Where the Tiny Things Are: Feathered Essays
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Biofuels Will Take You Home

I am traveling, by car, using regular old-fashioned gasoline, 140 miles from high-desert Flagstaff, Arizona, to low-desert Phoenix to visit Arizona State University’s Biodesign Institute to learn how microorganisms can make fuel from the sun. Although the distance is not far, the territory you pass through is like traveling to nine different planets. Each zone hosts different dirt, flowers, animals, but all of them are sunny. In Arizona, the sun follows you everywhere. My friend calls Phoenix the Valley of the Shadow of Death for its pavement plan, its lack of water, its traffic, its sprawl, and for its heat. It is easy to be devout to this religion—hating Phoenix.

It is March on the roof the Environmental Engineering building and it’s already hot. Regular July-in-the-rest-of-the-world type heat. There is still snow in Flagstaff, I keep reminding myself. The sun is everywhere, winking sinister “hello” up from the sidewalk, down from the sky, left from the parking structure, right from the glass building next door. I understand immediately why the work I’ve come to see happen, happens in Phoenix. Standing on a roof on the ASU campus at the end of winter and realizing I should have worn deodorant. I laugh that I brought my jacket at all, especially up here. But I can’t take it off now because of the sweat stains. I am trapped under that flat blue sky of Arizona with my brown jacket which may as well be black as it absorbs the heat. I wonder what microorganisms are hatching in my armpits.
Hot, the roof is a natural place to think about two things—solar power and greenhouse gases, if not necessarily microorganisms. In Margaret Atwood’s *Oryx and Crake*, people turn their air conditioners on in March, just like they do here in Phoenix. In her book, a whole planet turns Arizonan. From this roof, I can see pockets of palm trees transplanted from more formal deserts. Easy converts. Sand to sand. Dry to dry. From here, I can see mountains strangely shaped like meringue—their peaks are swept, but pointy and uneven, as if neither wind nor rain nor continental shift made them. They look like made-up and lopsided falling soufflés. It is a bad habit of mine, to want everything to be like food, as palatable as beer. Some people want mountains to be full of mineable ore. I want mine to be abundant, productive, edible. The mountains in Oregon are full of edible mushrooms. The rivers fatten with spawning salmon. You can even eat the ferns. The best I can think to do with a Phoenix mountain is to turn it into a metaphor of useful edibility.

Portland, Oregon starts with a P, as does Phoenix, but that’s about all they have in common. They don’t even have the “P” sound in common, just the letter. Portland is 2,000 miles away. Portland is green, mushrooms, water, salmon, coffee, and beer. Phoenix is brown, sand, Saguaro, golf, and sun. If left with Portland’s list of plentiful offerings, you could survive forever. With the Phoenix list, you would most likely die.
There are naturally sustainable towns like Portland and unsustainable towns, and Phoenix might be the least sustainable of all. The best thing to do to Phoenix is to leave it, which I mostly try to do.

Recently, my husband Erik and I visited my old boyfriend Van in Portland. Van started his own beer brewing company. It rained the whole time we were there, that persistent we-live-inside-a-cloud rain that dampens your hair and leaves your socks wet. The kind that allows for beer and salmon and mushrooms and green. At his bar, a renovated gas station, we drank a glass of “Axes of Evil.” Not as hoppy as the “Surly Overrated” or the boringly named “IPA.” I pointed out the nice floors. Polished concrete. The cabinets. Remnants from the Portlandia building remodel. The counter tops. An old middle school gym floor. Portland never increases, never decreases. It maintains.

We talked about the difference between making things in Portland and making things in Phoenix. “Oh. We know a lot about water,” I told Van. Van lives in Portland. I don’t anymore. I’d rather live in Portland so I keep up on water news like I still live there. I pretend no knowledge about Phoenix sun.

“Phoenix has a TDS of 650. Portland’s TDS is near zero. It’s the softest water around. Soft as a baby’s cheek.” Van made his big smile which takes his face from thin and triangular to square and fully British.

I nodded. But I have no idea what TDS is. Apparently, I know nothing about water.
“TDS. Total dissolved solids.” I thought about my bathroom shower. Lime. Calcium deposits. Who knows what else? I have used a chisel to a faucet in Flagstaff. But in Portland, mold grew on shower curtain doors. You couldn’t get that off even with a chisel. Mold penetrates. You had to buy a new shower curtain—small things build up in all towns.

“Portland is the place to brew beer. You don’t have to compensate for bad water.” Erik, who listens to beer people better than I do, asked if Van filters his water like some breweries in Salt Lake City, where Erik and I lived before Flagstaff and where the total dissolved solids in the water are nearly as high as in Phoenix.

“We don’t have to filter. The water is our baseline. Truly, for good beer, place only matters because that’s where you get your water. Portland doesn’t necessarily have the best brewers or the best equipment. Everywhere else you can get your hops flown to you. Your malt. But water. That’s what makes your beer yours.”

The water in Portland flows naturally from Mount Hood, Portland’s very own mountain which makes Portland’s very own beer. Water is to Portland as sun is to Phoenix—in most ways, too much. In Portland, treated water is released into the Willamette River, makes its way to the ocean where it’s quickly fermented into clouds, which snow and rain down on Mt. Hood all over again. Portland recycles itself. You don’t need to go anywhere.
In Phoenix, nearly everything comes from someplace else. The water is on loan from the Colorado which flows not anywhere nearby. Entire canals were built to force the water southward.

But one thing Phoenix does have in abundance is sun. A lot of sun without a lot of water is, in nature, not very useful. You can’t grow avocados, oranges, or pecans without a lot of water. But when you’re up on a rooftop in March in Phoenix and already ready for some air conditioning, the heat of the sun makes you think “abundance” in the same way nine months of every-day-rain in Portland makes you think of water’s abundance. You don’t like it. Too much of anything is never a good thing, so say the devout. At least with water, you can make beer. What can you do with all this sun?

Solar power. That is something you can do with all that sun. And one way to covert solar into power is through biofuel. Plants are already being used as biofuels like corn-based ethanol and soy/palm oil biodiesels. Corn, soy, and palm can be turned into fuel for your car, just like they can be used for fuel for your body (and, in the case of corn, sometimes in beer making). But growing food for oil has three problems: one, it is not scalable. You would have to cover all the arable land with corn, oil, and palm plants to use it to convert into energy for our cars. Feeding cars instead of people is ethically questionable. Second, it takes a lot of water per plant for the plant to grow into viable energy. And third,
it takes a lot of energy to cook the plant into oil, cutting into purpose as well as profits.

But edible plants aren’t the only organisms that harvest energy from the sun. Algae and cyanobacteria photosynthesize too. According to Rosa Krajmalnik Brown, a researcher at the Institute and Swette Center for Environmental Biotechnology, who also works on cataloging microorganisms that live in your stomach, cyanobacteria are much more amenable than algae.

“The genome of Synechocystis has been fully sequenced, and the microorganism provides a facile substrate for genetic modification of metabolic pathways to optimize yields of C-16 and C-18 lipids for biodiesel production,” she says. Lipids. Microorganisms that produce lipids.

I am on the rooftop of a building looking at a model for what they hope will one day be a large-scale biofuel processing plant that converts lipids to biodiesel. Synechocystis, this tiny microorganism that is fast at work. It is like the cactus of microorganisms. It can survive crazy heat and even cold temperatures. Feed it a little CO\textsubscript{2} with a side of salt and nitrogen and it just gets fat. Stick some in a puddle at the end of a gas flue at a currently polluting power plant and it will turn that pollution into the same fuel that the power plant produces. Send some agricultural run-off laden with nitrogen and it will eat that up and turn it into more fat. These fatty lipids, these are fuel themselves. Put them in an oil tanker,
send some to Portland where the only thing that doesn’t grow so fast is sun.

Behold! Microorganisms that can turn solar power into fungible energies similar to oil. Fungibility is important. The ability to move fuel from place to place is almost as important as procuring the fuel itself. Getting the oil to where people need it the most, to heat and cool their homes, or, sometimes, so they can move their cars and their planes with movable fuel to take them where they want to go, is one of the reasons solar power has met so much resistance. Solar power in the form of fatty lipids can go anywhere using infrastructure that has been in place for years: refinery to tanker. Tanker to train. Train to tanker. Tanker to town.

I wanted to see this in person. Actually, I want to visit Van again and drink more Gigantic Beer in Portland but Portland is far and Phoenix is close and I am only so fungible. The Biodesign people seem to be amenable to people from Flagstaff trolling around their rooftops to see where all the sun goes.

Josh, a master’s student in biophysics whose last name I neglect to ask for, who manages or grows or babysits the cyanobacteria (they are workers, plant-like photosynthesizers, tiny beings), works to explain green foam growing in open tubes stretched across the roof of the Chemistry building. He is very relaxed. He seems to have made friends with these microorganisms. Now, he sits back, talks about beer instead of microbes. Josh just received a beer-making kit from his girlfriend.
She regrets it because now that’s all he talks about, making beer. Their living room is strewn with beer magazines, carboys, and different strains of hops. At least he’s not talking only about cyanobacteria with his girlfriend, I joke. He looks at me blankly and says, “It’s kind of the same thing. Yeast. Cyanobacteria.”

I wonder if Josh is so laid back because he has all of these tiny organisms doing all this work for him. They’re his. He might love them a little. More than he loved the algae. Josh just finished working with a team who was working with algae to harvest bioenergy. They ran into problems with the water—there wasn’t enough of it (Arizona). In addition, by electrolyzing the water, unhealthy microorganisms grew, outnumbering the useful algae and preventing the algae from doing their photosynthetic lipid-making work.

The idea for both algae and photosynthesizing microorganisms is relatively simple: these photosynthesizing microorganisms use the sun as food, converting their extra energy into fatty lipids. The sun produces more food than the cyanobacteria can use. CO₂ and fixed nitrogen also feed the bacteria. The bacteria use that CO₂ and the sun, and a tiny bit of nitrogen as fertilizer, to produce fatty acid—lipids. What’s so exciting is that this is not a biomass product that must then be processed, like corn. They can be directly harvested. The cyanobacteria act like little factories, producing tiny bits of fuel. The bacteria have done all the conversion inside themselves. Just like the forests, this fat is ready to burn.
It’s like liposuctioning all the fat from all the fat Americans and filling your gas tank with it. You. Fungible. Human fat would need a lot more processing, and although there is plenty of fat in America, it’s still not enough to last. We need something that likes to sit and expel fat all day long, every day, nonstop. These microorganisms seem to like their job here in Arizona. I wonder how long I would have to sit here for them to make me enough fuel to visit Van at his brewery where he could tell me more about the awesomeness of Portland beer.

Up here, on the roof, it doesn’t look like you could get into much trouble with water. Long, flat, clear-plastic pipes were half-filled with water but the water is contained and it looks like less than a swimming pool’s worth. Much less.

“We just had a plastic guy up here. He was trying to sell us some great plastic—the kind that UV rays don’t turn brown. We brought him up here and showed him these.” Josh points to a pile of discarded brown plastic pipes. “Those pipes? They’re made of the same plastic he was trying to sell us. People understand sun but they don’t understand Arizona sun. Brown’s not good. Sun can’t get through brown.”

I ask why they didn’t use glass. There is an advantage to being an English major, not a scientist. I can ask stupid questions.

“It’s too expensive. It’s breakable. It’s heavy. But, if our tubes keep turning brown, maybe we’ll try it.”
It’s then that I realize how early they are in the process. They’re still buying and trying plastic from the “plastic guy.” They’re taking questions from English majors. They haven’t ordered the plastic they’ll need to cover acres of land. They’ll probably have to invent the right kind themselves. The pipes I’m looking at, filled with microorganisms that make the water look blue-green, only run four across. It’s the smaller of their two reactors, but the big one is not that big. The mechanism to harvest the fatty lipids hasn’t even been attached to the extruding end. Even if it could, maybe they’d scrape off a barrel full of lipids. At full capacity, this reactor could produce about three barrels of oil-like substance a day. Not exactly enough to run the planet on.

Still, when I look through the semi-scuffed plastic, I can see little flecks riding on the blue-green waves.

“Those are the fatty lipids. Those things are the oil we’re producing. Our own little Iran on the roof of the EE building.”

They look like tiny bubbles but they aren’t bubbles. Bubbles would have been a bad sign. Bad bubbles mean bad bacteria same as the problem with algae. It’s hard to grow one thing and not grow another. Josh says it’s always a fight—getting the cyanobacteria to grow while keeping other water- and sun-loving bacteria away. The best strategy was to keep the temperature a little colder than most bacteria liked. The cyanobacteria, unlike algae, don’t mind it a little cold.
“Yeah, in July, we’re running air-conditioning on our bacteria full-time.”

It seems a little counterintuitive, running a power-grubbing machine to keep these little bio-machines running.

“Eventually, the microorganisms will create enough juice to run the air-conditioner themselves.” I picture a person running on a treadmill to power a fan to keep themselves cool. Why not just sit and not move?

“Eventually, the system will be more sustainable. We’ll use gray water and water from cement factories. We’ll find ways to shade the plants when we move full-scale.”

I like the confidence of when we move full-scale but right now the whole thing looks like little more than a chemistry experiment. Which I guess it is.

“What do they feel like? Those little flakes when you harvest them and put them in a barrel? Like a handful of dead cells?”

“No, no. We call them flakes and they do look flaky on the lip of the waves, but when you stick your hand it, it feels juicy—like sticking your hand in a vat of dishwashing liquid. It’s liquid. Like oil.”

I want to test this theory. I want to stick my hands deep into a vat of Dawn and pull out solar power. I want to dig deep and squeeze out a force that could catapult my car. I want to know what the excretion of tiny organisms could band together to produce and see it as a new kind of life. It was a new kind of life. Fatty lipids that work like oil that
feels like Dawn dishwashing liquid that washes away the black oil stuck to the otter’s coat. As if that otter swims in the ocean ever again. As if that egret flies again. There is something to metaphor here—if you can believe in conversion—in carrying one idea over to another, that’s how you dig your way out of a pile of refuse, effluent, toxins, sorrow. You turn one idea into another without losing your scientist-eye of knowing the difference between the warmth made by methane gas and the warmth made by the sun.

The best thing, after climbing back through the door on the roof, is the air-conditioning. The other best thing is Josh offering us a beer from his fridge. The beer tastes okay—not too yeasty, not too hoppy. It doesn’t have that buttery aftertaste like some home brews which indicates bacteria has infiltrated the system. It still has all the hallmarks of homebrew—a little too sour, a little too yeasty, and the total dissolved solids scratches my throat. Or at least makes me think perhaps better water would make this beer better.

So here’s the plan. I will bottle up this fungible sun. Stick it in an oil tanker. I will send the sun now converted to flaky lipids up to Van in Portland. Van in Portland can use the flaky microbes to heat the water to sterilize his vats, barrels, and bottles. He can use the flaky lipids to power the machine that fills the bottles. Van can fill the sterilized bottles with Portland water converted into beer and send the beer back to me
using fuel turned from the sun into fatty lipids to power the truck that drives the beer, converting what is mine in abundance into something that everyone can share.

Phoenix recycling sun for Portland. Portland recycling water for Phoenix. A way to maintain, even possibly sustain. And a way for me to learn to love Phoenix.

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