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Meet the Anarchists Making Their Own Medicine

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www.fourthievesvinegar.org

The first time I encountered Michael Laufer, he was throwing thousands of dollars worth of homemade medicine into a packed audience at Hackers on Planet Earth (HOPE), a biennial conference in New York City.

“Does anyone here suffer from anaphylactic shock and not have access to epinephrine?” Laufer asked the audience. A few hands went up and Laufer stuffed a homemade EpiPen into one of them. “That’s one of the original ones we made,” he said. “Use it well.”

After a few minutes of gloating about pharma bro Martin Shkreli “rotting at Fort Dix” for raising the price of Daraprim, a lifesaving HIV medicine, from \$13 to \$750, Laufer grew serious. “It’s been two years, but despite everything that’s happened, the price of Daraprim hasn’t changed,” he said. He reached into his pocket and produced a handful of white pills. “I guess I better hand out some more,” Laufer said as he tossed the Daraprim into the audience.

With a shaved head, dark beard, and an ever-present camo jacket, Laufer doesn’t look like the type of person you’d seek out for medical advice—but that’s exactly his point. As the founding member of Four Thieves Vinegar, a volunteer network of anarchists and hackers developing DIY medical technologies, Laufer has spent the last decade working to liberate life-saving pharmaceuticals from the massive corporations that own them. Laufer has no formal training in medicine and he’ll be the first to tell you he’s not a doctor. In fact, from a regulatory standpoint he’s more qualified to do mathematical work on nuclear weapons than treat patients. But Laufer’s

never really been the type to let rules and regulations stand in his way.

I met Laufer at a bar across the street from HOPE after he finished his talk on DIY medicine. He was meeting with his Four Thieves collaborators who had flown in from all over the country to attend the conference and unveil the new medical technologies under development by the collective. Laufer kicked off the celebration with a toast.

“A toast to the dead, for children with cancer and AIDS,” Laufer said, raising a glass of bourbon and quoting the hip hop artist Felipe Andres Coronel, better known as Immortal Technique. “A cure exists, and you probably could have been saved.”

In the last decade, Four Thieves has run afoul of the Food and Drug Administration, billionaire pharma executives, doctors, and chemists at some of the United States’ most prestigious universities. Indeed, Laufer and his collaborators can’t stop pissing off powerful people because Four Thieves is living proof that effective medicines can be developed on a budget outside of institutional channels.

At the pharmacy, a pair of single use Mylan epipens can cost over \$600 and the company’s generic version costs \$300 per pair, but an ongoing shortage means you probably can’t find them, even if you can afford them. In response, Four Thieves published the instructions for a DIY epipen online that can be made for \$30 in off-the-shelf parts and reloaded for \$3. Shkreli drove the price of the lifesaving HIV medicine Daraprim sells up to \$750 per pill. So Four Thieves developed an open source

the cheaper “media rate” charged by the US Postal Service for items like books and compact discs while avoiding scrutiny from law enforcement.

In the meantime, however, Four Thieves is still mostly focused on improving its MicroLab and synthesizing new medicines. Recently the collective began producing its own custom circuit boards for the MicroLab, which will make it even easier to set up the device at home. Laufer said he plans to begin giving these circuit boards away as early as next month. At the same time, the group is working on perfecting the synthesis of Solvadi, a one-time treatment that can cure Hepatitis C. This drug has been on the market for nearly five years, but its \$84,000 price tag makes it inaccessible to many people who need it. If Four Thieves has its way, Hepatitis C will soon be a thing of the past for everyone, regardless of their income.

At a time when many Americans lack even basic health care services, Laufer’s ideas seem as intuitive as they are radical. His work is predicated on the notion that too many critical decisions about our health have been outsourced to private actors who care more about their bottom line than their customers’ well being. For Laufer, Four Thieves is as much about medicine as it is about the right to the free flow of information and personal autonomy. As far as he’s concerned, one cannot exist without the other.

“Pursuing science is a human right,” Laufer said. “In fact, it’s the human right from which all other rights flow. You have to be able to do whatever you want to your body and to think the way you want.”

In the future, Laufer wants Four Thieves to focus on manufacturing drugs for orphan diseases so that those with rare conditions will never be without their medicine. Yet these types of medicines come with their own unique problems.

For instance, Laufer said that many of the medicines for orphan diseases are made of biological material, such as fungus. Laufer said that Four Thieves is working to create a BioTorrent site to distribute the organic material needed to manufacture orphan medicines. BioTorrent would be like a normal file sharing site like the PirateBay, but instead of downloading music and movies, people could download instructions for how to synthesize their own medicine and share the organic material among one another. Since biological cells are self-replicating, this would simply require one user to grow a sufficient amount of cells for themselves before shipping some cells to another user who would repeat the process, similar to the way people 'seed' a media file on torrent sites.

The question, then, would be how to ship the biological material cheaply and without getting caught. To this end, Four Thieves is investigating the use of books and CD cases as grow media for biological precursors. Mycelia are basically the 'roots' of many fungi and feed on cellulose, which is found in abundance in the pages of a book. So Laufer and his collaborators began injecting books with mycelium, which feed upon the pages and grow out of the book. Similarly, compact discs are similar enough to petri dishes that if they're streaked properly they can be used as a growth medium for bacteria and other biological precursors. The advantage of this is that Four Thieves members using the BioTorrent site could ship these cells using

portable chemistry lab that allows anyone to manufacture their own Daraprim for just 25 cents apiece.

The pharmaceutical industry is valued at \$446 billion in the US and its walls are tightly policed by regulatory agencies like the FDA and Drug Enforcement Administration. By freely distributing plans for medical devices and pharmaceuticals, a loose collective of anarchists and hackers is threatening to pull the rug out from under one of the most regulated and profitable industries in the world. And they're just getting started.

Free Drugs

Four Thieves claims to have successfully synthesized five different kinds of pharmaceuticals, all of which were made using MicroLab. The device attempts to mimic an expensive machine usually only found in chemistry laboratories for a fraction of the price using readily available off-the-shelf parts. In the case of the MicroLab, the reaction chambers consist of a small mason jar mounted inside a larger mason jar with a 3D-printed lid whose printing instructions are available online. A few small plastic hoses and a thermistor to measure temperature are then attached through the lid to circulate fluids through the contraption to induce the chemical reactions necessary to manufacture various medicines. The whole process is automated using a small computer that costs about \$30.

To date, Four Thieves has used the device to produce home-made Naloxone, a drug used to prevent opiate overdoses better known as Narcan; Daraprim, a drug that treats infections in people with HIV; Cabotegravir, a preventative HIV medicine

that may only need to be taken four times per year; and mifepristone and misoprostol, two chemicals needed for pharmaceutical abortions.

Given the Trump administration's candidates for Justice Anthony Kennedy's seat on the Supreme Court, the collective feels an increasing sense of urgency to perfect its abortion drugs. They fear that the federal government will soon allow states to choose whether or not abortions can legally be offered and many residents will be left without any recourse to abort a pregnancy. This was a motivating factor for Tim Heilers, a former Navy sonar technician from Louisville, to join Four Thieves last February.

"Kentucky is a very conservative state and I think we have a very real possibility of becoming the first state with no abortion access whatsoever," Heilers told me. "Giving people the ability to make mifepristone if they need it is something I think is very important."

Although Four Thieves has successfully produced five drugs, so far only the Daraprim is available for download on the collective's website. This is partly due to the disparities in how hard the various molecules are to produce. Naloxone, for example, is particularly challenging because the antidote to opiate overdoses uses the same precursors as the opiates themselves. These precursors are controlled by the federal government and only allowed to be possessed by approved labs in small doses. To get around this issue, Laufer and his collaborators adopted a seemingly counterintuitive protocol: They'd make medicine from poison.

into the world. Getting access to Chematica's data on synthesis pathways would blow open the door for a new suite of DIY medicines, but until then it's going to be pretty slow going.

The Future of DIY Medicine

The most expensive drug on the market is called Glybera and is used to treat familial lipoprotein lipase deficiency, a hereditary disease found in only about 7,000 people worldwide. Lipoprotein lipase deficiency prevents the normal breakdown of body fats, which results in abdominal pains, acute pancreatitis, enlarged livers and kidneys, and the buildup of fat deposits under the skin. Glybera helps treat these symptoms and is critical to the quality of life of those with FLLD. The only catch is the medicine costs each patient \$1.2 million per year—if it's even available to them. In 2017, UniQure, the company that produces Glybera, stopped selling the drug in Europe due to the extremely limited demand. This means that the approximately 1,200 Europeans with FLLD are out of luck when it comes to treatment.

The situation is more or less the same for those afflicted with other orphan diseases, which are defined as conditions that affect fewer than 200,000 people worldwide. If a drug for the disease exists, it is generally prohibitively expensive to obtain. If the company doesn't see enough demand for its product, it will likely pull it from the market. So for many rare diseases, a cure or palliative medicine may exist but is too expensive for patients or not profitable enough to put on the market.

Four Thieves' most significant contributions to DIY medicine is prioritizing harm reduction in its research and development.

There's more than one way to produce a given molecule and some synthesis pathways are simpler or allow for far greater margins of error than others. Thus Four Thieves aims to discover synthesis pathways that lower the risk of toxic reactions to the lowest possible level. When the collective was first starting out, they had help doing this from a startup called Chematica, which had collected 250 years of research on organic chemical synthesis into a database and developed software that used this data to predict and create new synthesis pathways to desired molecules. With this database and software, Four Thieves was able to create simple and safe synthesis pathways that would produce life-saving drugs.

This worked great until Chematica was bought by Merck, an international pharmaceutical giant, last year. After the sale, Four Thieves lost access to the software and, more importantly, the database. Laufer told me that the Four Thieves data science team has created an open source version of Chematica's software and has even compiled a small database of organic chemicals to test it on. The software is crude compared to Chematica's, but Laufer said that it works well enough. To improve the software, however, the collective needs more data, which is now the property of Merck.

But as any hacker knows, sometimes data "falls off a truck," which is a nice way of saying that Chematica's database is currently posted on a password protected website on the dark web. During his talk at HOPE this year, Laufer implored the audience to help with cracking the password and releasing the data

Even though they couldn't legally buy the Naloxone precursors, Laufer realized that the opiates themselves are remarkably easy to obtain. After obtaining oxycontin on the street, collective members were able to perform a few chemical reactions to extract the necessary precursors from the drug and used them to make the Naloxone.

"Would you rather break the law and live, or be a good upstanding citizen and a corpse?"

"Some very clever drug dealers in the 90s discovered that you can do a one shot reaction [with oxycontin] and get oxymorphone, which is something like six times as powerful," Laufer said. "You can make Naloxone from oxymorphone in one step. It's fairly easy and now you've made medicine from poison."

These sorts of unorthodox approaches to healthcare are the name of the game in pharma hacking, where the goal is to help people at any cost.

There's a drug called cabotegravir, for instance, which is a pre-exposure prophylactic that has been demonstrated to prevent the spread of HIV through shared needles in macaques. Unlike other pre-exposure prophylactics that need to be taken daily, cabotegravir may only need to be taken four times per year to protect the user from HIV. Although the initial clinical results with cabotegravir were extremely promising, Four Thieves grew impatient with waiting for it to become commercially available. (The drug is currently undergoing Phase III FDA trials, which means it's being clinically tested on a large cohort of human subjects.) Moreover, based on other pre-exposure prophylaxis drugs, cabotegravir would almost certainly be sold at

an exorbitant cost—Truvada, a comparable drug that needs to be taken daily, costs around \$2,000 for a 30-day supply. So the group figured out how to make it themselves.

Cabotegravir is still in pre-clinical trials but that hasn't stopped Four Thieves from trying to get pre-exposure prophylactics (PrEPs) into the hands of those who need it. As the group continues to experimenting with synthesizing its own cabotegravir, some Four Thieves affiliates have started purchasing a commercially available PrEP called tenofovir, compounding it with an inert buffer, and then providing it to heroin dealers who can choose to cut their product with the PrEP as a "service" for their customers. For those customers who decide to take the dealers up on their service, "their heroin has a new side effect," Laufer said. "You don't get HIV from it any more."

Clearly, Four Thieves Vinegar Collective walks a fine line when it comes to the legality of their enterprise. Although Laufer has turned subversion of the medical industry into an artform, litigation remains a perennial threat to his mission to liberate medicine. When a pharmaceutical company manufactures a new drug, they own the patent on the molecules that make the drug effective. Nevertheless, Laufer and his colleagues are able to reproduce these molecules because they are described in patent filings and often in academic journals. All it takes is the right technology.

Since Four Thieves isn't actually selling or distributing the medicines made by its members, what they're doing isn't technically illegal in the eyes of the FDA, even though the agency has issued a public warning about the collective's DIY meth-

they are able to synthesize the same drugs Four Thieves is producing at low costs, but with "appropriate safeguards."

"Unless the system is idiot proof and includes validation of the final product, the user is exposed to a laundry list of rather nasty stuff," DeMonaco told me in an email. "Widespread use [of Four Thieves' devices] would provide an entire new category for the Darwin Awards."

Von Hippel and DeMonaco were in agreement that the ability to purify DIY drugs and run quality control tests on the final product is paramount for their safe use by patients. Von Hippel suggested that scientists with a background in medicinal chemistry will be necessary to address these issues in DIY pharma.

"I see Michael Laufer's activities as a valuable form of social activism that points the way to a promising future," von Hippel said. "But I think the equipment and the medicinal science issues have to be much further developed before DIY medicine production will be safe."

In a way, Four Thieves is just doing a small-scale version of what many hospitals are doing already. Faced with rising drug prices and shortages, many hospitals have started to manufacture their own medicines on site to save costs. The difference, however, is that these hospitals often have access to sophisticated laboratories and trained medical personnel, which significantly lowers the risk of something going wrong.

Four Thieves isn't naive about the risks of providing the documentation to allow others to make their own medicine. It's always possible that someone follows the group's instructions incorrectly and inadvertently produces a toxic chemical. Yet there are ways to reduce the likelihood of this happening and one of

All of Four Thieves' tools were developed on a virtually non-existent budget—the only money the collective has is whatever its members supply out of their own pockets—and so far the medicines they have produced haven't killed anyone. Yet some experts caution against taking medicines produced by DIY tech that hasn't been sufficiently vetted.

Harm Reduction

Eric Von Hippel, an economist at MIT that researches “open innovation,” is enthusiastic about the promise of DIY drug production, but only under certain conditions. He cited a pilot program in the Netherlands that is exploring the independent production of medicines that are tailor made for individual patients as a good example of safe, DIY drug production. These drugs are made in the hospital by trained experts. Von Hippel believes it can be dangerous when patients undertake drug production on their own.

“If one does not do chemical reactions under just-right conditions, one can easily create dangerous by-products along with the drug one is trying to produce,” von Hippel told me in an email. “Careful control of reactor conditions is unlikely in DIY chemical reactors such as the MicroLab design offered for free by the Four Thieves Vinegar Collective.”

His colleague, Harold DeMonaco, a visiting scientist at MIT, agreed. DeMonaco suggested that a more rational solution to the problems addressed would be for patients to work with compounding pharmacies. Compounding pharmacies prepare personalized medicine for their customers and DeMonaco said

ods. Shortly after Four Thieves unveiled its \$30 DIY epipen, the FDA issued a statement to the media that said “using unapproved prescription drugs for personal use is a potentially dangerous practice,” but didn't refer to Four Thieves by name. Ironically, only a few months later, the FDA issued a warning letter to Pfizer for failing to investigate “hundreds” of complaints about epipen failures, some of which resulted in the death of the user. In May, the FDA issued another warning that declared a chronic epipen shortage.

As for the DEA, none of the pharmaceuticals produced by the collective are controlled substance, so their possession is only subject to local laws about prescription medicines. If a person has a disease and prescription for the drug to treat that disease, they shouldn't run into any legal issues if they were to manufacture their own medicine. Four Thieves is effectively just liberating information on how to manufacture certain medicines at home and developing the open source tools to make it happen. If someone decides to make drugs using the collective's guides then that's their own business, but Four Thieves doesn't pretend that the information it releases is for “educational purposes only.”

“The rhetoric that is espoused by people who defend intellectual property law is that this is theft,” Laufer told me. “If you accept that axiomatically, then by the same logic when you withhold access to lifesaving medication that's murder. From a moral standpoint it's an imperative to enact theft to prevent murder.”

“So yeah, we are encouraging people to break the law,” Laufer added. “If you're going to die and you're being denied

the medicine that can save you, would you rather break the law and live, or be a good upstanding citizen and a corpse?”

Doctors without Orders

The catalyst for Four Thieves Vinegar Collective was a trip Laufer took to El Salvador in 2008 when he was still in graduate school. While visiting a rural medical clinic as part of an envoy documenting human rights violations in the country, he learned that it had run out of birth control three months prior. When the clinic contacted the central hospital in San Salvador, it was informed the other hospital had also run out of birth control. Laufer told me he was stunned that the hospitals were unable to source birth control, a relatively simple drug to manufacture that's been around for over half-a-century. He figured if drug dealers in the country were able to use underground labs to manufacture illicit drugs, a similar approach could be taken to life-saving medicines.

Laufer started the collective shortly after he returned from Central America, but its existence was only made public at HOPE in 2016. During his first talk at the hacker conference, Laufer demoed the group's \$30 DIY “EpiPencil,” distributed some homemade Daraprim to the audience, showed off an early prototype of the MicroLab, and gave Martin Shkreli a call on stage (he didn't answer.) When Four Thieves began, Laufer was mostly working by himself. Now that it's emerged from the underground, the group is much larger, although Laufer said it's impossible to know its actual size—members

come and go as they please, contributing as much knowledge and time as they can.

Everyone I spoke with at Four Thieves comes from a technical background, but none of them were medical professionals. Laufer, for instance, has a background in nuclear physics and is the director of the math program at Menlo College in Silicon Valley for his day job. The result of Four Thieves' diverse pool of technical expertise speaks for itself. The collective now has independent biology, chemistry, data science, programming, and hardware teams whose degree of collaboration is dictated by the project at hand.

Four Thieves doesn't sell anything, but the collective has two core ‘products.’ The first is open source hardware like the epipencil and MicroLab chemical synthesizer, which can be made from off-the-shelf and 3D printed components. The second is the instructions for how to use these tools to produce the drugs, which includes everything from how to use the MicroLab to perform simple reactions to how to procure chemical precursors.

“I think it's absolutely imperative that information about how to make your own medicines should be as easily accessible as possible to everyone who might have even a passing interest,” Laufer told me. “The goal of the group is to make it possible for people to be able to do these things on their own. The idea that someone could download the instructions, read the list of materials, order them, read the instructions for how to assemble it and program it, upload the code, order precursor chemicals, and then manufacture medicine.”