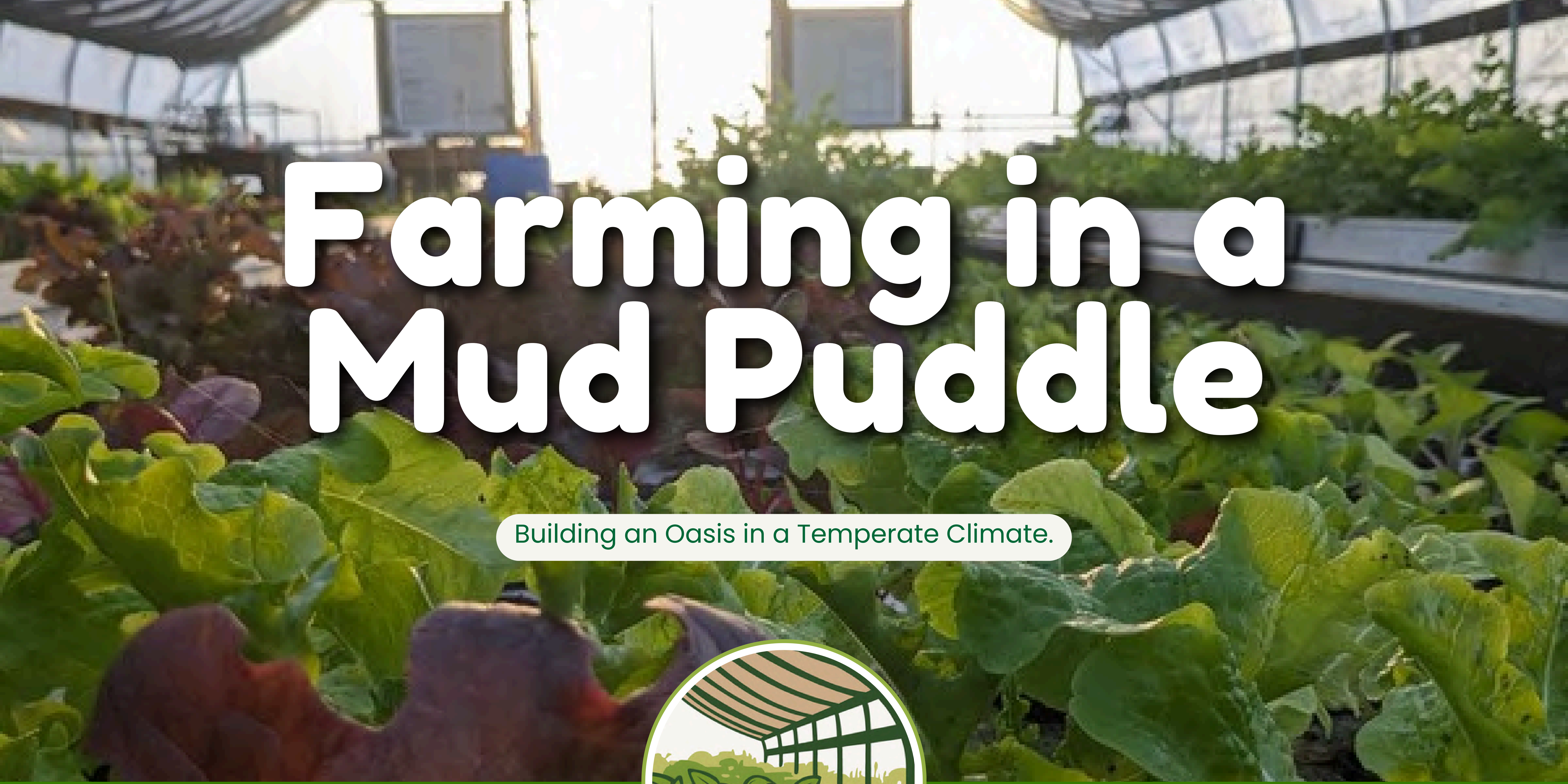
Farming in a Mud Puddle

Building an Oasis in a Temperate Climate.



1. Introduction: Why Aquaponics?

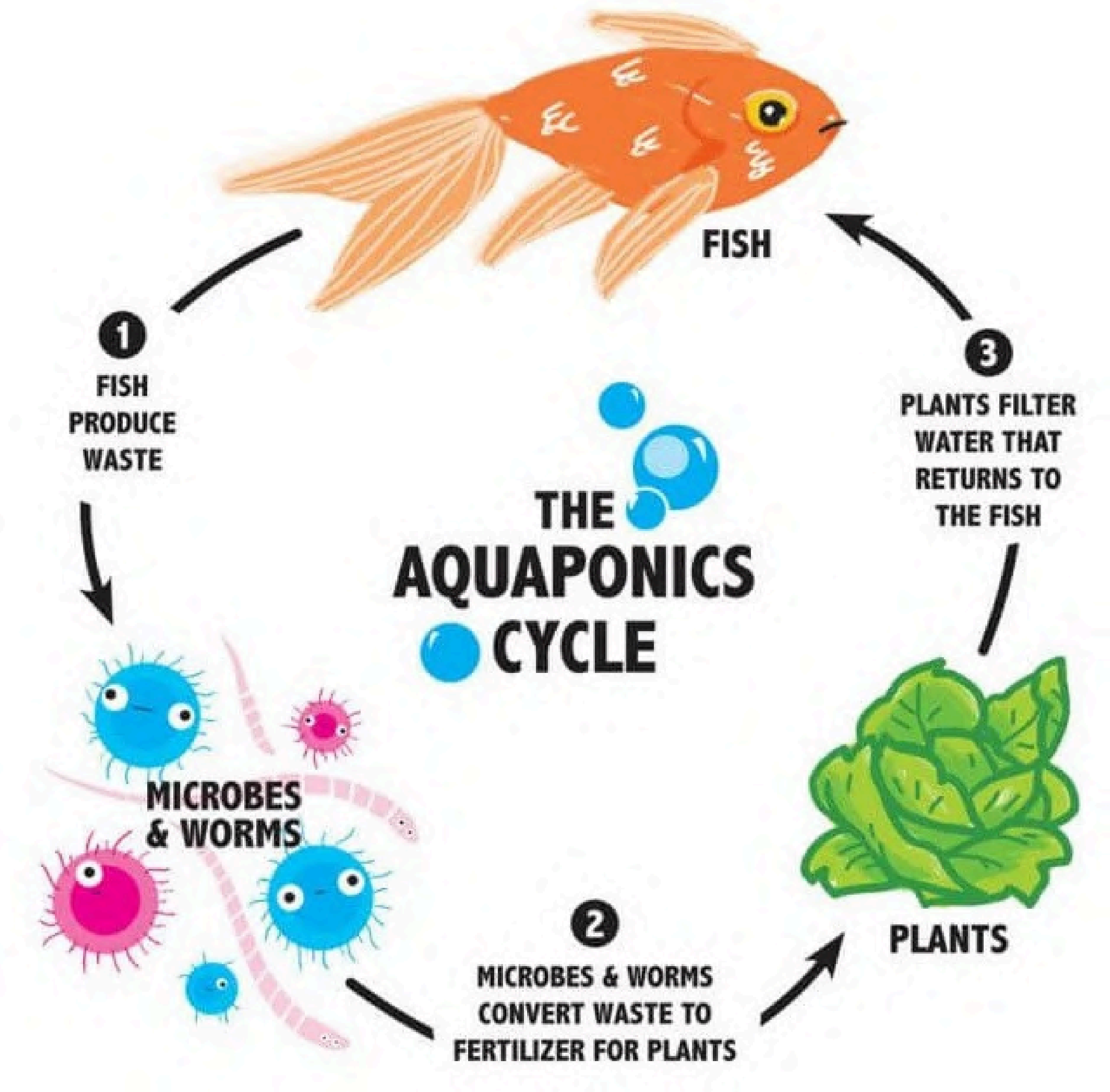
Motivation for the Research

- Increasing water scarcity and the need for water-efficient food systems
- Interest in low-input, regenerative growing methods that can function year-round
- Desire to explore food production systems that work in marginal conditions (cold, wet, low light)
- Alignment with community food access, education, and applied on-farm research

Why "Farming a Mud Puddle"?

- Working within imperfect conditions rather than idealized systems
- Embracing real-world constraints: weather, infrastructure limits, and budget
- Focus on adaptation, observation, and learning rather than optimization alone

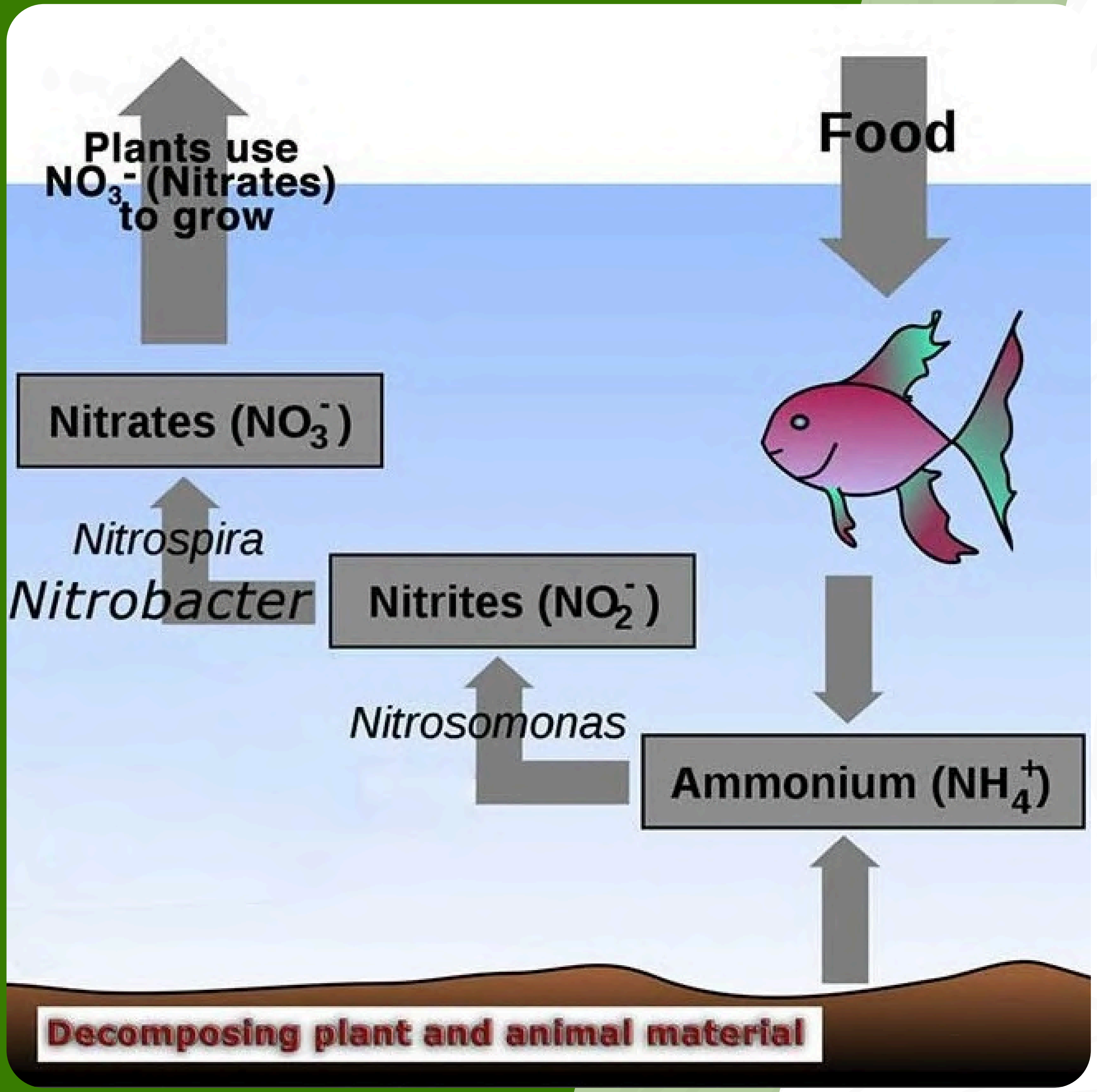
2. What Is Aquaponics? (System Overview)



Basic Concept

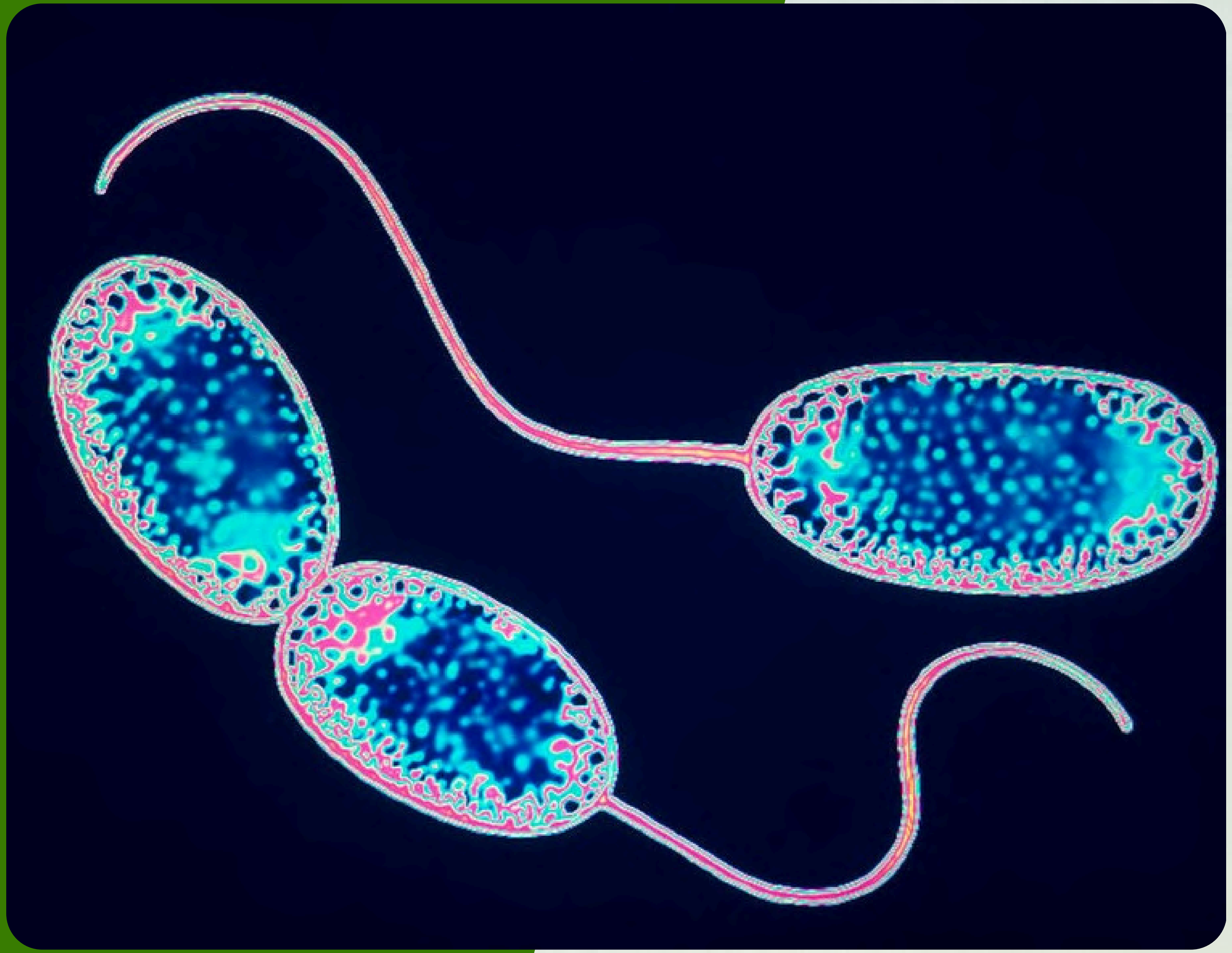
- Aquaponics combines aquaculture (raising fish) and hydroponics (soilless plant production)
- Fish waste provides nutrients for plants
- Plants and beneficial bacteria filter and clean water for fish
- A closed-loop or semi-closed system with continuous water reuse

Core System Components



- Fish tank (aquaculture component)
- Mechanical filtration (solids capture)
- Biofiltration (nitrification: ammonia → nitrite → nitrate)
- Grow beds / plant rafts / media beds
- Water movement (gravity flow or pumps)

3. The Nitrogen Cycle in Aquaponics



Fish Waste and Ammonia Production

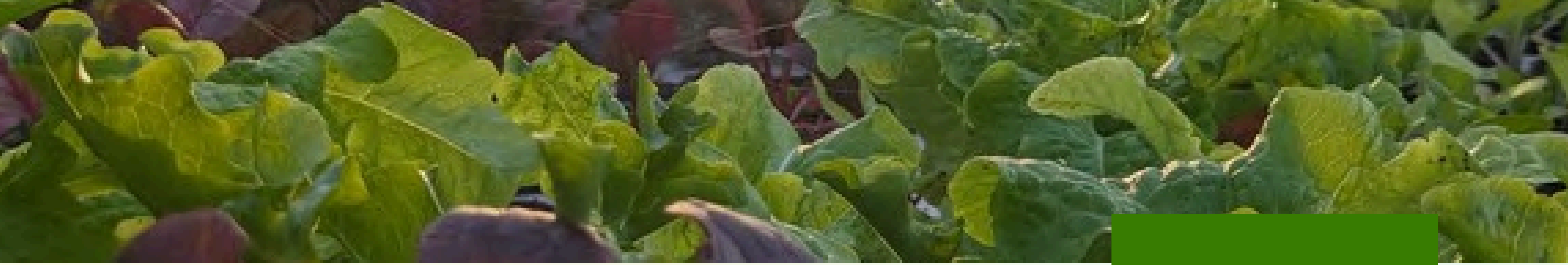
- Fish excrete ammonia (NH_3/NH_4^+) through gills and waste
- Ammonia is toxic to fish at relatively low concentrations

Beneficial Bacteria

- Nitrosomonas: ammonia → nitrite (NO_2^-)
- Nitrobacter / Nitrospira: nitrite → nitrate (NO_3^-)
- Nitrate is far less toxic to fish and readily taken up by plants

Key Conditions for Bacteria

- Adequate dissolved oxygen
- Stable temperatures
- Sufficient surface area for colonization (media, biofilters)



4. Oxygen: The Hidden Driver of the System

Oxygen availability shaped seasonal performance more than expected

- Dissolved oxygen influences fish health, bacterial efficiency, and root function
- Cold water holds more oxygen than warm water
- Summer oxygen stress became a greater limiting factor than nutrients

5. System Design and Scale

Small vs. Large Systems

Smaller systems:
Easier to stabilize temperature
Faster biological response
Lower fish-load risk

Larger systems:
Greater production potential
More difficult and expensive to heat
Higher risk during system failures or extreme weather

Why System Size Matters

- Larger water volumes take longer to heat and cool
- Greater thermal inertia but larger absolute temperature swings
- Harder to buffer against sudden cold snaps or heat waves

6. Water Temperature as a Limiting Factor

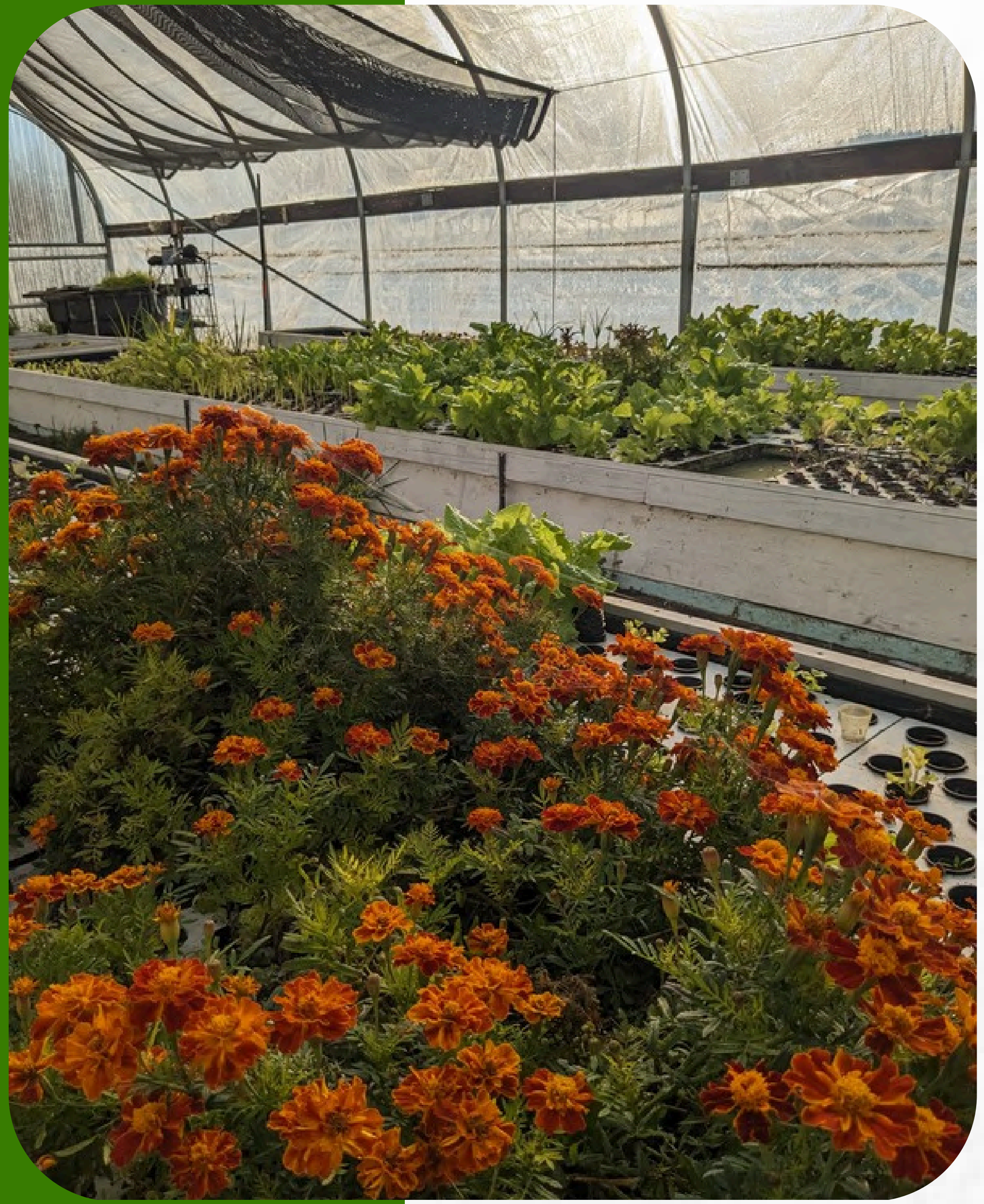
- Fish metabolism slows significantly in cold water
- Nitrifying bacteria activity decreases below ~55°F
- Plant nutrient uptake also slows
- Temperature consistency mattered more than absolute warmth

Winter Conditions

- Stable cold temperatures
- Higher dissolved oxygen
- Reduced pathogen pressure
- Slower but consistent plant growth

Summer Conditions

- Warmer water reduced oxygen availability
- Increased biological stress
- Growth limitations driven by oxygen, not nutrients



8. Winter Light Limitations

Sunlight Constraints

- Short day length
- Low sun angle reducing light intensity
- Greenhouse plastic and condensation reducing PAR

Plant Response

- Slower growth rather than plant loss
- Strong performance from leafy greens and native greens
- Basil and fruiting crops limited without supplemental light

Key Takeaway

- Survival ≠ productivity

9. Fish Selection: Why Carp?

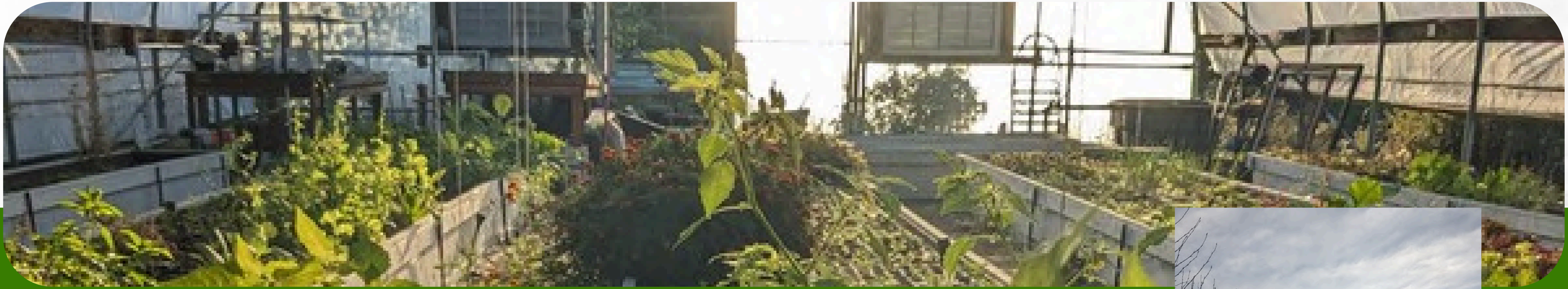
Selection Criteria

- Cold tolerance
- Hardy, adaptable species
- Ability to handle temperature fluctuations
- Ethical and regulatory considerations

Why Carp Worked Well

- Tolerate colder water than tilapia
- Remain active at lower temperatures
- Lower winter mortality
- Compatible with passive, low-energy systems

10. System Adjustments and Adaptive Management



- Adjusted flow rates during colder periods
- Media experimentation to improve airflow and oxygen exchange
- Seasonal crop selection rather than year-round uniformity
- Continuous observation guiding system tweaks

11. Emergent Ecology: Frogs and Tadpoles

- Frogs naturally colonized the system over time
- Tadpoles contributed to algae control by grazing biofilms
- Reduced algae buildup on tank walls and surfaces
- Frogs contributed to insect control within the greenhouse

Key Insight

- The system functioned not just as infrastructure, but as habitat

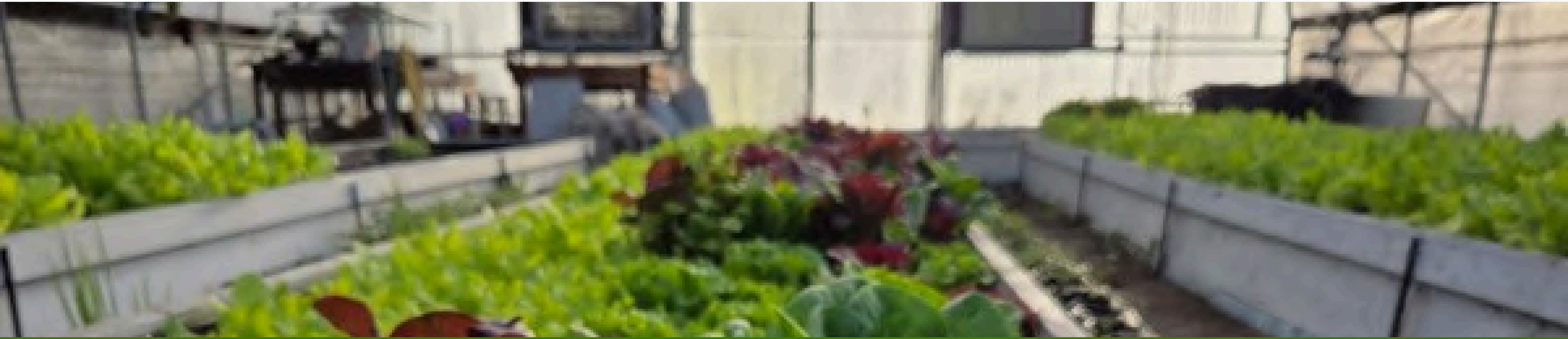
12. Expanding the Food Web: Snakes, Lizards, and Balance

- Presence of frogs attracted higher-level predators
- Snakes and lizards appeared as secondary occupants
- Insect pressure declined further
- System began functioning as a small ecological oasis

Observation

- Biodiversity increased system resilience rather than disrupting it

13. Lessons Learned



What Worked

- Cold-season production exceeded expectations
- Passive design reduced operating costs
- Ecological complexity improved stability

What Was Challenging

- Summer oxygen stress
- Temperature swings in large systems
- Balancing fish load with plant demand

14. Where the Research Goes Next

Broader Implications

- Applicability in temperate climates
- Community-scale food systems
- Low-resource or off-grid production potential

Future Questions

- Optimal media types for summer airflow
- Seasonal system tuning instead of static design
- Identifying temperature thresholds where heating becomes economical
- Intentional integration of ecological allies

15. Closing: Farming Imperfect Systems

- Aquaponics does not require ideal conditions to be useful
- Observation and adaptation matter more than technology
- Healthy systems invite ecology, not exclusion

Thank You

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