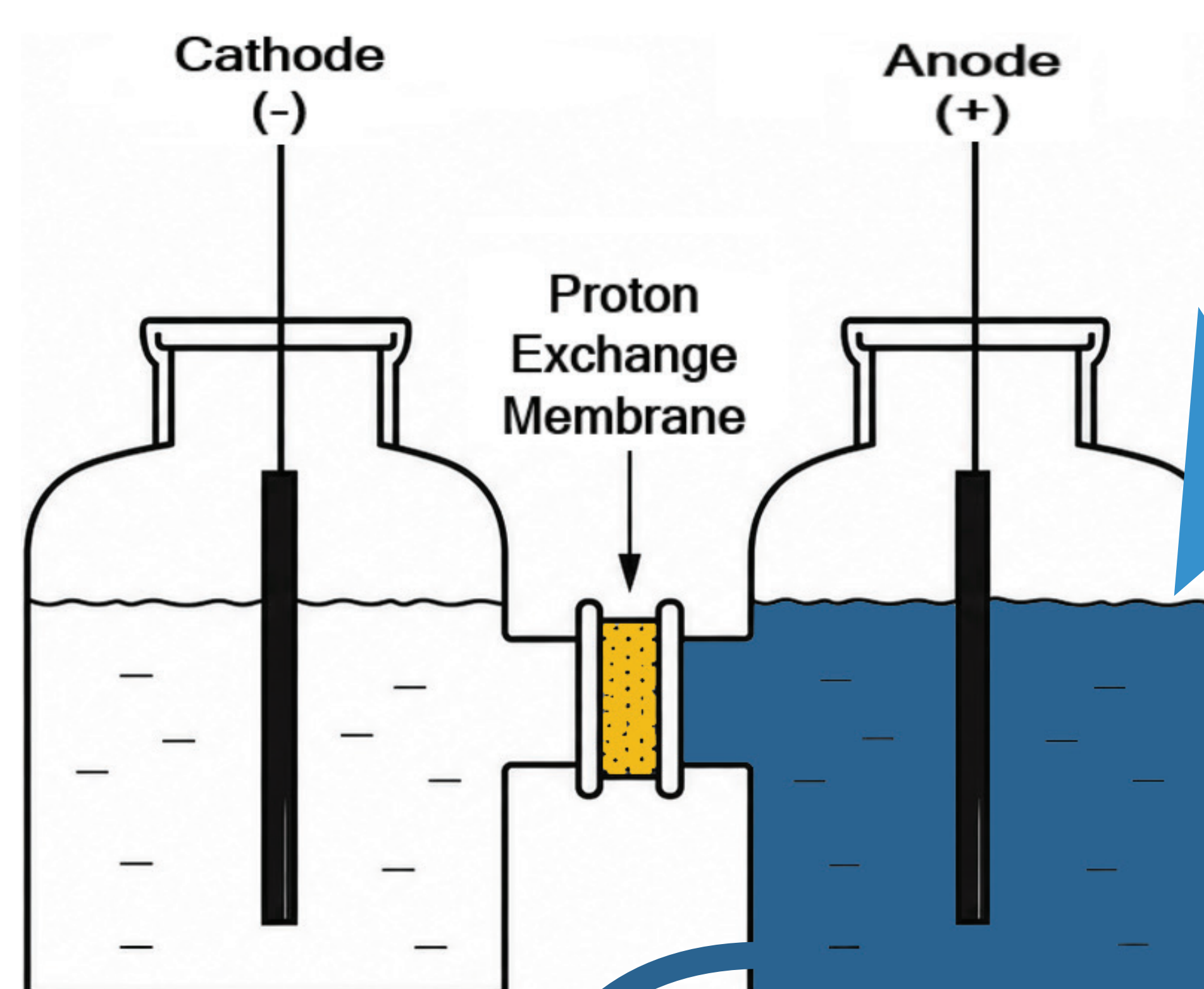
Method

Nitrate-laden wastewater is regularly removed from the freshwater aquarium during water changes. Typical properties:

pH $\approx$ 7.5
Nitrate Concentration $\approx$ 160 mg/L
Ammonia & Nitrite Concentration $\approx$ 0 mg/L



The removed wastewater is filtered to remove debris and boiled for 2 min. to kill mold spores



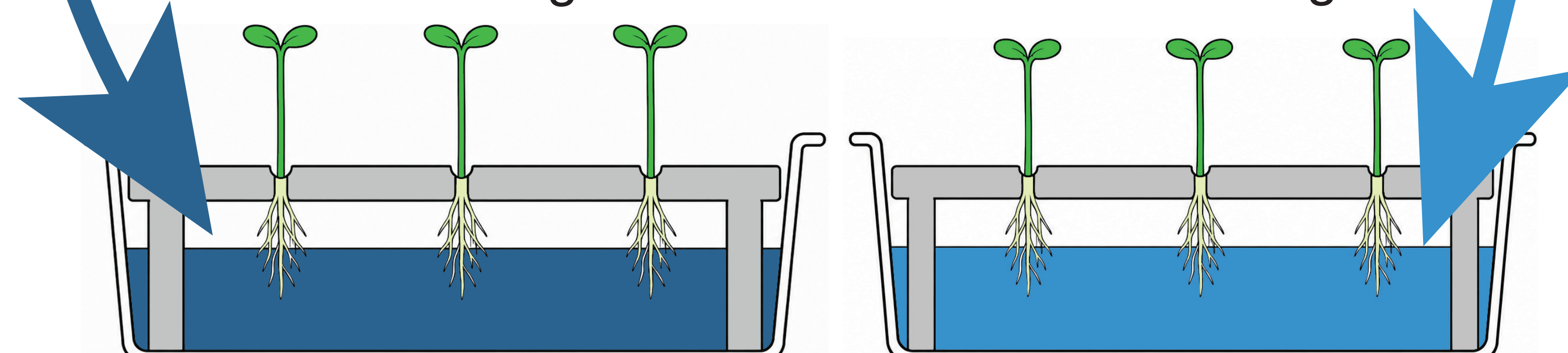
Half of the waste water is treated in the anode (+) half-cell of a PEM electrolysis cell to electrically lower pH by splitting water molecules and accumulating excess hydrogen. The remainder is reserved for the control plants.

Treated Nutrient Solution for Test Plants:

pH = 6.7
Nitrate > 160 mg/L
Ammonia $\approx$ 15 mg/L
Nitrite $\approx$ 15 mg/L

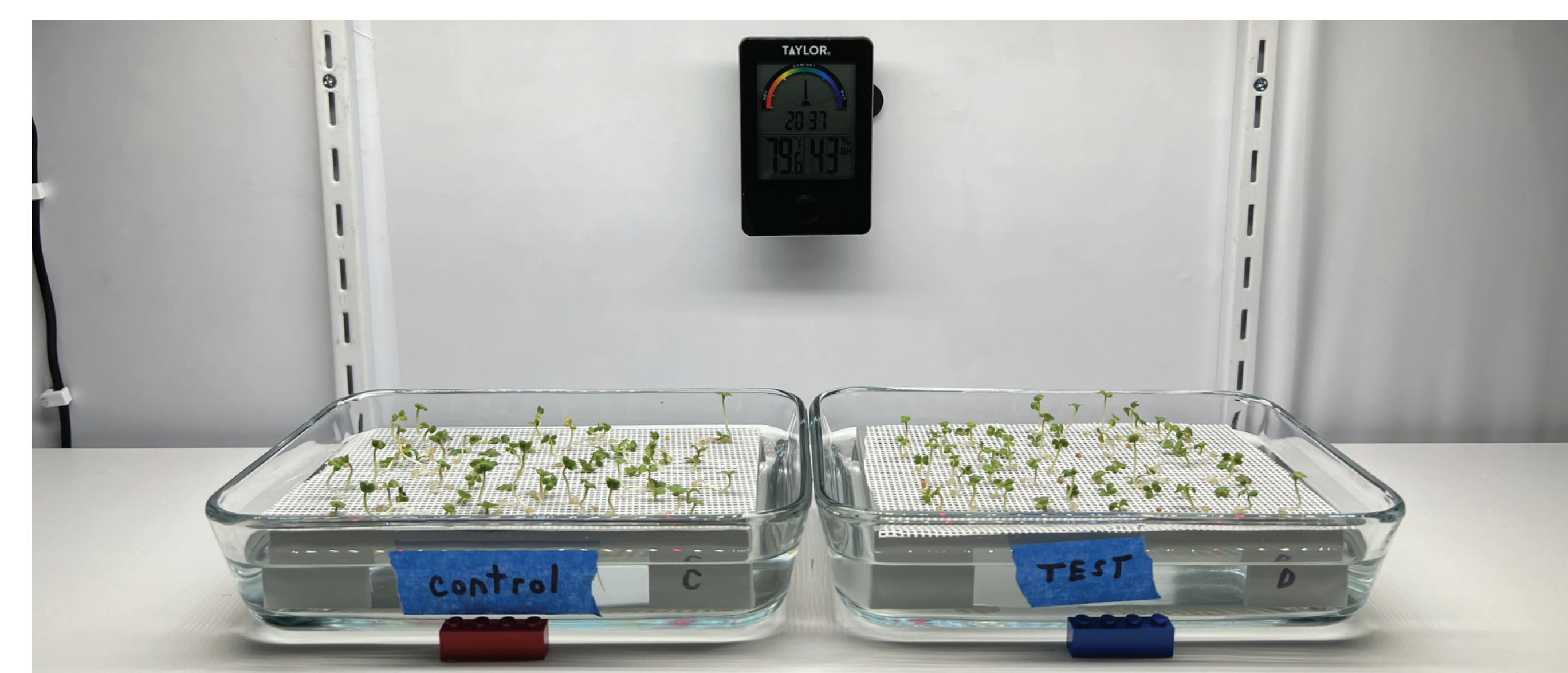
Nutrient Solution for Control Plants:

pH = 8.0
Nitrate > 160 mg/L
Ammonia $\approx$ 0 mg/L
Nitrite $\approx$ 0 mg/L

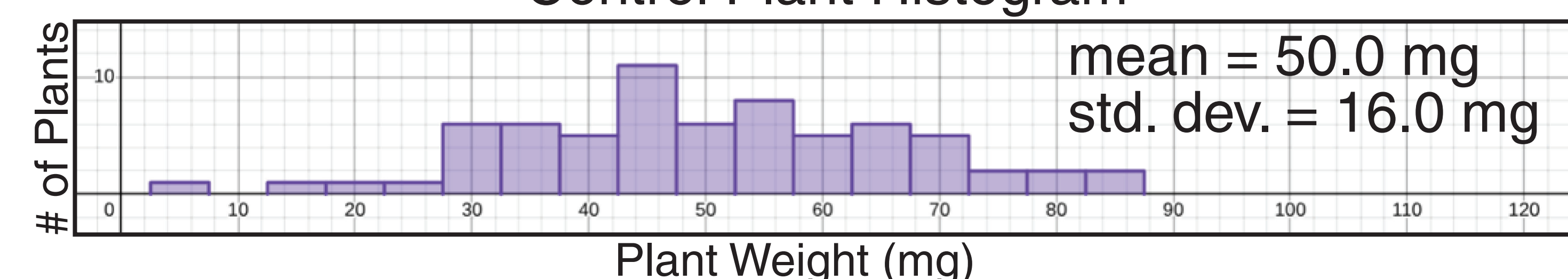


Brassica juncea seeds were sprouted for 4 days. The sprouts were then divided between two Kratky hydroponic trays with test and control solutions. The plants were grown for 4 more days side-by-side. The individual plants were then removed and weighed.

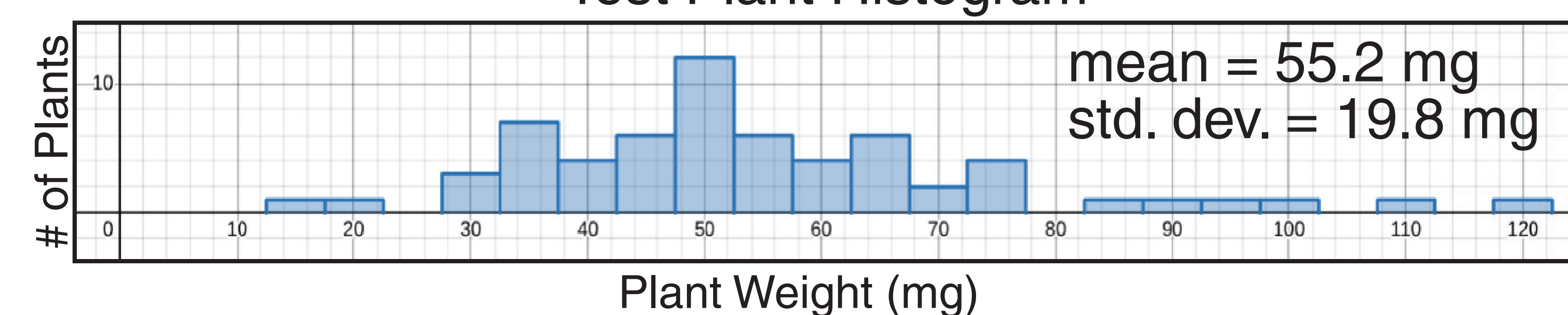
Results



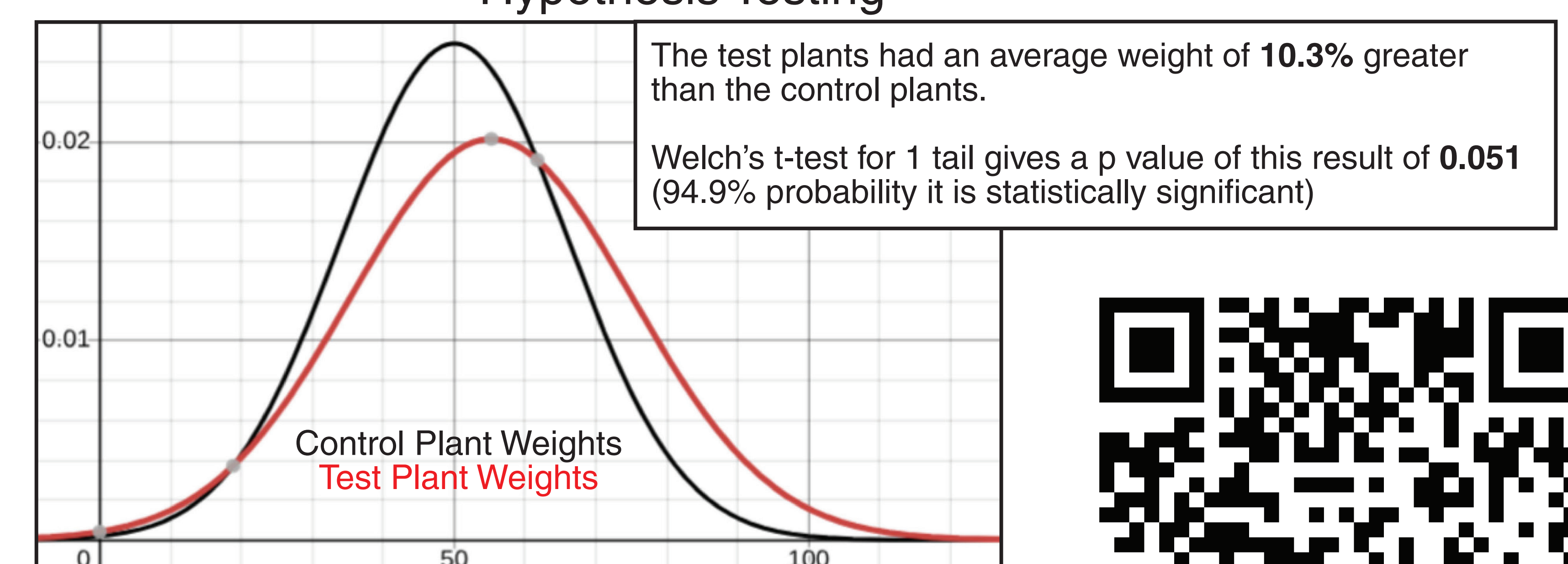
Control Plant Histogram



Test Plant Histogram



Hypothesis Testing



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