Aquaponics
Growing Fish and Plants Together
Aquaponics =

**Aqua**culture (raising fish) + **Hydroponics** (growing plants without soil)
The Aquaponics Cycle

1. Fish produce waste
2. Microbes & worms convert waste to fertilizer for plants
3. Plants filter water that returns to the fish
Why aquaponics?

- Uses 1/10th the water of soil-grown systems
- Plants grow 5 times faster
- No additional fertilizers
- Scalable from home systems up to small commercial
Why **here** and why **now**?

- Availability to local fresh food
- High cost of food
- Climate change
- Water conservation
Benefits of Aquaponics

• Better than hydroponics
  ▫ Plants grow twice as fast
  ▫ Plants taste better
• Better than aquaculture
  ▫ Fish diseases rare
  ▫ No *E. coli* or *Salmonella* in fish water

Healthy fish means healthy plants!
How does it work?
Aquaponics loosely described is the combination of aquaculture and hydroponics. **Aquaponics** means many different things to different people, but it’s basically all about growing fish and vegetables in a symbiotic system. *Fish and plants growing happily together.*
Common System Designs

- Flood-and-drain system
- Nutrient Film Technique
- Deep Water (Raft) Culture
What do you need?

- Water
- Fish - fingerlings
- Seedlings
- Air pump + water heater
- PVC piping
- Grow beds
- Growing medium
Aquaponics in the high desert

- Harvest everything and shut down for the winter
- Grow indoors
- Portable system
- Build a greenhouse

Put your system on wheels!
Deep Water (Raft) Culture

- Best for commercial production
- Good when the fish and plants need different temperatures
- Cost-efficient up to about an acre
Roots grow in water, not soil
Nutrient Film Technique (NFT)
Flood and Drain System

- Simple design
- Ideal for the home grower
- Use 1:1 grow bed volume to fish tank volume
- Can use 2:1 if two pumps are used – requires a sump tank

Tahoe Center for Environmental Sciences
Hybrid system

- Salad greens in raft or NFT
- Start in grow cubes
- Transplanted in 28 days
- Use media bed as your solids filter
Going Vertical

ZipGrow Towers

Graham Johnson, Fin and Leaf
Flood and Drain: Grow Media

Ideally:
- Does not affect pH
- Never decomposes
- Size (1/2- to ¾-inch)
- Porous
- No sharp edges
- Must be 12 inches deep
Most common...

- Expanded clay (hydroton®)
- Expanded shale
- Gravel – pH!
  - “fizz” test
- Scoria (volcanic)
Hydroton

- Good water and oxygen retention
- Promotes healthy root growth
- Reusable and lasts for years
- pH neutral

Bacteria convert ammonia to plant-friendly nitrate!
Why hydroton?

- Light weight
- Holds water and air
- Exceptional drainage
- Easy to clean
- pH neutral
- Costs $40 per 50-liter bag but lasts many years
Red wrigglers in media

• Suppress diseases, parasitic nematodes and insect pests
• Break down fish solid waste
• Eat dead roots
• ~1 lb. for every 20 cu. ft. of grow bed volume
Moving water around

- Pump and timer or...
- Auto siphon (or bell siphon)
Bell siphon: how it works...

1. Stand pipe
2. Siphon bell
3. Media blocker
Water from the fish tank (below) is pumped into the grow bed...
The grow bed fills with water until it reaches the top of the standpipe (~10 inches).
Water flows down the standpipe, pushing air out and creating a suction.
Water is sucked from the grow bed back to the fish tank, pulling oxygen into the grow bed.
Important stuff to know

- Flooding and draining pulls oxygen through the medium
- Must flow the entire volume of fish tank through the grow beds every hour
- Example: 100-gallon tank requires at least a 100-gph pump (plus 20-30% to account for head height and resistance from buildup of solids).
Questions?
The Fish

- Must use **freshwater** fish
- 1 lb. fish for every 5 gallons of fish tank water
- Limited by bio-filtering capacity of your grow beds
Fish adapted to aquaponics

- Tilapia – very forgiving!
- Catfish
- Trout
- Perch
- Barramundi
- Arctic char
- Bass
- Goldfish, oscars, koi – ornamental only

Trout grow well at only 63 degrees F.

Consider the temperature where your tanks will be.
# Selecting your fish

<table>
<thead>
<tr>
<th>Carnivores:</th>
<th>Omnivores:</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Trout</td>
<td>• Tilapia*</td>
</tr>
<tr>
<td>• Bass</td>
<td>• Catfish</td>
</tr>
<tr>
<td>• Perch</td>
<td>• Pacu</td>
</tr>
<tr>
<td>• Barramundi</td>
<td>• Koi</td>
</tr>
<tr>
<td>• Arctic char</td>
<td>• Goldfish</td>
</tr>
<tr>
<td>• Oscars</td>
<td></td>
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</tbody>
</table>

What’s legal and available...
*Tilapia is restricted in Nevada

- License not required to own “aquarium fish”
- Commercial license for other wildlife - $500/yr
- Noncommercial license - $15/yr
Feeding the fish

- Food should be consumed within 5 min.
- Feed 1 to 3 times per day.
- Supplemental food:
  - Duckweed (for omnivores)
  - Worms
  - Black soldier fly larvae

Duckweed grows fast, is high in protein and efficiently filters water.
Vermicomposting for fish feed

- Harvest vegetables
- Produce more vegetables
- Feed scraps to worms
- Feed worms to fish
- Produce more vegetables
Plants adapted to aquaponics

- Lettuces, herbs, spinach, chives, basil, broccoli, watercress
  - Low nutrient requirements
  - Require lower fish stocking density

Vegetables raised in aquaponics taste better!
Plants adapted to aquaponics

- Tomatoes, peppers, strawberries, corn, cucumbers
  - Higher nutrient needs
  - Require higher fish stocking density
Root-zone temps are important...

Prefer warm root zone (70 F)

- Tomatoes
- Corn
- Squash
- Cucumbers
- Beans
- Strawberries

Prefer cool root zones (60 F)

- Lettuces
- Spinach
- Peas
- Chard
- Broccoli
- Carrots
Who says you can’t grow root vegetables?
Seed starting using plugs
Use IPM to control insect pests

- Regular monitoring
- Identify the pest
- Set tolerance levels
- Using least harmful methods:
  - Feed them to fish!
  - Spray with water
  - Introduce beneficials
  - Last resort: insecticidal soap or neem oil
More benefits of aquaponics

- Waist-level gardening
- No weeding
- No fertilizers
- Can easily move plants around
Must keep everybody happy...

<table>
<thead>
<tr>
<th></th>
<th>pH</th>
<th>Temp</th>
<th>Oxygen</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fish</td>
<td>6.5 to 8.0*</td>
<td>74 to 80 F*</td>
<td>&gt; 3-6 ppm</td>
</tr>
<tr>
<td>Plants</td>
<td>5.0 to 7.0</td>
<td>60 to 80 F</td>
<td>&gt; 3-6 ppm</td>
</tr>
<tr>
<td>Bacteria</td>
<td>6.0 to 8.0</td>
<td>77 to 86 F</td>
<td>&gt; 3-6 ppm</td>
</tr>
<tr>
<td>Worms</td>
<td>6.0 to 8.0</td>
<td>55 to 77 F</td>
<td>&gt; 3-6 ppm</td>
</tr>
</tbody>
</table>

* Range depends on species
Monitoring Water Quality

• Fish and bacteria need:
  ▫ Dissolved oxygen
  ▫ Low carbon dioxide
  ▫ Low ammonia and nitrates
  ▫ Proper pH – 6.7 to 6.9
  ▫ Water temperature – 70 to 86 deg.

• Allow water to sit for 24 hours to de-chlorinate

Test pH weekly
Adjusting pH

Raise pH if drops below 6.6

- Calcium hydroxide (hydrated lime or builder’s lime)
- Potassium carbonate or potassium hydroxide
- Be cautious using “natural” products (eggshells, snail shells, seashells)

Lower pH if goes above 7.6

- pH Down (for Hydroponics, not aquarium)
- Nitric or phosphoric acid
- Use vinegar, hydrochloric acid or sulfuric acid only as a last resort
- Never use anything containing sodium
- Never use citric acid (antibacterial)

Never move pH more than 0.2 in a day
Aeration stones/bars
Getting Started...Cycling

- Creating your biofilter –
- Must introduce ammonia: fish or fishless
- Monitor, monitor, monitor
- Goal: cycle ammonia* to nitrite* to nitrate
- Takes 4 to 6 weeks

* Toxic to fish
Cycling with fish

- Use goldfish
- Feed only once per day
- Monitor daily for ammonia and nitrite levels
- Monitor pH – adjust **slowly**
- Nitrites suffocate fish – if levels rise above 10 ppm:
  - Stop feeding fish
  - Water exchange
  - Add non-iodized salt (1 part per thousand)

AquaponicGardening.com
Cycling without fish

Basic process
- Add ammonia
  - Synthetic
  - Organic
  - “Pee-ponics”

Murray Hallam process
- Add liquid seaweed
- Add plants
- Wait two weeks
- Add fish

- Ammonia attracts Nitrosomonas bacteria.
- Nitrite attracts Nitrobacter bacteria.
- Nitrate is safe for fish and plants.
Maintenance – what to look for:

**Daily**
- Feed fish
- Check fish tank temperature
- Check pump(s) and plumbing

**Weekly**
- Check pH
- Check ammonia
- Watch for insects

**Monthly**
- Clean pump and pipes
- Agitate solid waste
- Check nitrates
  - > 150 ppm is toxic to your system – add plants or harvest some fish!
Plants grow fast in aquaponics!

Seedlings just started  
13 days later  
25 days after seedlings started
## Return on investment

<table>
<thead>
<tr>
<th>Aquaponics System</th>
<th>Typical backyard system</th>
</tr>
</thead>
<tbody>
<tr>
<td>Retail value of live barramundi ($12.00 each)</td>
<td>$264</td>
</tr>
<tr>
<td>Retail value of live trout ($9.00 each)</td>
<td>$198</td>
</tr>
<tr>
<td>Retail value of vegetables and herbs</td>
<td>$800</td>
</tr>
<tr>
<td>Total potential retail revenue</td>
<td>$1,262</td>
</tr>
<tr>
<td>Total potential net revenue</td>
<td>$900</td>
</tr>
<tr>
<td>Payback Period (years)</td>
<td>2.5</td>
</tr>
</tbody>
</table>

### Commercial:
- Produce 45 to 70 lbs. of produce for every lb. of tilapia (S & S Aqua Farm, MO).
- Yields of aquaponic basil 3x greater than field grown; 18x greater with okra (Univ. of Virgin Islands).
- Net of $134,245/yr. compared to only $36,808/yr. with field grown (same size area).

Richard Chiang, Univ. of Queensland, 2009
## Aquaponics Resources

<table>
<thead>
<tr>
<th>Local:</th>
<th>Other:</th>
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</thead>
<tbody>
<tr>
<td>• Fin and Leaf Consulting</td>
<td>• Aquaponic Gardening by Sylvia Bernstein</td>
</tr>
<tr>
<td><a href="mailto:gjohnson@finandleaf.com">gjohnson@finandleaf.com</a></td>
<td>• Aquaponic Gardening Community</td>
</tr>
<tr>
<td>• Reno Hydroponics and Organics</td>
<td><a href="http://aquaponicscommunity.com/">http://aquaponicscommunity.com/</a></td>
</tr>
<tr>
<td>(775) 284-8700</td>
<td>• Backyard Aquaponics Magazine</td>
</tr>
<tr>
<td>• Anything Grows Hydroponics</td>
<td><a href="http://www.theaquaponicstore.com/">http://www.theaquaponicstore.com/</a></td>
</tr>
<tr>
<td>(530) 582-0479</td>
<td>• Backyard-Aquaponics-Magazine-s/62.htm</td>
</tr>
<tr>
<td>• The Hydro Store</td>
<td>• The Aquaponic Source</td>
</tr>
<tr>
<td>(775)787-2760</td>
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Questions?

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