**Symbiogenesis**

**Design Narrative**

Rays of sunshine race across the vacuum of space, graze just over the hilltops, and knock a few electrons off of a small solar panel on top of a shipping container in the desert of Northern Nevada.

As that trickle of electrons find its way to Earth through a labyrinth of silica and copper, the container begins to pulse imperceptibly, radiating information, waiting. The crew, having arrived later than they would have liked the night before, rise from their tents and RVs, eat a cold breakfast, and get to work unpacking the containers.

None of them have ever done this before, though more than few of them are quite familiar with the art of desert camping. “DON’T PANIC”, the wifi network radiating from the containers and the only one for miles, contains all the information they will need. Some connect to the network with their phones, while a few flip through the paper manuals packed inside each of the 5 containers.

Rolled shade cloths are unfurled and stretched between the ring of containers and hoisted tightly above their heads, just in time to provide some relief from the midday sun. Bucket-brigade style, the crew unpacks an array of solar panels onto the roof of the south-most container and connect them together into a 3 kilowatt array, turning the morning’s trickle of sunshine into a steady downpour.

By evening, the crew has unpacked the containers and assembled most of the contents into their corresponding structures and infrastructures, establishing 5 key spaces - a kitchen, a bathroom, a workshop, a recycling center, and a powerplant, the life-support systems of the camp that will be their home for the foreseeable future.

As the sun sets behind the mountains, the crew spends the few watt-hours they gleaned from the afternoon sun to power LED string lights that illuminate the camp, and cook themselves a hearty dinner in the electric pressure cookers in their newly-assembled kitchen.

The next day, the crew wakes to a considerably more comfortable situation than the day before. Between the power left in the batteries and the morning sun coursing through their solar panels, there is more than enough power to boil water for coffee and tea, and after a solar-powered breakfast, the crew begins to assemble the rest of the machinery in the containers, preparing each workspace for operation.

The tools and technologies that make up the camp have been selected for their affordability, compatibility, and accessibility, and above all else their ability to be easily replicated with widely available tools, parts, and materials. Many of them are based upon open-source designs pioneered by groups around the world, while others are simply widely available off-the-shelf parts. All of them are useful, though none are as useful as all of them are together. As energy begins to flow through them, the camp begins to come to life.

In the power plant, a team assembles a biomass reactor, connecting it to a series of water-cooled heat exchangers. They work their way down a checklist of assembly instructions and safety checks, making sure the seals are tight, and connecting the water lines that run to and from the bathhouse to heat the showers.

They collect the various organic wastes that have begun to accumulate around the camp- offcuts of wood, cardboard from packaging, dried husks of food scraps, and load them into the reactor.

Once full, they seal the reactor and fire up its two 750 watt heating elements, giving their power inverter its first real load test. Inside the reactor, the elements glow red-hot, causing the wood and cardboard around them to begin to break apart. Unable to fully burn, the hot smoke is pushed through the maze of heat exchangers, condensing out the heavier compounds and refining the gas into a clean-burning mixture of short-chain hydrocarbons, clean enough to be used as a fuel.

After about 30 minutes, the crew opens a valve, delivering this gas to an inverter generator with a 3D printed adapter that the crew has added to its air intake, allowing it to accept gaseous fuel instead of gasoline. After some fine tuning, the generator roars to life, converting the biomass-gas into electricity, carbon dioxide, water vapor and heat.

Power from the generator flows through the system, charging up the batteries and increasing the capacity of the AC micro-grid that now encircles the camp. With the biomass reactor up and running, the crew achieves it’s first goal: an organotrophic metabolism, the ability to break down organic wastes as a source of energy and carbon.

In the recycling center, another team assembles an open-source shredder box, and connect it to a powerful electric motor and gearbox. With the proper safety mechanisms in place, they plug the shredder in for the first time, and begin shredding the plastic wastes that have accumulated since the previous morning, turning them into small flakes, sorted by type and color, and collecting them in bins.

As the bins fill up with shredded plastics, crew members deliver them to the workshop, where another team has been busy assembling and calibrating a series of rapid-fabrication machines. The recycled plastic flakes are fed into the hopper of a large-format flake-extruding 3D printer, and they begin 3D printing new parts for the camp, from the library of stl files stored on the local server.

They begin with simpler objects, such as cups and plates for the new kitchen, getting a feel for their new tools, before attempting the more complex objects, like the wind turbines and geodesic dome hubs. Lower grade plastics are fed into a plastic beam extruder, forming them into strong, lightweight beams to be used for building additional structures.

As each system comes online, the crew installs sensors that gather critical data and feed it back to the central computer system, providing the crew with a real-time view of the performance of the camp as a whole. A timer counts how long the metabolic system has been alive: 5 hours, 3 minutes, not very long, but a new record anyway.

At dinner that evening, the crew sits in the shelter of their new home, and laugh about how bad their first 3D prints are. Two of them slip off to one of the recirculating showers, enjoying their first hot shower in days, to make sure its filtration systems are working properly. A few get up to wash dishes in the kitchen, as the ones who cooked sit down to relax, play music, and look up at the stars. With most of their critical life support infrastructure in place, their research can begin.

**Prototyping**

*Symbiogenesis* is a proposal to establish an off-grid research center at Fly Ranch, for the ongoing research and development of open-source living infrastructure.

While this narrative is fictional, the machines and technologies it describes are all real, designed to be low cost and easy to build. The cost to replicate the basic systems described in the narrative falls in the range of $10,000 to $20,000, excluding the cost of the shipping containers.

If selected for prototyping at Fly Ranch, the honoraria grant funds will be used to establish a “minimum viable” base camp similar to the one in this narrative, roughly 40 meters across, providing a platform for inventors, designers, scientists and artists to experience living as part of a complex system, providing them with immediate feedback to help them improve upon each system.

**Environmental Impact Statement**

*Symbiogenesis* is intended to be an ongoing process that participates with its surrounding environment in the same way that a living organism does. It’s environmental impact is best assessed in terms of its metabolism, which evolves over the course of its lifecycle.

When the camp is first established, its metabolism is organotrophic- it relies on an external input of biomass, including the food that supports its human symbiont crew, and waste generated within the camp, as it’s primary source of energy and carbon. During this phase, the camp “breathes” oxygen and “exhales” carbon dioxide, just like a human or a mushroom does.

The carbon dioxide it exhales, coming from non-fossil biomass, does not contribute the net amount of carbon dioxide in the atmosphere, and any biochar that the crew manages to produce and sink into water filter cells or nutrient rich soil, represents carbon dioxide that has been removed from the atmospheric carbon cycle.

During this phase the camp consumes plastic waste from the surrounding environment, and from wastes generated within the camp, and synthesizes it into new useful objects, - bio-accumulating these plastics from the local ecology by incorporating them into its own structure.

While it is possible to produce hazardous organic compounds in the process of plastic recycling and biochar making, the production of these compounds can be mitigated using proper heat control and ventilation. Charcoal is an extremely effective filter medium for removing these organic compounds from air and water, and is widely used industrially for this exact purpose.

Eliminating plastic wastes from the environment, while ensuring that no additional hazardous compounds are released in the process, is a primary goal of the project, with sensors in place from day one to monitor VOC and CO levels in real time, and with the machinery that might produce these compounds housed within containers so that emissions can be monitored and ventilated.

As invasive species, plastics, and other MOOP are systematically cleared from the area and incorporated into the structure of the camp, native plants, such as fast growing Cottonwood trees, and food crops can be planted in their place, generating a more temperate local micro-climate, and providing the camp with a steady income of locally generated biomass to reduce its reliance on outside resources.

As the camp begins to power itself using biomass produced within its immediate local environment, it becomes increasingly phototrophic, able to nourish itself primarily from sunlight, and beginning to release oxygen into the atmosphere, to balance the oxygen it consumes.

If, one day a crew ever succeeds in the fantastically difficult but entirely feasible challenge of growing all of their food, using only locally-incident sunlight for energy, then they will have achieved autotrophy, the third and final trophic level of the camps lifecycle - capable of nourishing themselves, and others, on an ongoing basis, using only sunshine, air, and rain.