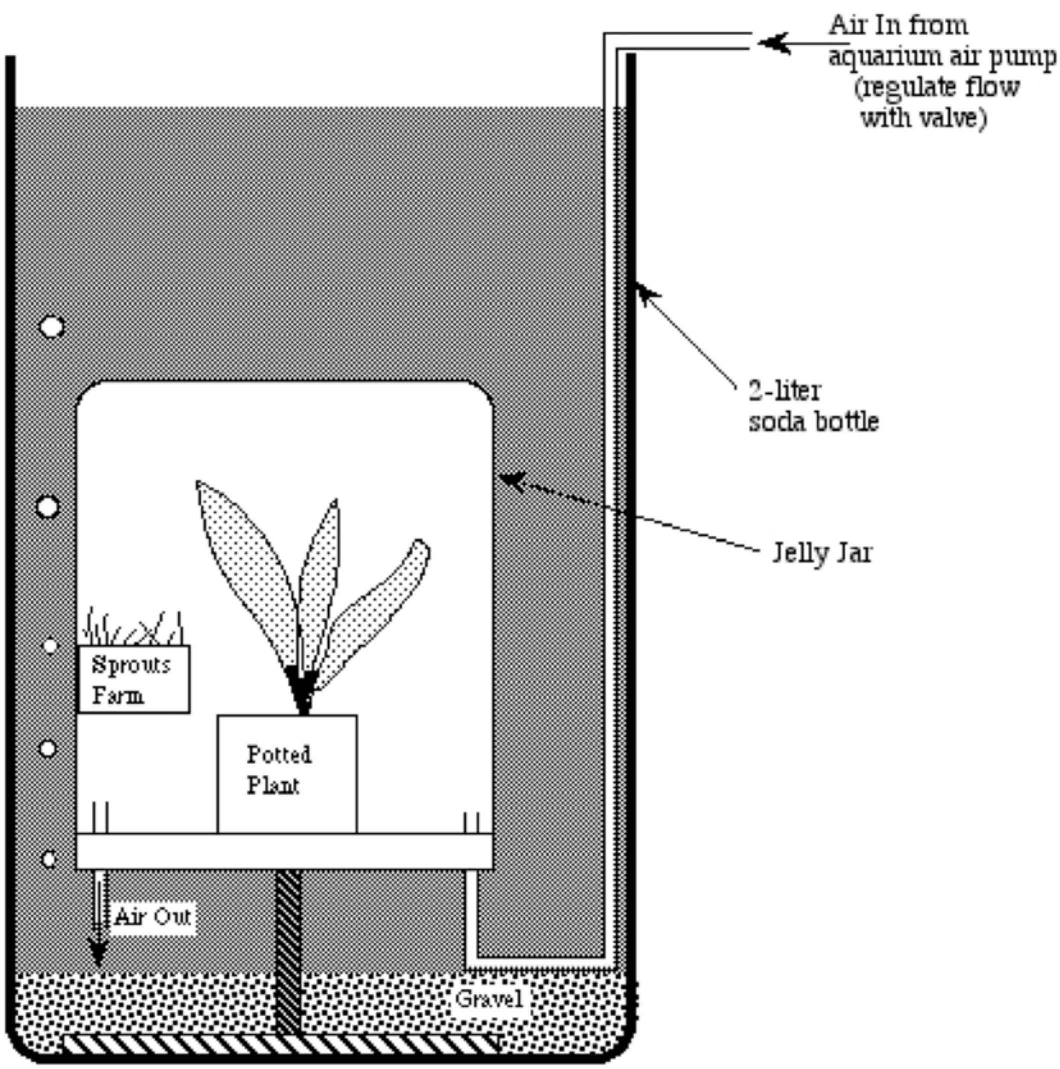
Atlantis: The Lost Island

A Focus Project in Science and Technology



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Build an underwater habitat for air-breathing plants.

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I. About Atlantis

"We step across this sandy beach, above us ocean waves inside out, delivering a soft nudge left-and-right as they pass over. Ahead, a bubble of our world here below."

Atlantis places terrestrial plant life in a submerged terrarium for a week's duration. The habitat provides conditions that allow the plant to survive and grow, perhaps even thrive. Similarities to the U.S. Navy's Sealab II Project, operated off the coast of La Jolla, CA, Jacques Cousteau's Conshelf habitat, and NASA's planned space colonies will be drawn.

II. Materials Required

1. Aquarium, 5 gallon, from aquarium shop or Craig's List ("Test Tank")
   alternate: 2-liter soda bottle (cut top off) becomes the aquarium
2. Jelly or jam jar, big enough to fit sprouts cup or small plant pot
   plus a second jar lid for a ballast tray, about 4-6 oz in size
3. Aquarium gravel, aquarium air pump, air line, flow control valve, check valve
4. 2 ea ¼-20 x 3" bolt, (must have full thread), zinc plated steel
5. 8 ea ¼" flat washer, zinc plated steel
6. 6 ea ¼-20 hex nut, zinc plated steel
7. Straws that big enough to pass aquarium air line hose
8. Tire weights, several, 1-4 oz each, about 20 oz. total (from tire store, or road find)
9. Sprout seeds, hard red winter wheat or alfalfa
10. Tools: measuring tape, battery powered drill motor, 17/64"D drill bit for 1/4:" bolts,
    5/16"drill bit for straws, hot melt glue gun, soldering iron, solder, center punch,
    small hammer, ruler
11. Buckets, siphon hose, paper towels

12. Optional: flashlight for night light, indoor-outdoor thermometer (cheap one), microphone (Radio Shack p/n 270-092) and speaker (Radio Shack p/n 277-1008)
13. Adult assistance with center punching, drilling, hot melt gluing, soldering
14. A little imagination, patience, attention to detail, and a desire to explore, learn something different, and see what you can do.

III. Build the Atlantis Habitat

Step 1. Gather all the Atlantis materials together in one place. (See “II. Materials Required” list above.) Pick a straw that is big enough to easily pass the aquarium airline through.

<u>Step 2</u>. Pick the jar you want to use for the habitat. It is a trade-off between big enough for the plant, and small enough for your aquarium. Remember the bigger the jar, the more water it displaces, so the more weight you'll need to sink it. The Ancient Greek scientist Archimedes was the first to write this observation down. Make sure the clear silicone seal ring inside the **base lid** is not cut or scraped off anywhere, the metal lid is not bent, and the lip of the glass jar is not chipped, cracked or uneven. The second lid we call a "**ballast tray lid**". It will hold the lead tire weights needed to make the Atlantis habitat sink to the bottom where we want it.

Step 3. Locate the washers for the ¼-20 bolts the same distance from the center, and 180º apart on opposite sides. Position the washers to be well inside the clear silicone seal bead that seals the lip of the glass jar. If either of the washers overlap the silicone seal bead, the jar will not seal properly, and water will leak in on the floor. Even worse, the jar may not be captured properly to the base lid, and could loosen, float off, flood and sink! So this is important. A wreck at sea can ruin your whole day. The bolts make the "legs" of the habitat. The legs have to be long enough to leave room for the air line to get in, the air exhaust straw to stick out clear of the sandy bottom, and provide room for the lead weights needed to sink the habitat.

Step 4. Using an indelible pen like a Sharpie, draw circles in the center of the washers where you want the legs of the habitat to go.

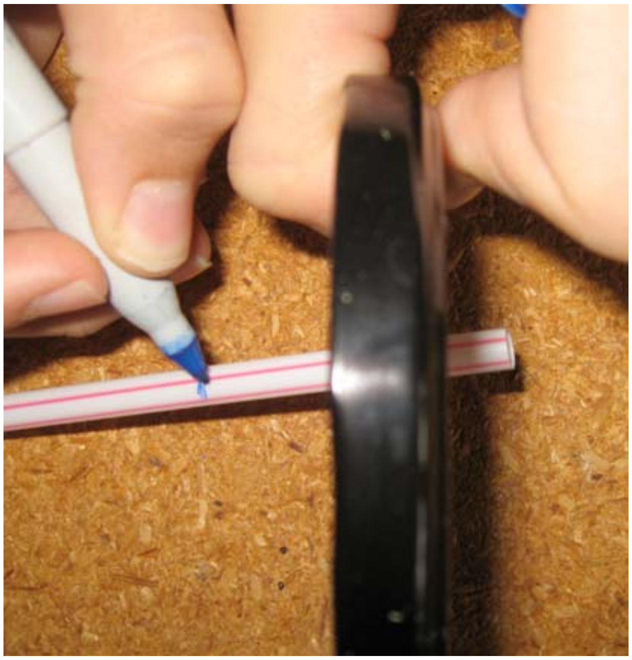
Step 5. Move the washers out of the way, and put a dot at the center of the circles.

Step 6. Using a center punch, make a dimple where you are going to drill the bolt holes.

Step 7. Get some grown-up guidance with this step. Using a drill press or electric hand drill and the 17/32” drill bit, drill the two holes for the ¼-20 bolts. Wear shop safety glasses in case metal chips fly off toward your eyes, and keep your hair back away from the spinning drill motor head! Hold the part firmly to keep it from turning, and press slowly and evenly down. Support the lid with a piece of scrap wood underneath. Drill through until wood chips start piling up.

Step 8: Using the **base lid** as a template, mark similar locations on the **ballast tray lid**. The holes in both of these lids have to line-up so the ¼-20 bolts can pass through both. Place the **base lid** on top of the **ballast tray lid**, mark (transfer) the hole locations with the pen, put a dot in the center, use the center punch, then drill as in Steps 4, 5, 6, and 7.

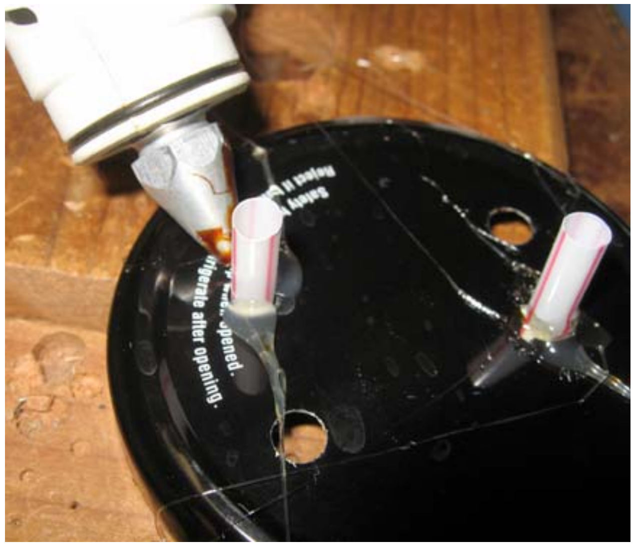
Step 9. Use the washers and indelible pen to locate the two holes in the **base lid** for the *air line in* and *air exhaust* out. Put one of the holes near one of the legs so you can later use a twisty-tie to hold the airline to the leg so it doesn't move. Pick a drill bit a tiny bit bigger in diameter than the straw diameter. This is a good time to add another hole if you are going to run some wires for a night light, microphone, or temperature sensor as described in "Section IV. Additional Teacher Material." Repeat steps 5, 6, and 7.



Step 10. Mark the straw length, 1-1/4" long, with about ½" outside, and ¾" inside.

Step 11. Cut two pieces of straw the same length for the air line in and air exhaust, and any others needed for wires as described in Step 8.

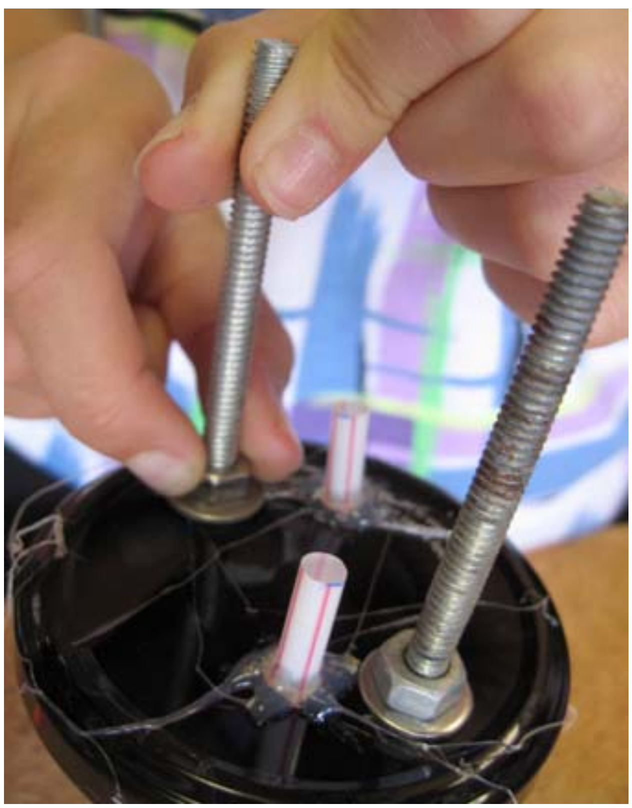
Step 12. Set the **base lid** on two pieces of ½"thick scrap wood spaced a little apart to position the straws for the right height. The lid is outside surface up.



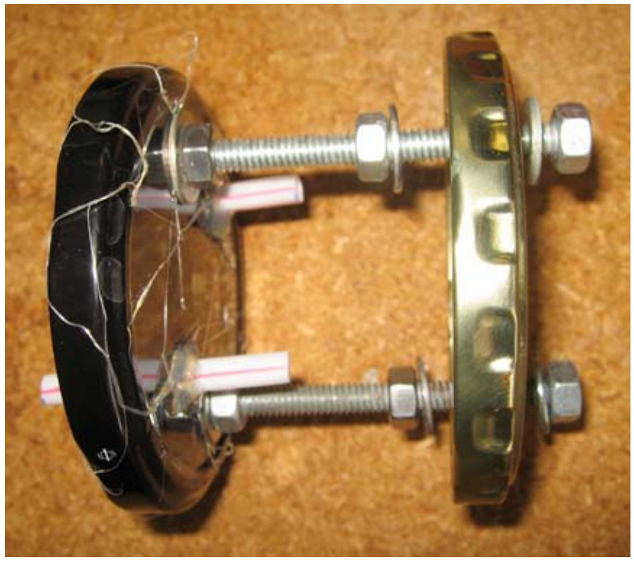
<u>Step 13</u>. Ask for some grown-up help if you haven't used a hot melt glue gun before. Tack the straws in position on the **base lid** with holt melt glue. Be careful not to melt the straws, or get any glue on your fingers. It's wicked in that it is very hot and won't shake off your hand. (If you get some on you, rub it briskly or have a bowl of cold water standing by to stick your hand in.)

<u>Step 14</u>. Once the hot melt glue solidifies, flip over the **base lid** and glue the interior of the straws. Be careful to keep the glue off the clear silicone seal bead.

Step 15. Place a flat washer on each bolt, and drop through the holes drilled into the base lid from the inside surface.



Step 16. Place another flat washer on each bolt, then run down a hex nut against the lid. With a screw driver on the screw head, tighten the hex nuts until tight using a 7/16" open end wrench.



Step 16. Spin on another hex nut an inch or so onto each leg. Place another flatwasher on each leg. Install the **ballast tray lid**. Flex the legs a little as needed to get them into the holes drilled in the **ballast tray lid**. Add another flat washer to each leg. Spin on a final hex nut until the bolt is even (flush) with the outside face of the hex nut. That is, the bolt should be all the way through the hex nut but not beyond. In the example shown, the **ballast tray lid** is assembled with the outside rim pointing toward **base lid**. If flipped over to point the other way, it makes a nice pedestal for the Atlantis to sit on out-of-water, as the last hex nut on each leg is recessed inside the **ballast tray lid**.

Step 17. Spin the inner hex nuts down to finger tight against the **ballast tray lid**, which in turn is pressed against the outer hex nut and flat washer.

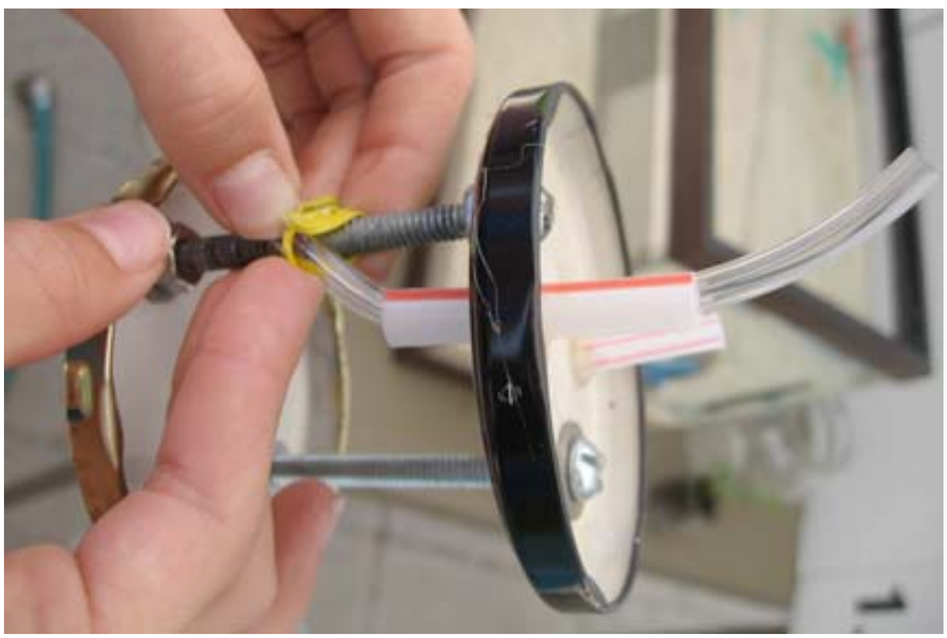
Step 18. Tighten the inner hex nut with a 7/16" open end wrench.

Step 19. Check the glass jar fit against the clear silicone seal bead. It should clamp down and hold tight.

Step 20. Check your Atlantis habitat to be sure the hex nuts are all tight, the legs solid, straws are secure, and glass is intact.

Step 21. Start filling the aquarium. Engineers call this a “test tank”.

Step 22. Get your plant ready to go below, and stack up the lead to weigh down the habitat.

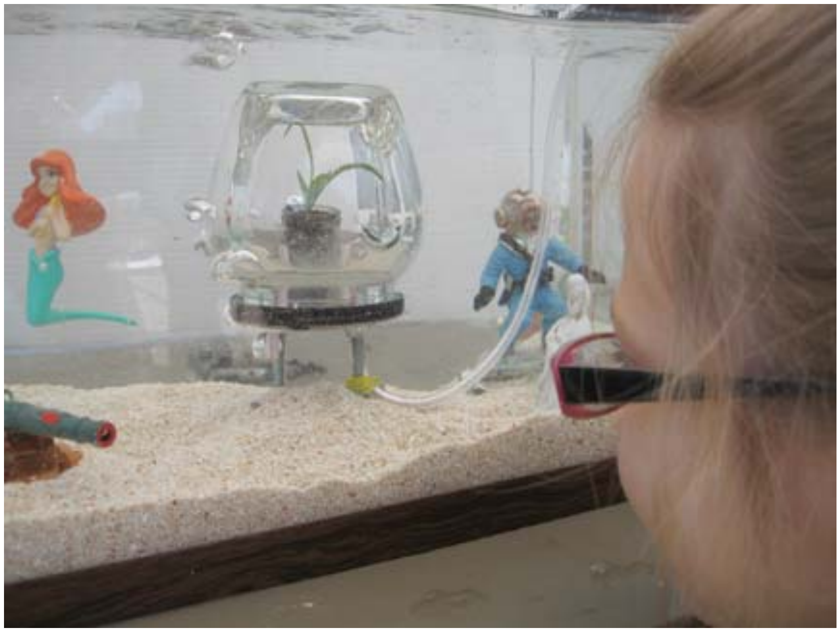


Step 23: Install the airline from the air pump. Use a twisty-seal to secure it to one of the legs of your Atlantis habitat. The air line brings a continuous flow of fresh air from above to your undersea habitat.

Step 24. Start the air pump. Place the plant inside on the **base lid**, make sure the clear silicone seal bead is clean, install the **glass jar** on the **base lid**, twist and tighten, stack **lead** on the **ballast tray lid**, and prepare to place in the aquarium. This is the big moment!

Step 25. Slowly lower Atlantis into the aquarium. Check to see that air is bubbling from the air exhaust tube, and no air is coming from between the **base lid** and **glass jar**, indicating a leak in

the area of the clear silicone seal bead. If there is, you may need to bring it up, clean the seal of dirt or debris, and try again.



<u>Step 26</u>. The **ballast tray lid** is buried in the sand. A **valve** in the air line regulates how much air we pump through the habitat. We don't want a wind storm inside! The plant looks happy. Everything looks good.

<u>Step 27</u>: Atlantis looks good from every angle. We're here below the waves, with a few custom touches to the scenery. Imagine we're sitting next to the plant, eating peanut butter and jelly sandwiches, watching fish swim by the coolest clubhouse ever.

Thanks to these young Aquanauts!

Thanks to Sarah Hardy (left) and her sister, Jennifer, for showing us how to build and operate an Atlantis underwater habitat.

IV. Additional Teacher Materials

A. Atlantis provides lessons and hands-on experience in

Mathematics, graphing data, calculation

Physics

Biology/Botany

Chemistry

Electricity

Mechanical Design Skills

Ocean Engineering

Shop skills

Writing and presentations

Architecture

Logical thinking

Creative Problem Solving

Teamwork

Planning

Self-confidence

History and Literature

Marine archaeology

Subject Terminology

B. Suggested class outlines

1. Introduction/Outline (1 class)
    - A. Objective. Project Outline. What does it mean?
2. Botany (2 classes, start and finish. Dual set-up, 1 in each class)
    - A. How much do we feed and water the plant for 5 days?
      How much space does that take?
    - B. How much food does the plant need for 5 days? What is "food"? Food from the sea.
    - C. What else does the plant need? (Light? Air? Humidity? Warmth?)
3. Design (1 class)
    - A. Statement of Problem.
    - B. Discuss Design (Drawing, math, computers, imagination, knowledge of tools, knowledge of materials, knowledge of science, progressive design <simple first>)
    - C. How does size affect design. (scaling size and weight, consumables, cost)
        - a. Why a sprouts instead of corn? a tree?
    - D. Materials. Properties, cost, availability.
    - E. Safety

a. inherent design safety

inverted glass jar with all seals at base

stability with “buoyancy high-weight low”

Discuss "Fail/Safe", "Go/No Go"

b. additional safety features (check valve, siphon break design)

Force failure: like pulling tube out of air pump and see what happens

c. back-ups (such as dual air pumps, battery powered air pump for black-outs)

F. Special problems underwater. Buoyancy, electricity, air, food, room to grow.

G. Special features: 1) Night Light; 2) water pipe; 3) other?

H. Remote Sensing (temperature sensor, humidity sensor, soil moisture, other?)

I. Testing to be sure design works, or doesn’t, to gain confidence in operation.

J. Operational planning:

How do we get the habitat and water into the aquarium at the start?

Place habitat in empty aquarium, then fill? Or lower habitat into aquarium?

How do we get the habitat and water out at the end? (lift habitat or drain tank?)

How would we do it for a habitat in the sea or lake where we can’t drain it?

4. Start: Atlantis (1 class) (Monday)

A. Measure and load supplies on board. Start air pump.

B. Place sprouts on-board.

C. Seal terrarium.

D. Submerge by filling 2-liter bottle aquarium.

Place guppies or goldfish into tank if desired.

E. Place identical sprout cup next to aquarium. (Experiment “control” plant.)

5. Class monitors progress daily, logging relevant data onto chart.

A. Possible measurements include humidity in terrarium, soil moisture, air flow, temperature in terrarium, temperature of aquarium water, temperature of room, pressure in habitat.

B. Schedule media visits to class?

6. End: Atlantis (1 class) (Friday)

A. Remove fish from aquarium. Drain aquarium with siphon.

B. Shut down life support systems (air, water). Open terrarium.

C. Remove sprouts from Atlantis.

D. Measure growth of sprouts grown inside Atlantis against control.

E. Celebrate success of completion!

7. Final Report Presentation (1 class)

A. Compare plant growth between the ones underwater and ones above water.

B. What did we learn?

C. Display for parents to see at the end of the school year.

D. Ceremony: Young Aquanauts Certificate

E. Speculate: What if we had put an animal in the terrarium? Introduce "habitat." What other special conditions would we have to be concerned about? (air, water, food, food scraps, animal waste, room to roam, overpopulation..)

C. Variations to the course of study

1. Have two classes build their own habitats independently. Tell each group of students “The other class is doing something differently with their <choice of plant, interior design, plant watering system, or … >. Both solutions are good. I won’t tell you they’re doing, but you are free to ask, and they are encouraged to tell you.” Atlantis becomes a subject of conversation on the playground, which models the intellectual exchange between researchers at different universities working on the same problems. This keeps the student-teacher ratio smaller, and provides more hands-on opportunities for the students.

2. Botany experiment: To see how well the plant does inside Atlantis, place a second identical plant next to aquarium. In experimental science, this is called the “control”. Use a fast growing plant, like sprouts. See if Atlantis plant is bigger or greener than the one outside. Look at what’s different and guess what affect the difference might make. In experimental science, that’s a “hypothesis.” Consider whether the slightly higher pressure provides more oxygen or nitrogen for growth, or, in the case of a 2-liter soda bottle made into a tank, maybe the circular shape of the tank focuses and increases light on the plant? Maybe the constant temperature has an affect?

3. Botany experiment: For a science fair experiment, one seventh-grade student in San Diego made four Atlantis habitats. Their hypothesis was based on the question: “Does the color of water affect the growth of the plant?” Their experiment had a “control” plant growing

outside on the counter. Inside the four underwater terrariums were the same plant as the "control". One tank had clear water, the others were colored green, blue, and red. Hmmm, I forgot how that turned out. Do you have any guesses?

4. Add a night light. Two wires solder directly to a flashlight bulb or flashlight bulb socket, and run to a battery pack outside on the counter top. It's a simple electrical circuit, that some students are excited to build and operate. The plastic insulation on the wires keeps the water from shorting out the circuit. Add a switch for easy on-off, or just pop the battery in and out of the battery holder.

3. Use an in-door-outdoor thermometer to take temperature measurements inside Atlantis. The remote thermal sensor goes inside Atlantis, and the remote read-out sets on the counter top, and measures the room temperature. Add an aquarium thermometer to measure water temperature. Collect the three temperature measurements every two hours during the day. Plot the data on a graph. Are there any patterns that emerge with the lines? Is there any connection to Atlantis's inside temperature and the water or room temperature?

4. Add a microphone inside with an external speaker so students can hear the sounds from inside Atlantis.

5. Add a small video camera inside connected to a TV monitor so students can see what it would be like to be inside and looking out from Atlantis. Small, inexpensive, low voltage b/w or color cameras are available on-line from SuperCircuits.com. This is much more fun if the aquarium is set-up with fish. Large goldfish are giant-like as they swim by.

6. Add a sign to the countertop where the air pump valves and readouts are that says "Atlantis Topside Control Room". For special effect, a **control panel** made of thin plywood, masonite, Plexiglas, or heavy corrogated cardboard painted silver adds a finishing touch.

7. Experience true metal casting with pewter "artifacts". The melting point is not extremely higher than room temperature. Caution against burns is still needed, but the peril is far less. There are no heavy metal poisonous fumes to contend with, but it is still good to have ample ventilation by being near a window or out on a patio. Low cost introductory sets are available on-line with simple molds. Make catalog mold small statues, or possibly custom coins. Make enough for every student to get one to keep. They'll keep them forever. Maybe add a latin collegiate expression like "As I try, all becomes possible".

8. Watch Walt Disney's "20,000 Leagues Under the Sea."

9. Watch the SeaLab Trilogy (offered through MTS?)

D. Supplemental lesson plans

1. Air takes up space

Step 1: An inverted jar, with the opening down, is slowly lowered into a clear tank of water.

Step 2: Inside the jar, the captured air displaces and holds out the water. Like an undersea lake, a water surface is seen inside the glass. A cork would float on this surface, and anything above it inside the glass jar would stay dry in the air pocket captured inside.

Step 3: A paper towel stuffed inside the jar is kept dry in the captured air pocket even though the bottom of the jar is open to the water.

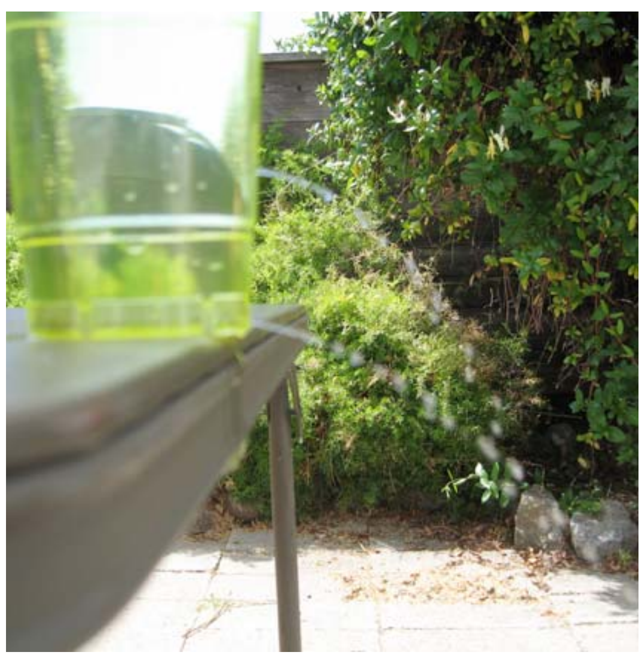
Step 4: The jar is removed from the water, and the paper towel is removed from jar. The paper towel is completely dry. Anything on the inside would likewise be kept dry. However, animals and plants use oxygen from the air to breathe and would suffocate with fresh air being brought in from above.

2. Refreshing the air inside

Step 1: Aquarium air pumps can generate enough pressure to push air to the bottom of a tank.

Step 2: We place the aquarium air line inside the jar. Extra air just bubbles out from underneath. If we know how much volume the jar has, and we capture and measure how much air is bubbling out, we can calculate the “volumetric exchange” of air flow in the habitat. Architects do this with buildings that have no windows, like skyscrapers.

3. Water pressure



Step 1: The deeper you go underwater, the higher the pressure because of more water piled on top of you. It happens even in a soda cup! Here, two holes are punched, one near the bottom, and one mid-way up. The cup is filled with water. The higher pressure at the bottom of the cup pushes the water further out than the hole above it.

4. Ballasting

Step 1: As we saw above, air takes up space. With water displaced by air, there is a buoyant force created. With enough displacement, the habitat will float! Here we show an Atlantis habitat about to be placed into a tank of water. Notice there is no lead on the ballast tray lid.

Step 2: No surprise, the Atlantis floats. The water displaced by the air in the jar weighs more than the glass, metal, air, and plastic tubing of the Atlantis, and the habitat floats. Not bad if you want a semi-submersible habitat, but we want to go to the bottom.

Step 3:   The Atlantis habitat is pulled out and lead is added to the ballast try lid.

Step 4: Atlantis is returned to the test tank.

Step 5: Atlantis rests comfortably on the seafloor.

5. Diver Dan

Step 1: If the jelly jar was big enough to fit over your head, and your air pump was strong enough, you'd have the start of a deep sea diver hard hat rig. Remember air takes up space and makes a diver buoyant, so divers wear lead weights on their belts to hold them down. SCUBA replaced the helmet with a regulator, and air tanks on a diver's back replaced the hose, providing a diver greater freedom of movement in the sea.

Step 2: Diver Dan uses the same science to work below as the Atlantis habitat.

E. Web references

1. Google for the U.S. Navy's "SeaLab", Jacques-Yves Cousteau's "Conshelf", "Project Tektite," and "Underwater habitat".

A model of the U.S. Navy's SeaLab III with three divers outside their undersea home. The model substitutes a clear shell for steel to show the interior arrangement. This model is now on display at the Naval Undersea Museum in Keyport, WA.

(Model built by Jerome J. McAuliffe, seafloor painted by Loralee McAuliffe.)

Jacques-Yves Couteau's Conshelf II in the Red Sea, 1964.

A diver passes outside a window of his undersea home, Conshelf II, 1964.

Conshelf II, submarine garage, still there, 2010.

2. For outer space analogs, Google “International Space Station,” “SkyLab,” “Manned Orbiting Laboratory,” “lunar colonies,” Martian colonies,” “space colonies”, and “space habitats”. The Apollo Lunar Module (LEM) was a manned habitat for up to three days during the days of the U.S. lunar landings. How’d the astronauts eat, drink, sleep, work, go to the bathroom, shower, do laundry, or handle trash during their time on the moon?

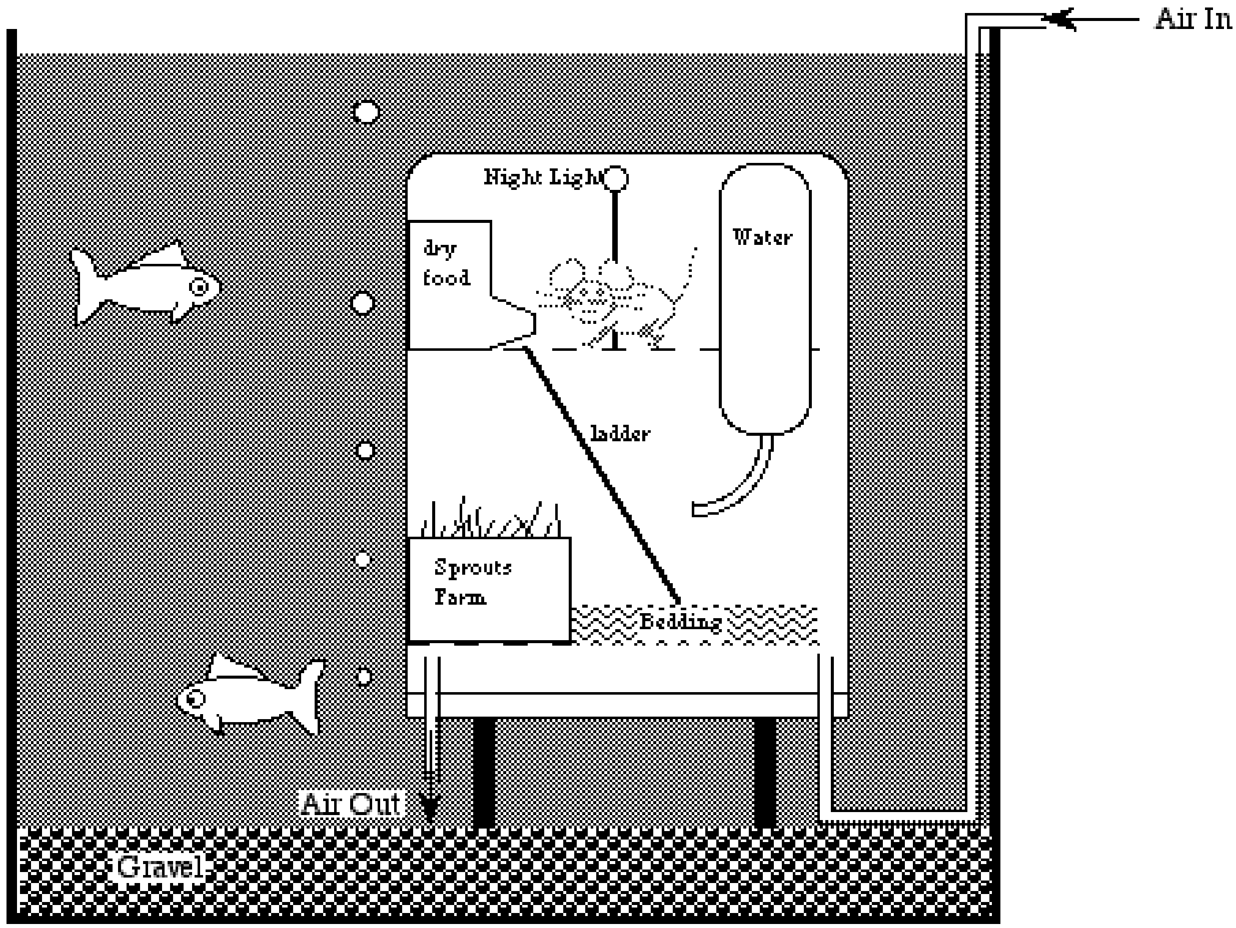
F. Text references

Look for these references at “Bookfinder.com”

1. “World Without Sun”, Jacques-Yves Cousteau
2. “Who Says You Can’t Teach Science?”

Other books: “Magilligott’s Pool”, Dr. Seuss; “Living and Working in the Sea;” “Blind Man’s Bluff”

V. Future Project: MouseHouse



The MouseHouse Underwater Habitat is a more serious development. The school year-long program develops the capability and confidence of students to design and manage this project. Mice are burrowing animals, and do quite nicely in the close confines of an undersea habitat. However, they do have shortcomings, such as they don't know how to take the trash out. We respect that they are living mammals, and we must do everything to ensure their survival for the planned five day deployment. Additional safety features are employed, such as a back-up air pump, and a third battery powered air pump that comes on in the event of a blackout, plus check valves and other safety features.

This project has been run with complete success by four groups of fifth graders. Students, teachers and parents sailed far past the original horizon of the project to uncharted lands of understanding and personal growth.

Detailed lesson plans and construction guidelines are in development, and will appear on this website.

VI. Acknowledgements

Michelle:

Marilyn:

Kevin: To two special high school teachers, Dale Falter, Physics, and Mary Strieb, Journalism, who showed me how things worked. To Mary Lou Cannon, one of the women behind the Men-in-the-Sea. In memory of Captain Jacque-Yves Cousteau, on the occasion of the Centennial of his birth.

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