Introduction to Aquaponics

What you need to know

and why
Aquaponics
Please Define Your Terms

- Aquaponics is a system of agriculture involving the simultaneous cultivation of plants and aquatic animals (such as fish or prawns) in a symbiotic environment
  - A hybrid of **Aquaculture** and **Hydroponics**
  - **Aquaculture** is “Fish Farming”—raising fish in controlled, concentrated numbers
  - **Hydroponics** is growing plants without soil
    - Nutrient Film (Laminar Flow) Technology
    - Raft grow beds
    - Media-based grow beds
Aquaponics
Why Bother?

- Food is the new gold
  - Brigham Young said that a bushel of corn would be more valuable than a bushel of gold

- Food shortages
  - LDS Cannery raised prices 7~65% (19%) April 4
  - LDS Canneries have run out of wheat and flour

- Long Term and Short Term issues
  - Truckers’ strike, weather
  - Worldwide shortages
Aquaponics
Why Bother?

• Food costs in USmerica include a lot more than food
  - Transporting food is a major (often biggest) component in the price you pay
• Governments have confiscated stored food in the past, and stigmatized the prepared as “Hoarders”
• Others may steal your food
  - Even Saints have said, “I don’t need to store anything, I’ll just come and take yours
  - People in other “adventist” churches know who we are and where we live and have organized to take stored food
Aquaponics Basics

- Three “crops” in aquaponics
- Fish, high quality protein
- Plants (vegetables primarily, but some fruit)
- Bacteria
  - The most important
  - Need hard surfaces to grow on
  - Makes the others possible
Aquaponics Basics

- Fish defecate, urinate and breathe
- All contain Ammonia ($\text{NH}_3$ or $\text{NH}_4^+$)
  - Ammonia is fatal to fish and plants
- Bacteria convert Ammonia ($\text{NH}_3$ or $\text{NH}_4^+$) to Nitrites ($\text{NO}_2^-$)
  - Nitrites are fatal to fish and plants
- Bacteria convert Nitrites ($\text{NO}_2^-$) to Nitrates ($\text{NO}_3^-$)
  - Nitrates are plant food (fertilizer), benign to fish
Aquaponics Basics

Beneficial Bacteria

Fish

Ammonia

Nitrates

Plants

Clean Water
Aquaponics

**Bacteria**

- “Nitrificating” Bacteria
  - Occur naturally in atmosphere, water
- *Nitrosonomas* (various species)
  - Ammonia ($\text{NH}_3$ or $\text{NH}_4^+$) to Nitrites ($\text{NO}_2^-$)
- *Nitrobacter* (various species)
  - Nitrites ($\text{NO}_2^-$) to Nitrates ($\text{NO}_3^-$)
- Nitrification produces Nitric Acid, which counters the base, Ammonia
Aquaponics

Fish

- Very high “conversion rate”
  - Feed to food ratio
- Low susceptibility to disease
  - No *E. Coli*
- A very good source of protein
Aquaponics

Fish

- Food Fish (Eat ’em)
  - Tilapia
  - Bass (Large Mouth)
  - Blue Gill
  - Catfish
  - Exotics
    - Barramundi
    - Jade Perch
    - Silver Perch
    - Murray Cod

- Ornamental Fish (Sell ’em)
  - Koi
  - Goldfish
Aquaponics

Plants

- Lettuce ✔️
- Chives ✔️
- Spinach ✔️
- Basil ✔️
- Mint
- Cabbage ✔️
- Tomatoes ✔️
- Cucumbers ✔️
- Squash and Melons ✔️
- Peas
- Beans ✔️
- Stevia ✔️
- Peppers ✔️

Starting Dirt Garden Plants
- Cole (cabbage, broccoli)
- Tomatoes ✔️
- Strawberries
Aquaponics
It’s Chemistry

- Chlorine (Bromine)
- pH
  - Low (0~7) Acidic
    - <5.5 very acidic
  - High (7~14) Basic
    - >8.5 very basic
    - Alkalinity: measure of buffering capacity
Aquaponics
pH and Nutrient Uptake

• pH affects nutrient uptake in plants
  – Plants do not absorb Nitrogen, Phosphorous, Sulfur, Calcium, Magnesium, Molebdenum when pH is below ~6.5
  – Plants do not absorb Iron, Manganese, Boron, Copper, Zinc when pH is above ~7.8
Aquaponics

Toxicity

- Chlorine (and Bromine) in Aurora water toxic to fish, plants, and bacteria
- High pH (over ~7.8) kills fish
- Low pH (under ~6.5) kills plants
- Ammonia kills plants and fish
- Nitrites kill plants and fish
Aquaponics
Oxygen ($O_2$)

- Fish do not breathe water
  - Fish don’t drink water, either
- Gills separate dissolved oxygen from water
- Different species require different levels of dissolved oxygen
  - Tilapia thrive where trout would die
  - Catfish have low $O_2$ requirements
Aquaponics
Oxygen ($O_2$)

- **Air pumps**
  - Extra cost of pump, air stones, and power to operate
- **Splashing**
  - No additional costs when water falls far enough
Aquaponics
Nutrient Flow Technology

- Plants grow in small containers with their roots dragging on the bottom of long tubes or gutters
- The water flows from the fish tanks into the gutters
- There is little or no filtering done in the gutters
- Filtering happens in separate tanks
Aquaponics
Raft Systems

- Styrofoam boards (4'x8'x$3/4$")
- High plant density
- Needs external bio-filtering
- Used in large-scale, commercial operations
- Primarily leafy plants (basil, lettuce, etc.)
- Cyclical growth and harvesting
Aquaponics
Flood and Drain Systems

- Water is continually pumped into the grow beds until the level reaches the top of bell siphon, when it automatically drains back down to the fish tank
- One pump can deliver water to several grow beds
- Multiple pumps give redundancy to protect the whole system
Aquaponics

Bell Siphon
Our Experimental System

The Grow Beds——Photo 1
Our Experimental System

The Fish Tanks——Photo 2
Our Experimental System

Electrical Controls——Photo 3
Our Experimental System
Melon Plant with two weeks growth—Photo 4
Our Experimental System
The Sacrificial fish—Photo 5
Aquaponics
Growhaus System—Raising Trout
Aquaponics
Growhaus System—Tilapia