WHEN LIFE GIVES YOU ACORNS...

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ABSTRACT This article recounts the experiences of an undergraduate in chemistry who seeks to understand the roots of our civilization and self-sufficiency—and how these two ideas can fit into the narrative of environmentalism. In a turn for the absurd, he opted to begin his exploration by first collecting twenty pounds of acorns.

As with all research projects, mine began with a question. The question, however, was broader than most, and was closely related to my motivation for majoring in chemistry. The question, phrased simply, is "How self-sufficient can a small community truly be?" To what reasonable degree can the needs of a small group of people be met through careful cultivation and sustainable interaction with the environment? That question does not insinuate an attempt to sever the connection of a group from the world economy entirely. Instead, it entails an attempt to find a middle ground between a hermetic lifestyle and that of a consumer society where individuals are dissociated from the actual production of most, if not all, goods.

For example, consider the laboratory setting. It is there that the advancement of chemistry as a science occurs, where chemists have access to extremely pure reagents in order to ensure the fidelity of the science they are performing. I often found myself feeling unstimulated during laboratory internships because, in this setting, I felt removed from the world at large, and the science felt meaningless. My role as an intern was one of faithfully reproducing a laboratory protocol, and as a result, the inquiry and critical thinking aspects of science that drove me to dedicate my college experience towards it were absent.
This question of mine did not come about until, ironically, I read a book featuring alchemists. It told of sulfur from the slopes of a volcano in Italy and formic acid distilled from the bodies of ants—a mysterious, complex, and interconnected world from which pure and useful compounds can be isolated and utilized.

To me, chemistry is not the study of matter or of atoms and molecules. Instead, I assume the worldview of alchemists, one that has, as its primary assumption, the notion that there is a latent power in objects in the natural world, which can be isolated and purposed to useful ends. From my perspective, all the progress that has arisen from the times of alchemy until now is the result of this same ethos.

With this mindset, I examined my surroundings as a college student in America and very quickly realized both how little I knew about the production of nearly all of the material aspects of our society, and how inaccessible the means of production are.
From there, the questions arose naturally: What modern necessities could I realistically make myself? To what extent could I produce the things that I needed? Most importantly, how much could I produce in a sustainable way?

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While environmental concerns are an important aspect of sustainable thinking, for me there was more to be considered. Sustainability is the only way I am able to lower my participation in the global economy to any meaningful degree. Furthermore, when we trace back the origins of our chemical components, they oftentimes lead to mining and petrochemicals—which are, at this point, an unavoidable aspect of our overall world economy. For myself, however, I would consider the ability to replace any product produced by such means, with one I produced more sustainably, to be a success.

So, where to begin?

Fuel, the ubiquitous topic of sustainability discussions, seemed like a good place to start. The idea of biodiesel, fuel produced from fats and oils, was particularly appealing. In terms of sustainability, it seemed like a great method of producing fuel, evidenced by the large number of individual-scale biodiesel production operations appearing across the United States, as well as the success of the local company Piedmont Biodiesel. From there, new questions arose. Could it be possible for a small community to produce enough fats and oils to meaningfully offset their own fuel consumption, or will it always be necessary scrounge from restaurants and other, exterior sources?

To begin, I started to consider all the possible sources available to a small community: fat could be obtained from cooking leftovers, and, theoretically, from the growing of crops with the explicit purpose of producing oils for biodiesel. In the spirit of self-sufficiency, however, one would assume this community would also go to significant lengths to grow as much food for itself as possible. Given this, and the fact that the labor resources would be limited, I realized that the growing of crops specifically for oil would be difficult to balance with the production of food. The best approach, I felt, was one which was not overly reliant on any single source, but instead was bolstered by a number of smaller sources. What other sources could one conceivably use in a sustainable and self-sufficient manner? What other common sources could be used to bolster a supply of biodiesel, without cutting too much into food cultivation? While discussing this matter with my roommate, I remembered that I had read somewhere that acorns have a high fat content. As they are ubiquitous enough without being something that one could overly rely on (oak orchards are out of the question), I decided to give it a try. As silly as it sounds, I had resolved to making acorn biodiesel.

My friends and I set out to acquire some acorns. After about thirty minutes in the park, we had acquired about fifteen pounds of acorns. Not a bad quantity for the amount of time spent working, odd looks considered. Now we had to consider how best to extract the oil from the acorns. Mechanical extraction seemed like the best for any kind of large scale project, but it raised further questions with regards to shelling, and the construction or purchase of an expeller. For the sake of simplicity in this early R&D stage, where production scale concerns were less important, we decided to use a solvent extraction, in which we would get the fat out of the acorns by dissolving it. We milled the acorns to a fine powder with an initial crushing followed by blending at high speed, and added a solvent to dissolve the fat.

The next step was to determine which solvent was the best—from both a cost and an efficacy standpoint. I had previous experience in the usage of solvents from chemistry labs and internships, but in those cases the solvents had been provided for me with little explanation as to why. The ideal solvent would be one that was volatile enough to evaporate easily, relatively nontoxic, cheap, and capable of dissolving the fats I was working with. Moreover, it had to be something I could purchase easily. The main candidates were charcoal lighter fluid, zippo lighter fluid, acetone, and 90% isopropyl alcohol. While I could use my general chemistry knowledge to guess which the best from an efficacy standpoint was, the other factors weighed in as well. After some experimentation, I came to some conclusions. Acetone was great in that it fulfilled the above requirements, but it led to poor purity because it also dissolved substances we did not want in the biodiesel. Charcoal lighter fluid was cheap, but it was not very volatile and was more toxic than acetone. Isopropyl alcohol, at 90% concentration, still contained too much water to be of much use. Zippo lighter fluid, despite its toxicity and higher cost, was deemed to be the best solvent due to its high volatility and insolubility in water.

Next, I had to determine if I had, in fact, extracted any oils from the acorn powder. In a crude experiment, I placed a small amount of the solvent that had been soaking the acorn powder on a "watch glass" (read: mason jar lid), and a roughly equal amount of pure solvent on another lid and let them evaporate outside. Upon evaporation, I saw that there was a greasy film that appeared to be oil on the lid that had the acorn-solvent mixture, while the pure solvent lid was completely dry. Within the context of my limited resources, I had confirmed that the extraction worked.

I had previously consulted the literature to see if there was any information about acorn fat extractions and acorn biodiesel, and from this determined that a substance called hexane was the solvent of choice for solvent-based fat extractions. Zippo lighter fluid (naptha) is a mixture of carbon- based molecules between six and twelve carbons in length, so its efficacy as a solvent was expected based on the similarity it shares with pure hexane, which is six carbons long. The oil that I obtained from the acorns ranged from a murky and woody-smelling sludge (from acetone) to a very pure looking golden liquid that smelled like vegetable oil (from naptha). Serendipity is celebrated as an important part of scientific discovery. The discovery of penicillin is the quintessential example, but I myself had an experience with this aspect of science in undirected experimentation with the solvent-fat solution. After adding isopropyl alcohol to a small sample of the mixture, the whole solution turned white. Mystified, I checked the internet for anything related to what had just happened, and found out that I had just conducted what is called "the emulsion test", which is a way of confirming that a solution has fat in it, as evidenced by its turning white. Now twice confirmed, I felt fairly sure that my solvent extraction had worked.

I was surprised by the complexity of this first stage of the project—I had not even carried out any real chemical reactions yet, but I had already run into a number of problems that I needed to work around. I enjoyed the holistic view that running my own research project entailed; by myself I constituted the lab hands, the PI in charge of the direction of the project, and, of course, the funding. Having the chance to be responsible for every aspect in a research project gave me a new appreciation for the structure of scientific research. In addition, anything I learned was intended for scaling up, so I had to consider the scalability of any method that I used in the process (and the solvent-based extraction was definitely not easily scalable).

Having confirmed the extraction and isolation of oils from the acorns, I moved on to the step of converting the oils into a useful biofuel. Not wanting to waste the oil that I had spent so much time extracting, I decided to use some left over cooking oil, kindly provided to me by members of my residence hall, in order to figure out the best way to carry out the reaction.

One of the largest challenges with making biodiesel is the necessity of mixing two chemicals that are not soluble in one another. In order to ensure the reaction was thoroughly mixed, I decided to try using the residence hall kitchen blender as a means of mixing the reaction. Not wanting to pour caustic chemicals into the blender kindly provided for my use, I used a reaction which works in a very similar fashion but has a product that is both non-toxic and easy to clean—saponification. In other words, I made soap.

The reaction worked very well, showing that the blender was an effective method for mixing the chemicals and carrying out the reaction. Unfortunately, due to the fact that I was living in university housing, I never had a chance to actually manufacture the biodiesel, out of concern for carrying out a potentially dangerous reaction. However, because I successfully extracted the oil and figured out an effective way of carrying out the reaction, I proved to myself that the production of biodiesel from acorns is something that can be done with limited resources and a small budget. I still intend to finish the project once I have an appropriate space to do so. That being said, the process was a great learning experience and provided me with a better understanding of many of my initial questions.

Through my work on this project, I feel that I have gained insight into the process of science and how it relates to the objects we use in our daily lives. In managing my own project, I had to consult my own sources, devise my own methods, and conduct my own experiments. The complexity of creating any single product is difficult to overstate, and I am glad that I had access to a variety of scientific knowledge in order to use the information gained by others' experiments. In a field such as chemistry, theoretical models can only provide the basis of one's thinking—to “know”, one has to rely upon the experimental process.

While I think most people are aware of this fact, it is a different experience to experience it. We have all been taught the basic steps of the scientific method far too many times to ever forget it. To independently have to adhere to its principles for the purpose of discovering something for myself gave me a better appreciation for the scientific method for what it is essentially: an iterative truth-generation method that draws itself asymptotically closer to truth through trial and error, skepticism, and self-reflexivity. Being forced into writing a lab report as part of a class, and being told in a prescriptive way about what sections to include, teaches the form of science, but not the function. Having to pore over the writings of scientists for my own ends was far more edifying—each section of an academic paper provided me with useful information. Often, the papers’ conclusions held all the information I needed, but in many other instances I had to dig deeper into their methodology in order to better understand how to replicate their findings. Each discrete section of a paper corresponds to a different part of the scientific method, and that method of organization allowed me to easily use the information I needed for my own ends.

On the other hand, I tried to avoid relying too heavily on the writings of others. I wanted to learn by applying the principles that I learned in class and see how they translated into practice. This too, provided me with insight into the process of science. When following lab protocols as part of internships, I would often wonder why a particular chemical was used in a particular situation. It was often mystifying to see very specific amounts of very specific chemicals that are often used in such protocols. Each chemical had a function in the process, but why were some used in lieu of others? Through my own project, I came into contact with the variety of factors that come into play when deciding which chemical or method is best for a process, as well as how considerations of scale come up in a laboratory environment. Through my own experimentation, I came to see how much work is required

required to yield results that are then taken for granted in the laboratory setting. I do not mean "taken for granted" in a negative sense, but rather that after the bulk of the work is done in coming to a certain conclusion, the information gleaned from a past experiment can then be applied to future experiments. In this way, scientific knowledge builds on itself and makes the process of science itself more efficient.

More broadly, I also came to realize the wonder of the consumerist global economy. Because I had previously only fulfilled the role of a consumer in the process of product generation, I was aware that there was a large amount of work involved in bringing a product to the market. However, I had very little experience with the production end of things. Despite the fact that my initial question was a matter of self-sufficiency, my experience only led me to gain a deeper appreciation for the system of the world that, from sources across the globe, converges together to bring even the simplest product to us in a highly consistent way. The act of purifying what we need from the natural world is a very complicated process, and the degree to which we can do so is truly an amazing feat. Interestingly, it caused me to reflect in particular on the world's reliance on petrochemicals. It is their consistency and separability that makes them desirable as a starting material for so many products. In realizing the difficulty of separating products from the natural world, I also realized the allure of oil, and by extension, the difficulty of coming up with good alternatives to it.

What I learned through this experience reinforced my feeling that a complete separation from the rest of the world is not desirable, if even possible, and as consumers we should be mindful of the interconnected network which makes our world possible. I still feel that it is worthwhile to interact with this global system in a way that promotes sustainability, rather than waste, and that any way an individual can be self-sufficient and sustainable is worthwhile. As for myself, I am going to continue to try to understand the world around me, both as an aspiring natural scientist and as a member of society, and in the process, hopefully grow to have a more benign impact on the rest of the world.