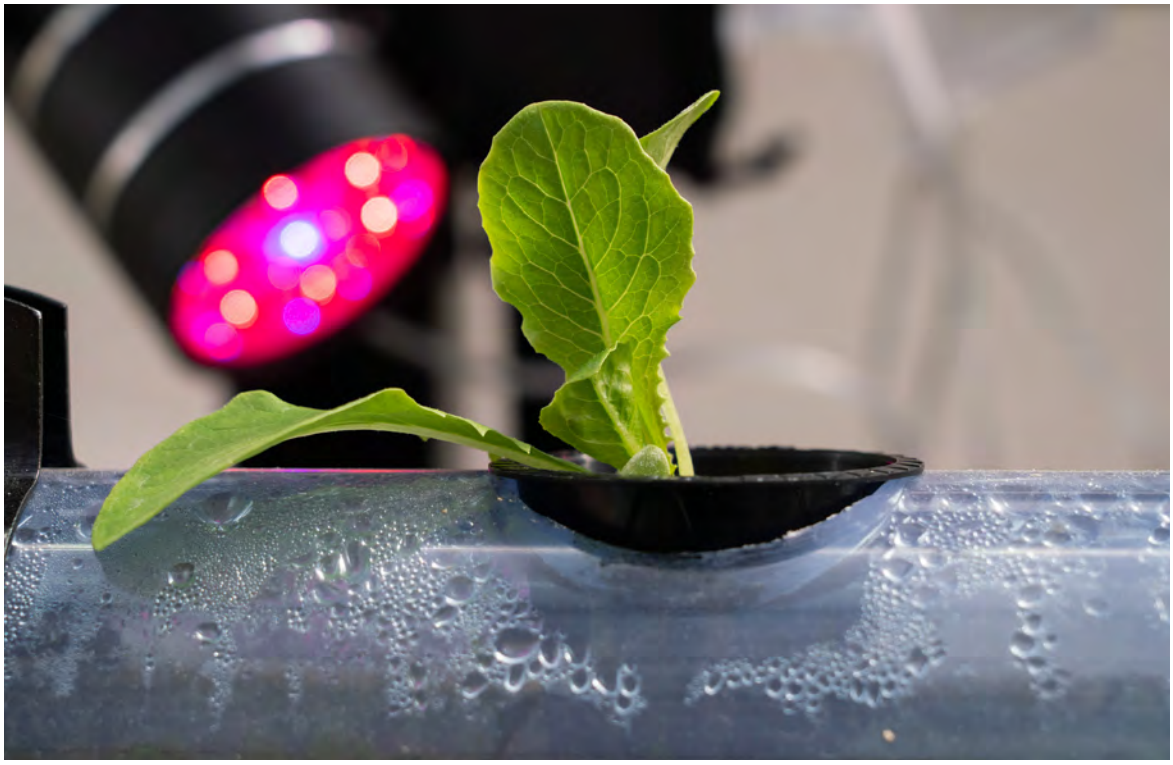


Aquaponics in the classroom

The McGraw way

By Gordy Gotsch
Director of Fisheries Research and Management
Max McGraw Wildlife Foundation

Introduction

Researchers at the Max McGraw Wildlife Foundation have long studied aquaponics as a way to grow bigger game fish, ensuring a higher survival rate for stocked fish. This groundbreaking research holds enormous potential for private and public fish hatcheries worldwide, and will benefit recreational anglers for generations to come.

Working out of McGraw's Ken Wegner Family Center for Aquaponics Research, the team also has raised hundreds of bushels of delicious lettuce. In addition, McGraw's director of fisheries research and management, Gordy Gotsch, has developed a program to bring low-cost aquaponics into the classroom, enabling teachers to demonstrate concepts such as:

- Fish and plant biology
- The nitrogen cycle
- Photosynthesis and respiration
- Water conservation
- Sustainable agriculture
- Chemistry
- Mathematics
- Living systems
- Bacteria's role in ecology

Because schools typically have limited space and funds, McGraw has designed a miniature aquaponics system that takes up only limited space and costs less than $150, using materials easily purchased online or in a pet store.

What is aquaponics?

Aquaponics is the combination of raising fish and plants in the same water system, creating a symbiotic relationship. Fish provide nutrients for plants while plants filter water for the fish. It is an environmentally friendly, efficient and sustainable way to produce food.

Why aquaponics?

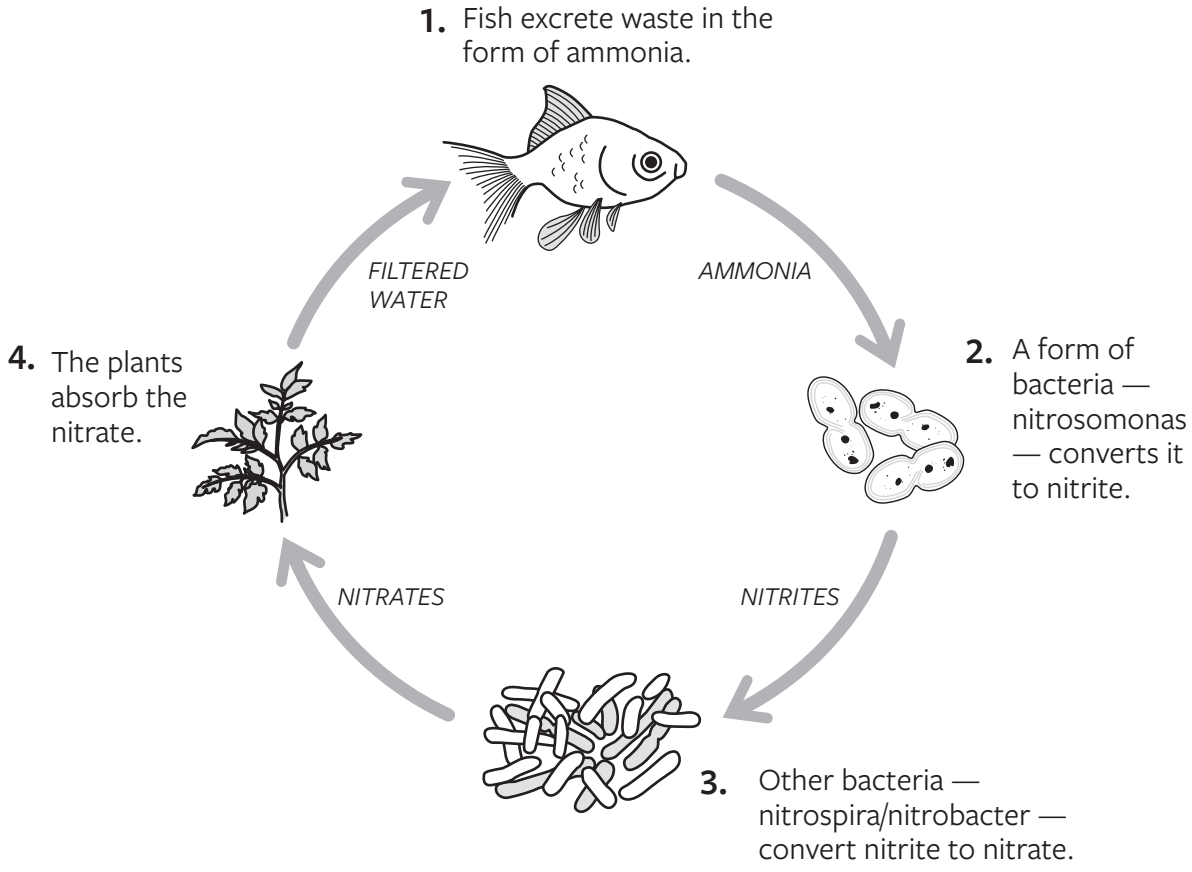
- Low environmental impact
- Produces high-quality fish and organic vegetables
- No artificial fertilizers, herbicides or pesticides
- No hormones/antibiotics
- Uses 90 percent less water than conventional farming
- Produces food continuously year round.
- Sustainable and highly productive

How aquaponics works

Fish excrete ammonia through their gills. This ammonia, which in even low concentrations can kill fish, must be converted to nitrate to prevent fish mortality. The process is known as the nitrogen cycle.

The nitrogen cycle in aquaponics

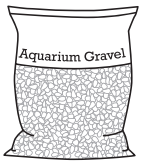
The nitrogen cycle is the conversion of ammonia to nitrite to nitrate.



Getting started

The main components

Fish tanks can be an aquarium or any other clean container that holds water. Ten-gallon tanks are around $15, but frequently can be found on sale for less.

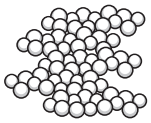


Aquarium gravel is found anywhere fish tanks are sold. Buy enough to cover the bottom of the tank by a half-inch.

A **water pump** recirculates water through the system, moving it from the fish tank into the grow bed. It then returns to the fish tank via gravity.

An **air pump** delivers air through tubing and into **air stones** at the bottom of the tank. Small bubbles produced from the air stones help to increase oxygen levels, benefiting fish and plants.

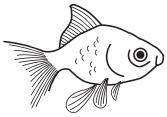
A **grow bed** is a container for the plants that is placed above the fish tank. There are many options — we used a 41-quart plastic container.



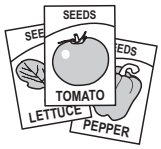
Grow media holds moisture and helps support the plants. It should be made from chemically inert materials. Examples include perlite, expanded clay pebbles or pea gravel. You need enough to fill the grow bed three to eight inches deep.

A **water chemistry kit** lets you monitor the pH, ammonia and nitrogen levels.

The main components

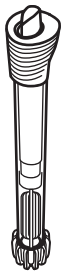


Fish
Commercial aquaponics systems use food species such as tilapia, channel catfish and rainbow trout. At McGraw, our research focuses on game fish such as walleye. For the classroom, we recommend goldfish, guppies or angelfish.

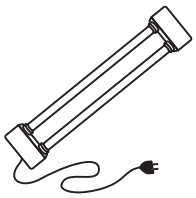


Plants
Leafy lettuces and many herbs and sprouts thrive in small aquaponics systems. Fruiting plants such as tomatoes, peppers and cucumbers require higher nutrient levels and larger, well-established systems.

Some optional equipment

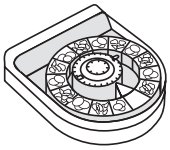


You might need an **aquarium heater** if you set up your system in a cool room. Warm-water species need water between 70 and 80 degrees. Heaters with thermostats are a bit more expensive, but allow you to maintain a desired temperature.

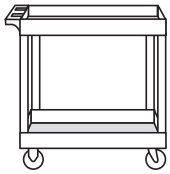


A **plant grow light** provides additional lighting.

You can use a **24-hour timer** to provide 16 hours of light for the plants.



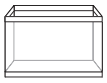
Automatic feeders feed the fish when you are not around on weekends or holidays.



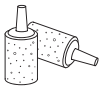
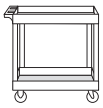
An **aquarium stand** or **rolling cart** is an excellent way to display and access the system.

Shopping checklist

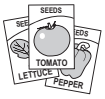
Here are the materials needed to construct a classroom aquaponics system as described in our video at *mcgrawconservation.org/aquaponics*. You can find all of this online or at your local pet store:

ITEM	WHERE TO FIND IT
 10-gallon fish tank	Pet stores and other places that sell fish
 10 pounds of aquarium gravel	Pet stores and any place that sells aquariums
 Water pump rated for 100 to 150 gallons per hour	Pet stores or online
 Four feet of ⅜-inch inside diameter / ½-inch outside diameter plastic tubing to attach to the water pump	Hardware stores
 ½-inch rubber grommet	Hardware stores (look in electrical section)
 Air pump	Pet stores and other places that sell fish
 Four feet of air line	Pet stores and other places that sell fish

Shopping checklist *(continued)*

ITEM	WHERE TO FIND IT
 Air stones	Pet stores and other places that sell fish
 Grow bed	Hardware, and big-box stores
 Grow media	Hydroponic stores, online
 Ebb and flow fitting with ½-inch barb	Hydroponic stores, online
 Four feet of ½-inch inside diameter plastic tubing for overflow	Hardware stores
 Small zip-ties to organize cords	Hardware stores
 Cart or aquarium stand	Hardware stores, pet stores or online
 Rock wool or cotton balls	Hydroponic stores, online
 Water chemistry kit, chlorine remover, pH adjusting products	Pet stores
 Plant grow light (optional)	Pet stores and home centers

Shopping checklist *(continued)*

ITEM		WHERE TO FIND IT
	Aquarium heater (optional)	Pet stores and other places that sell fish
	Automatic fish feeder (optional)	Pet stores or other places that sell fish
	24-hour light timer (optional)	Hardware and big-box stores
	Electric power strip	Hardware and big-box stores
	Scrub brush	Pet stores
	Fish food	Pet stores
	Fish	Pet stores and some big-box stores
	Plant seeds	Garden stores, online

Tools you'll need

Scissors

Drill

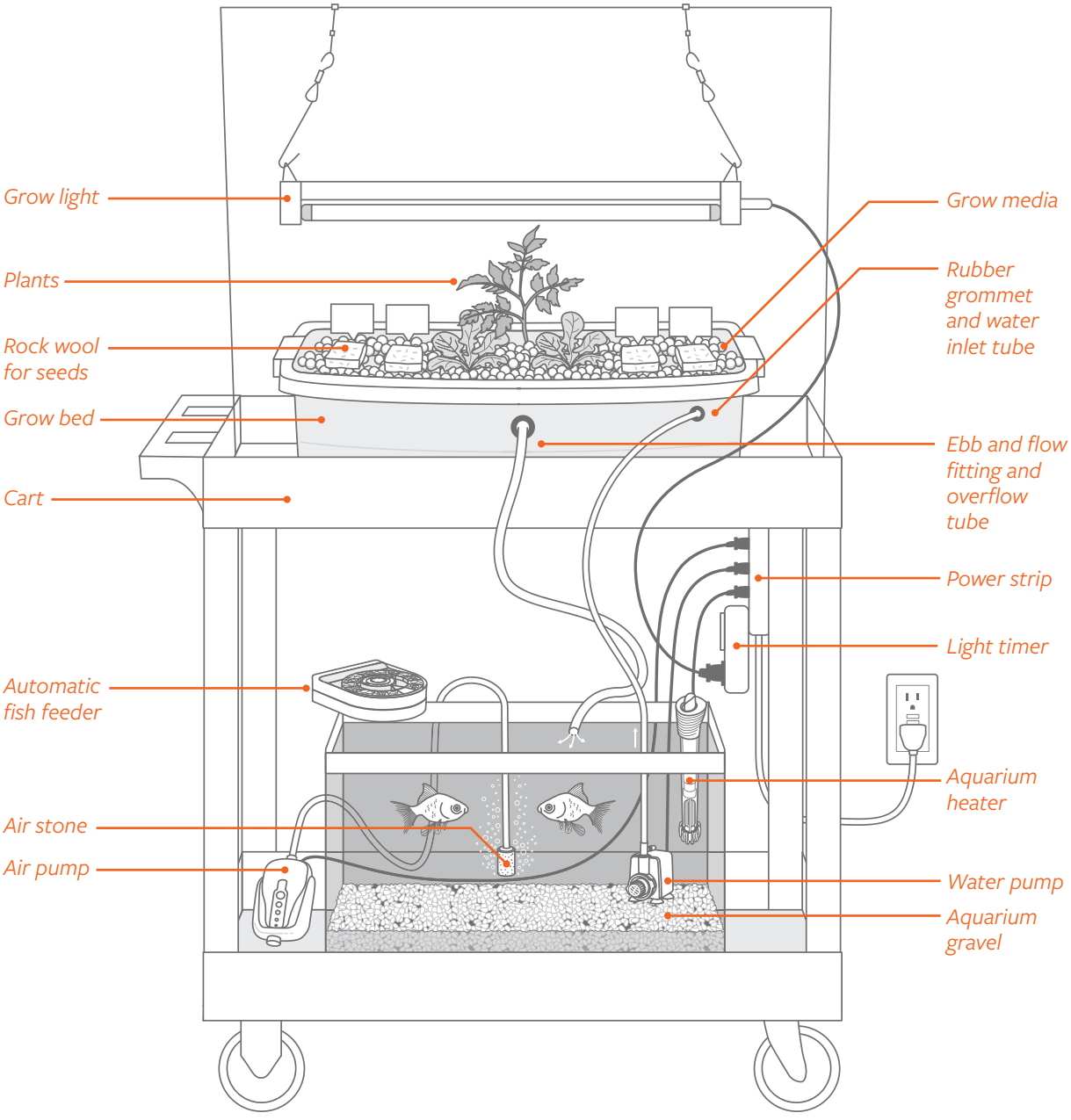
1½-inch hole saw

⅝-inch drill bit

Assembly

Your aquaponics system

Once you have all your parts and tools, you can quickly assemble the system and start growing. The following pages contain step-by-step directions to build your aquaponics setup. Don't worry if it doesn't look exactly like ours, below. As long as the pieces go in the right places, it will work fine.



Assembly

BEFORE YOU START

Watch our video at *mcgrawconservation.org/aquaponics* for step-by-step instructions and tips.

1. Thoroughly wash the gravel in a colander or sieve. Rinse well and place in bottom of fish tank. Place the fish tank on the bottom shelf of the aquarium stand or cart.

2. Drill a ⅝-inch hole in the grow bed for the inflow, approximately 1 inch below the top of the grow bed. Insert a ½-inch rubber grommet in the hole.

3. Drill a hole with the 1½-inch hole saw about 2 inches below the inflow. Attach the ebb and flow fitting with the barb facing out.

Hint: Hold a block of wood on the back side while drilling. This will reduce the chances of the plastic cracking.

4. Place the water pump in the fish tank, then set the grow bed on the top shelf above the fish tank. Attach the ⅜-inch inside diameter tubing to the water pump and feed it through the rubber grommet in the grow bed. Extend the tubing to the front of the grow bed and cut to length with scissors. Attach the ½-inch inside diameter plastic tubing to the overflow barb fitting and trim to length.

Hint: Wet the tubing before feeding it through the rubber grommet.

Assembly *(continued)*

5. Rinse grow media as you did with the gravel. Fill the grow bed with rinsed media until it is about ½ to 1 inch above the overflow tube.

6. Fill your fish tank with water. Municipal water typically has chlorine in it, so either add de-chlorinator to the water or let it stand in a bucket for 24 hours so chlorine can dissipate. De-chlorinator products are sold at most pet stores.

7. Plug in the pump and ensure that the water is pumping into the grow bed and continuously trickles down through the grow media back into the fish tank. You will need to add additional water as the grow bed fills.

Note: It is normal for the water to become cloudy when starting up the system. It should clear up quickly.

8. Measure the water's pH. Plants generally prefer slightly acidic pH levels in the low sixes and upper fives. Fish and bacteria prefer the high sevens to low eights. In aquaponics systems, you want the pH between 7.0 and 7.5. Pet stores sell products to adjust pH levels.

Note: Avoid large swings in pH. See page 20 for more information.

9. Connect a 4- to 6-inch piece of air line to the air pump and install check valve. (The check valve prevents water from filling the air lines and damaging the air pump). Cut a piece of air line long enough to go from the check valve to the bottom of the fish tank. Attach one end to the check valve and connect an air stone to the other end. Place the air stone in the tank.

Hint: Use an electrical power strip to plug in the pumps and light. If using a rolling cart, the power strip can be screwed onto one of the legs.

Assembly *(continued)*

10. Add fish to the fish tank. A rule of thumb is 1 inch of fish length per gallon of water, but you should start out with ½ inch of fish per gallon until you are certain that ammonia and nitrite levels have stabilized—a process that can take several weeks. Then you can add more fish.

11. Place seeds on rock wool cubes or cotton balls. Saturate them with water and place in the grow bed so the bottom third is submerged. The seeds should germinate in a few days.

Note: Fluff cotton balls by pulling on the fibers before adding the seeds.

Possible experiment: Compare seed germination rates using rock wool or cotton balls.

12. Install the grow light about four inches above the grow bed. Plug the light into a 24-hour timer and set it for 16 hours of continuous light, then plug in the timer. As the plants grow, raise the light to keep it four inches above the plants.

Keeping your system healthy

Maintenance

Water levels in the fish tank will drop due to evaporation and transpiration. Top it off as needed, using water that has been de-chlorinated or that has been standing in a bucket for 24 hours.

If flow rates slow down or water levels fluctuate in the grow bed, check the tubing and the water pump's intake screen for clogs. If clogged, simply remove the piece, rinse it and replace it.

Measure ammonia, nitrites and nitrates weekly. If ammonia and/or nitrites spike after the system cycles, make sure the water pump is working, siphon the gravel to remove solids, and change out 50 percent of the water.

Siphon the gravel every two weeks to remove solid waste.

Use a scrub brush to clean the inside glass of the fish tank as needed. Be sure the scrub pad does not contain soap or cleaner.

Feeding

Use commercial fish food from the pet store. Feed your fish small amounts of food two or three times a day. Do not overfeed. Uneaten food can accumulate on the bottom of the tank and create problems in the water quality.

An automatic feeder will allow you to feed the fish when you're away, such as on weekends and holidays.

Balancing temperature and pH

The three living components of aquaponics systems — fish, plants and bacteria — have different optimal temperatures and pH levels. A compromise is needed so all living elements can flourish

		Optimal temperature		Optimal pH
Fish		60 – 80°F	(15 – 26°C)	7.0 – 8.0
Plants		60 – 80°F	(15 – 26°C)	5.8 – 7.0
Bacteria	*Nitrosomonas*	68 – 86°F	(20 – 30°C)	7.8 – 8.0
	Nitrobacter	82 – 100°F	(28 – 38°C)	7.3 – 7.5
Compromise		70 – 80°F	(21 – 26°C)	7.0 – 7.5

Fish disposal

You can bury dead fish in a garden or dispose of them in the garbage. Do not flush them down the toilet.

At the end of the school year, check with your local pet store to see if it will take your live, unwanted fish. Otherwise, euthanize the fish on ice or in a freezer, then dispose of them in the garbage or in your garden.

It is illegal to release fish into ponds, lakes, streams and rivers.

Learning from aquaponics

Once your system is up and running, consider these experiments as part of your lesson plan:

- Compare the growth of lettuce in aquaponics to lettuce grown in soil and straight hydroponics.
- Compare the growth of leafy crops such as lettuce to fruiting crops such as peppers or tomatoes.
- Examine how changes in fish density affect water chemistry and plant growth.
- Manipulate the distance between plants and light, and see how it affects plant growth.

Keep checking our website at *http://www.mcgrawconservation.org/aquaponics* for more teaching ideas.

About the Max McGraw Wildlife Foundation

The Max McGraw Wildlife Foundation of Dundee, Illinois, is named for Max McGraw, an avid outdoorsman, conservationist and business leader. In 1937, Mr. McGraw began to acquire property along the Fox River, 40 miles from Chicago. Ultimately, he accumulated thousands of acres that he developed into prime fish and wildlife habitat.

He established the Foundation in 1962, and before his death in 1964 he transferred his Fox River property, facilities and funds to the Foundation.

The Foundation lives on today as one of the premier research facilities for fish and wildlife management, as well as for conservation education. Its mission: "Secure the future of hunting, fishing and land management through programs of science, education, demonstration and communication."

Questions?

Contact us at *aquaponics@mcgrawwildlife.org*

The Max McGraw Wildlife Foundation thanks its members, and especially the Ken Wegner family, for their generous and ongoing support of its aquaponics program.

MAX McGRAW WILDLIFE FOUNDATION
P.O. Box 9, Dundee, Illinois 60118

847-741-8000 (main)
847-695-4610 (fisheries)

mcgrawconservation/aquaponics
aquaponics@mcgrawwildlife.org