Aquariums in the Classroom

(a work in progress)
By Ryan Lenz
2006/7 GK-12 Undergraduate Fellow
ryanjohnlenz@gmail.com

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Lesson Plan Ideas *These are only rough ideas--they are included as jump-off points for further development. The ideas below are also easily incorporated into other units. Some of these ideas are very brief and have not been fully developed. Please let me know if you try any and have suggestions! Email me at ryanjohnlenz@gmail.com*

Heat Exchange

Overview: The aquarium is meant to simulate the cold water of the Oregon coast. Because the room temperature of the school is about 70 degrees and the ocean water is about 53 degrees, we have to remove heat from the aquarium.

Show the students the chiller coils of the aquarium (most aquariums are on wheels and can gently be moved away from the wall). Point out that as water flows by the coils, they transfer heat to the liquid that is circulating inside the coil. This heat is carried under the tank, and dissipated by a fan. The heat enters the room.

Guiding questions: Why does the water need to be kept cool? [Living organisms are adapted to the temperature range of their natural environment.] Why does the aquarium constantly warm up? [Because heat from the room is transferring through the glass by conduction.] Does the refrigeration unit always stay on? [No, it only comes on when needed.] How does the refrigeration unit know when to turn off? [A thermostat disconnects electricity when the set temperature is reached.]

Selecting appropriate organisms for the aquarium

Overview: Students often make requests for inappropriate animals in the aquarium (shark, whale, turtle, jellyfish etc.). Discuss the limits of your particular aquarium: size, availability of the proper food (many animals feed solely on plankton), incompatibility with other organisms, incompatibility with water conditions (especially temperature), status of the organism in the wild (endangered). Point out that most of the organisms in the aquarium are from tidepools. Come up with similarities between the tide pool environment and the aquarium. These include: both are small, enclosed bodies of water; both have rapidly changing conditions (compared to the open ocean); both are heavily aerated; both must endure periods of stressful water conditions.

pH monitoring and adjusting (chemistry)

Overview: pH is an extremely important parameter in marine aquariums. It can be easily monitored with inexpensive, simple test kits, or with a real-time pH probe. It is also possible to adjust the pH with safe chemicals. Keep in mind that if adjustments are made, they need to be small and gradual, using products made specifically for marine aquariums. With a pH probe, daily fluctuations in pH can be observed. The pH begins to increase as soon as the lights turn on, because algae begin to use dissolved CO_2, which lowers pH. In the morning, the tank will be at its lowest pH. In the afternoon (just before lights out), the pH will be at its highest. Vernier Labware could be used to log the pH over a 24-hour period.

Graphing the pH over the long term would probably show a gradual decline, punctuated by brief increases after water changes. Generally the pH in closed aquariums tends to fall (become more acidic), due to acidic products of respiration and digestion.

Creating specific biomes (ecology)

Overview: Most aquariums are a very unusual and un-natural mixture of creatures from all sorts of microhabitats. Try to recreate a very specific part of the ocean; imagine the aquarium as a square meter of the ocean, and stick with animals only from that exact spot. Examples: Seagrass bed, tidepool (at a specific distance from the waters edge), sandy bottom lagoon, wave exposed rocks, etc. Depending on the conditions in your tank, some biomes are more appropriate to model than others.

Brine shrimp salinity experiment (inquiry, experimental design)

Overview: Students design an investigation into the ideal salinity for hatching brine shrimp. This is a good introduction to the ongoing activity "Brine Shrimp Duty". Brine shrimp hatcheries are inexpensive and simple to operate. Set up several hatching cones and fill each with a different concentration of saltwater. Let hatch, record results. Try to get students to explain their results using the concepts of biological niche and evolutionary adaptation (Brine shrimp have an advantage over their predators and competitors by tolerating extremely high salt concentration).

Similarities and differences between aquarium and oceans (environmental science)
Overview: In small groups, students brainstorm on the differences and similarities between the Earth's oceans and the aquarium. As a whole class, create a master list. Discuss what the consequences of these differences are (relate to appropriate selection of organisms for the aquarium)

Aquarium artists (art)
Overview: An introductory (or recreational) activity to aquarium-based lessons is to have students draw the aquarium. Small groups are most productive. Have students focus on very specific parts of the tank. This lesson can be repeated multiple times, focusing on the filter system, the cooling system, the stand, the actual aquarium (perspective drawing?), the aquascape, a particular organism, etc. Consider placing the drawings behind the aquarium on a bulletin board.

Diversity Survey (observational skills, classification)
Overview: Working in small groups, students attempt to find and draw/name every type of living organism they observe in the aquarium. As a whole class, compile a list of everyone's observations.

Photography (art)
Overview: Aquariums present a challenge to photography because of the obstructing glass viewing panels. Experiment with different modes, focusing depths, polarizers, etc. Also, fish and other moving objects are difficult to capture clearly--try lots of light and a quick shutter speed. Also, you could try to photograph through the surface of the water to avoid the glass issue. A clear plastic shield can help to eliminate surface shine. Print out the best photos and post them on a bulletin board near the tank.

Life as an aquarium fish (literature)
Overview: Students write a first person narrative as an organism in an aquarium. Include life in the wild, the collection process, transportation, acclimation, introduction to the aquarium, adjustment to aquarium life, and life in the aquarium.

Effect of aquariums on mood (literature)
Overview: Aquariums have profound effects on people. Doctors' offices commonly place aquariums in the waiting rooms because they are reported to reduce anxiety, blood pressure and improve moods. Public aquariums are very popular family destinations and tend are very effective free-choice learning environments. Most students have had some interaction with aquariums and these experiences are almost always positive.

Have students write about their experiences with aquariums, either as brief journal topics, as introduction to an aquarium-based lesson, or as a formal paper. Include experiences at public aquariums, home aquariums, school aquarium, etc.

Determining the volume of the aquarium (math)
Overview: Students will estimate, then measure the area and volume of the aquarium. Using this information plus the density of water, students can determine the mass of the aquarium. Concepts covered include: area, volume, 2-dimensional measurement (squaring), 3-dimensional measurement (cubing), displacement, conversion factors, comparison, multiplication, addition, and estimation. Important conversion factor: there are 231 cubic inches in a gallon. If you find the volume in cubic inches (L x W x H), divide by 231 and you have found gallons. Remember to factor in displacement by rocks, organisms, glass panes, filter material, etc.

How could we find out how much water the aquarium holds? [Fill it with containers of known volume (i.e. 2 liter pop bottles, 1 gallon milk jugs, etc.), measure each dimension and multiply them together, divide them by a conversion factor such as 231 cubic inches per gallon.]

Why is it important to know how much water is in the aquarium? [To know how much water to bring to fill it up, to know how much it weighs so that we can build a stand strong enough, to know how big of a heater/chiller we need, to know how many fish it can hold, to know how much medicine to add if the fish are sick, etc.]

Possible Extensions: Using the density of water, the mass of the aquarium can also be calculated. Water weighs approximately 8.5 lbs/gallon.

Impact of the aquarium industry (social studies, environmental science, research skills)
While cold-water marine aquariums are very rare, tropical (warm water) saltwater aquariums are a very large industry. Most of the fish and corals for these aquariums are taken straight from coral reefs. What are the effects of this industry on coral reefs? Are there any regulations on this industry? Most coral reefs surround very poor countries (Fiji, Philippines, Polynesia), and these countries rely heavily on money from this industry.
Ask students

Debate: Should wild-collection of coral reef animals be allowed? (social studies, environmental science, debate)
Overview: The aquarium industry relies almost entirely on collection of coral reef animals from the wild. Coral reefs are under increasing pressures from climate change, overfishing, pollution, invasive species, etc. Taking these animals off the reef obviously puts further pressures on populations. However, it is in the self-interest of collectors to harvest at sustainable levels. Does the aquarium industry foster a 'stewardship' type interaction, or an 'extraction' industry? If we banned collection, what effect would that have on the economies of the Philippines, Fiji, etc? How would they treat the reefs if they stopped earning an income from them? What about aquaculture of these animals?

There are several websites that can be quickly found doing an Internet search for "Impact of aquarium industry" or similar terms. Have students take a side and present their arguments in a debate fashion. Remember--there is no easy answer!

Ongoing Activities

Maintenance tasks: Most of the maintenance tasks can be handled by a responsible group of students. The teacher should not do routine maintenance! This is a wonderful way to create personal connections and responsibility for the aquarium. Create a calendar and allow students to sign up. Stress that students must RINSE their hands with water before touching the water! Do not use soap--it is more likely to cause more harm than good (soap residues are easy to miss). It might be useful to put together a maintenance kit: Algae scrubbers, towels, extra filter material, length of hose, salt, hydrometer, buckets, etc.

Water change duty: This is the kind of maintenance task that can easily be handled by a group of 2-4 responsible students. Create a water change schedule and allow students to sign up. There is no maximum limit to how frequent changes can be done--but change at least 25% per month. Don't change more than about 50% of the water at once--you can shock the animals. You can either provide the water (by collecting it from the OIMB open-tank room) or you can allow students to mix it from synthetic seawater themselves (see lesson plan "Making Artificial Saltwater"). Things to watch out for:

- Students need to know what to do with the old saltwater: consult custodians. Saltwater should not be dumped onto soil! Street/house drains are ok.
- Be aware the water is very heavy and a long hose is preferable to carrying buckets.
- Give plenty of towels/newspaper for cleaning up inevitable spills.
- Make sure that students measure the quantity of water they are removing--you don't want to be caught without enough water. Better to have some leftover.
- Make sure the temperature of the water is close to the tank temperature--a quick finger/thermometer check is adequate (try to be within 5-10 degrees)
- Before doing the water change, use hands to create gentle "storms" that stir up the muck from the bottom of the tank
- Be careful of the strength of siphons--they will easily pick up/suck up rocks, anemones, etc.

Algae scraping duty: Depending on the amount of light on the tank, this may need to be done once or twice a week. Increasing frequency indicates a buildup of nutrients in the tank--it might be time for a water change. Old credit cards work well, as do scrubbing pads. If your tank is acrylic, be very careful not to scratch the viewing panels (watch out for getting small rocks/sand under the scrubber). Again, make sure to rinse hands well with NO SOAP.

Feeding: Students can be in charge of feeding--this is always a popular duty. Be very careful with overfeeding, almost everyone tries to feed too much! Its difficult to say how much food is necessary, but a general guideline if feeding daily is to give an animal no more than the volume of both of its eyes in food. (Yes, this is very rough, and is hard to apply to animals without eyes...) For a 40-gallon tank, a ping-pong ball size wad of food is way too much. Shoot for something closer to a marble. If you are feeding twice a week rather than daily, the amount can be increased. In any case, if you notice cloudiness, excess algae growth, or lots of foam--you are feeding too much! Do a water change and reduce feeding.

Brine shrimp hatchery duty: Brine shrimp make excellent food for many of the critters in our tanks. They are very easy to hatch--look online for instructions. Brine shrimp eggs are inexpensive and tough. When the eggs have hatched (1-3 days), create a bright spot in the hatching container and disconnect the air supply. Within 20 minutes the shrimp will migrate to the light, where they can harvested via siphon or fine net. Do not overfeed the tank--brine shrimp are very rich food.

Filter changing and maintenance: All filters eventually need some kind of cleaning or replacement. Impellers (the spinning paddle-wheel inside the pump body) get slimed up; intake screens get clogged; filter material (looks like polyester batting) gets fouled up. Most of the aquariums in the GK-12 program use somewhat sophisticated filters--this is probably an activity that should be supervised by a teacher. But mechanically inclined students love to take things apart--let them do as much as possible!

Monitoring:

Graphing of water parameters: See lesson plans "Testing, Testing". Nitrate is the most interesting parameter to graph, as it will consistently increase over time. After a water change, you should see a dramatic decrease in concentration (indicate when the water change was done on the graph to infer a cause-effect relationship). pH is somewhat less impressive, but it might be worth graphing (it will likely slowly drop over time). Ammonia and nitrite should be zero after about a month, but from the initial start-up they will both spike and then taper off (Ammonia first, followed by nitrite). Water clarity is another possibility, and an interesting exercise in quantifying and standardizing measurements (perhaps a Secchi disk type tool could be used? Or a series of increasingly faint lines on a note card held behind the tank?)

Updated list of inhabitants: Keep a chart next to the tank with detailed information about the organisms in the tank. Include: Name (common and scientific), date added, type (i.e. arthropod, bony fish, mollusk, etc.), diet, adult size, etc. You could also include space for a drawing of the creature. Also, consider allowing students to vote on a name for the critter.

Record keeping: You can (and should!) keep a journal of the aquarium.
Livestock updates: Types of events to record: Molting, predation, growth over time, disappearance, spawning/egg-laying, appearance of mystery creatures, etc.
Maintenance tasks: Water changes, pH adjustments, temperature, etc.

Feeding shows: Students love to watch animals feed! Adding clams to a tank with starfish is always exciting (did you know clams could jump?). Also, large crabs are voracious eaters (but be careful not to add too much food!). Brine shrimp will bring out small fish. Chopped up seafood can be fed to anemones, which will close stick to and envelope their food quickly--a good reminder that these are animals, not plants! These kinds of events are easily turned into journal topics, research questions, inquiry projects, etc. etc.