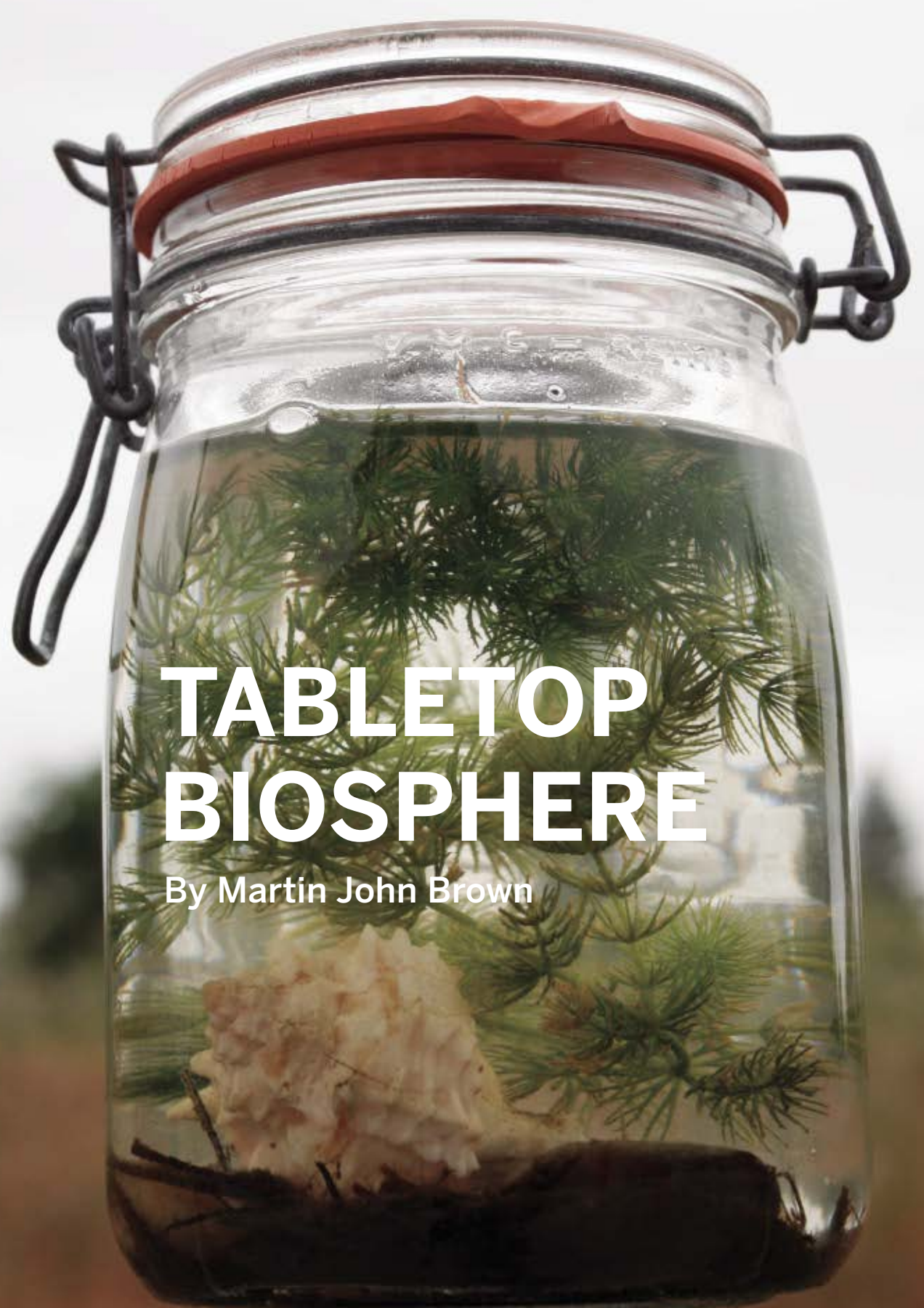

TABLETOP BIOSPHERE

By Martin John Brown

ECOSYSTEMS ENGINEERING

The Tabletop Shrimp Support Module (TSSM) is a fun demonstration of the ecological cycles that keep us alive — and an enticement to muse on everything from godhood to space colonization.

When my 7th grade vocational aptitude test came back stamped "Forester" instead of "Astronaut," I knew the test-makers had screwed up. Sure, I liked sitting in streams, and peering down those creepy holes by the roots of old trees. But I also knew that someday the whole frickin' park would be flying through space. Hadn't anyone else seen *Battlestar Galactica*?

Now we know that space colonists are just as likely to be muddy ecologists as hotshot flyboys — the kind of people who assemble ecosystems instead of engines. Today's pack-it-in, pack-it-out life support is impractical for long, manned missions, but in the future, regenerative systems could provide years' worth of food, air, and water while processing human waste. It's recycling and reuse on a radical scale, light years beyond anything pitched by those hairy guys down at the co-op.

Here's a mini version of this dream, a sealed system that supplies a freshwater shrimp "econaut" with food, oxygen, and waste processing for a desktop journey of 3 months or more.

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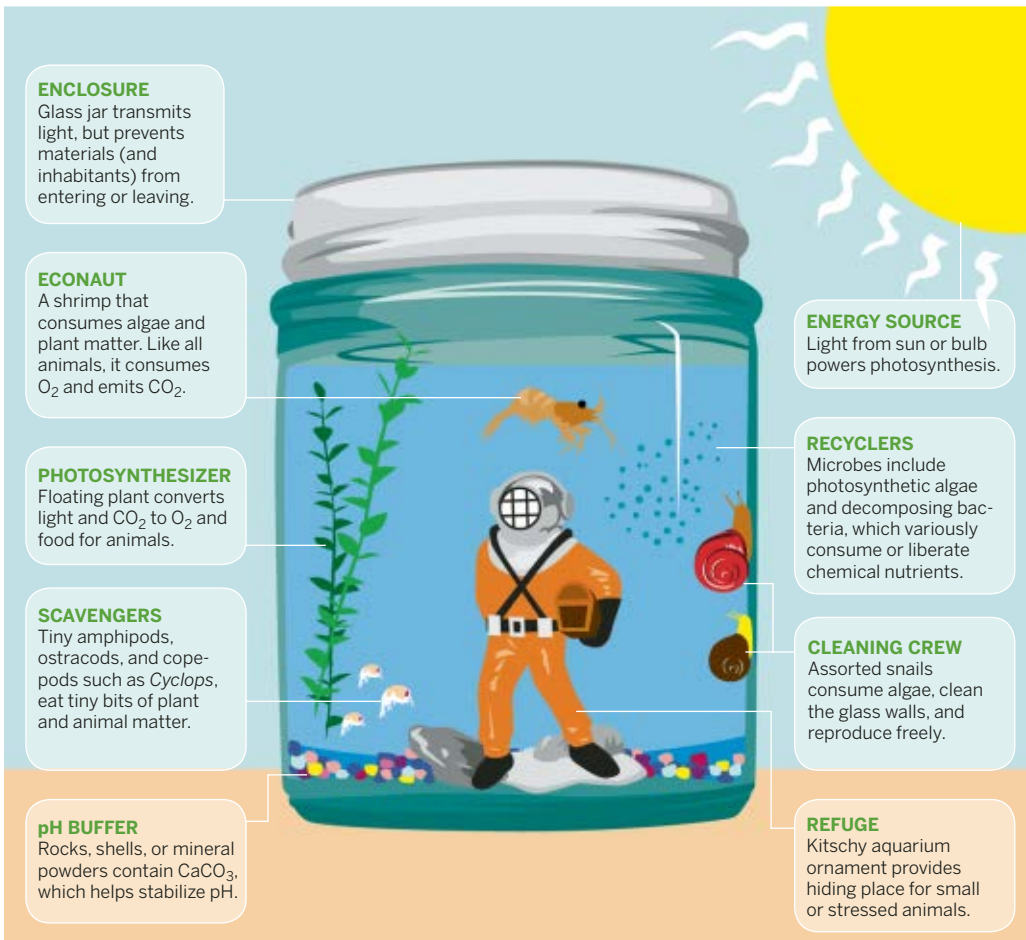
Martin John Brown (**martinjohnbrown.net**) is writing a book about isolation, biological and otherwise. He really likes the blog **bottleworld.net**.

Photography by Sam Murphy

TABLETOP SHRIMP SUPPORT MODULE: HOW IT WORKS



On Spaceship Earth, little goes in or out except light and heat, and all organisms live off each other's waste, whether it's oxygen from plants or feces from animals. Our world is bottled up.

Ecologists have often scaled down these processes, creating sealed aquariums for research. Meanwhile, space scientists have searched for organism and machine combinations that could cooperate to support humans in a space colony.

The TSSM's basic principles come from ecologist H.T. Odum, but many details derive from the Autonomous Biological System (ABS), a sealed aquarium invented by Jane Poynter, which has returned healthy from extended trips on the space shuttle and the Mir and ISS space stations.

The Cast of Waterworld

In our TSSM, the "econaut" we imagine ourselves in the place of is a shrimp. We encourage photosynthesis and waste processing with abundant light and vascular plants, and we limit oxygen demand by constraining animal biomass and algae-fertilizing nitrate and phosphate. Protection against chemical spikes comes from pH buffers.

Illustration by Dustin Hostetler/UPSO

SET UP.

MATERIALS

[A] 1-quart glass canning jar Don't use plastic; it may bleed air.

[B] Clear bottles or plastic containers for sampling and a "holding tank"

[C] Tap water

[D] Small river rocks just enough to cover the jar bottom. Rocks piled too thick let muck and algae build up where snails and shrimp cannot eat them.

FROM AN AQUARIUM STORE

[E] Tap-water dechlorinator

[F] Aquarium ornament(s) or other glass or ceramic obstacle(s) Seashells also are nice, and supply extra calcium carbonate.

[G] Fine fishnet or kitchen strainer

[H] Freshwater minerals such as "Kent Freshwater" or "cichlid salts" These are essential trace nutrients.

[I] Amano shrimp (1) (*Caridina multidentata*) an algae-eater with a reputation for tolerating high pH

[J] Snails (4) of assorted species smaller than 1cm each.

[K] 8 stem inches of hornwort (*Ceratophyllum demersum*)

[L] 2"×2" piece of duckweed (*Lemna*). You can also collect this from a local pond.

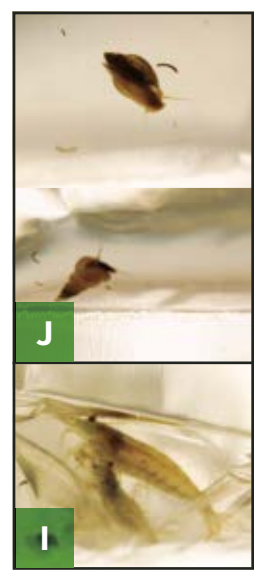
[NOT SHOWN]
1Tbsp powdered calcium carbonate This is your primary pH buffer.

FROM A LOCAL POND

Assorted amphipods (2–8) These are tiny crustaceans; try to collect 8, but you can use fewer.

1 or 2Tbsp pond sludge hopefully containing copepods and ostracods (even tinier crustaceans), bacteria, microalgae, etc.

NOTE: Aquarium fish, shrimps, and snails may be invasive and destructive if released into the environment, so boil or freeze them after the experiment. Or keep them living in an aquarium environment.



Materials and shrimp photography by Sam Murphy; snail photography by Martin John Brown; hornwort photo by Christian Fischer

MAKE IT.

CREATE YOUR BIOSPHERE

START **Time: A Day** **Complexity: Easy**

1. GATHER THE AQUARIUM SUPPLIES

1a. Visit an aquarium store for the materials listed on the previous page. While you're there, ask them how to dechlorinate local tap water for aquarium use.

NOTE: The store staff might not believe that your Tabletop Shrimp Support Module will work. Make nice anyway.

1b. At home, dump your shrimp, snails, hornwort, duckweed, and the water they came in into an open "holding tank." I use a plastic Tupperware or yogurt container. Add some dechlorinated tap water to keep everything comfortable (alive).

2. COLLECT THE POND LIFE

Go to a local pond. Spring and summer are best. Bring a net or bottle (or other container), and visit during late afternoon. That's when the pH is higher, like that of your TSSM.

2a. Find a good, shallow area of the pond to collect your goodies. If you see duckweed, water lilies, or other vascular plants, try near there. I've done well in areas with a mixture of substrates, like sand, rock, and decaying wood.

Aquarium store and pond photos by Martin John Brown

2b. Drag your bottle or net through mud, rocks, and half-submerged plants. Examine your take for shrimp-like creatures 1mm–10mm long. These are probably amphipods; collect up to 8 of these if you can. You need to look aggressively, getting into the muck and shaking bits of plant away. Then collect 1 or 2Tbsp of pond sludge from the pond bottom, which should contain some nearly microscopic copepods and ostracods. Back home, dump your pond samples and sludge into the holding tank.

3. BOTTLE IT UP

3a. In a new container, whip up a gallon of NPFW (nitrate-poor fresh water). This is tap water, dechlorinated and supplemented with your freshwater mineral mix (follow package directions).

3b. Thoroughly rinse your "fixtures" — quart canning jar, ornaments, rocks, etc. — with NPFW.

NOTE: Waters from the aquarium store and pond are probably loaded with algae and algae-supporting nitrates, which will lead to algae takeover. Diluting with NPFW helps prevent this.

Photography by Sam Murphy

3c. Fill your jar halfway with NPFW, and transfer all the ingredients to the jar, except for calcium carbonate powder, if used: shrimp, snails, hornwort, duckweed, amphipods, sludge, ornaments, rocks, seashells. Use the quantities listed. Do not put in extra animals or sludge, or otherwise mimic a traditional aquarium. What makes this system work is its sparseness.

3d. Fill the remaining volume of the canning jar with NPFW, leaving 1" or 2" of airspace at the top. If you have calcium carbonate, add it last, and note that it will cloud the water for hours.

3e. Say a little prayer as you tighten the cap on the jar.

3f. Your biosphere is complete! Place it in a spot with a fairly consistent temperature (70–80°F) and 12–16 daily hours of moderate light. Standard room lighting is too dim, and direct sun is too much. A bright north window or a 50W bulb a few feet away are both good, but watch the temperature.

FINISH X

NOW GO USE IT »