# The Secret, Magical Life Of Lithium

One of the oldest, scarcest elements in the universe has given us treatments for mental illness, ovenproof casserole dishes and electric cars. But how much do we really know about lithium?

Finn Berenbroek for Noema Magazine

Feature Climate Crisis

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JUNE 27, 2024

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## Act I: In The (Very) Beginning

The universe was born small, unimaginably dense and furiously hot. At first, it was all energy contained in a volume of space that exploded in size by a factor of 100 septillion in a fraction of a second. Imagine it as a single cell ballooning to the size of the Milky Way almost instantaneously. Elementary particles like quarks, photons and electrons were smashing into each other with such violence that no other matter could exist. The primordial cosmos was a white-hot smoothie in a blender.

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One second after the Big Bang, the expanding universe was 10 billion degrees Kelvin. Quarks and gluons had congealed to make the first protons and neutrons, which collided over the course of a few minutes and stuck in different configurations, forming the nuclei of the first three elements: two gases and one light metal. For the next 100 million years or so, these would be the only elements in the vast, unblemished fabric of space before the first stars ignited like furnaces in the dark to forge all other matter.

Almost 14 billion years later, on the third rocky planet orbiting a young star in a distal arm of a spiral galaxy, intelligent lifeforms would give names to those first three elements. The two gases: hydrogen and helium. The metal: lithium.

This is the story of that metal, a powerful, promising and somehow still mysterious element on which those intelligent lifeforms — still alone in the universe, as far as they know — have pinned their hopes for survival on a planet warmed by their excesses.

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Scientists generally consider it uncool to anthropomorphize, but as a nonscientist, I can say that if lithium were a friend, it would be the sort of friend who is humble and unassuming and yet also seemingly everywhere all at once doing really fabulous and important things. Lithium, in my imagination, is the envy of the other elements.

“I’m such a fan of lithium,” the astronomer Brian Fields told me over the phone recently. “It’s the third simplest element. And yet it’s always got surprises for us.” Fields teaches astronomy and physics at the University of Illinois Urbana-Champaign. He specializes in a field called galactic chemical evolution, which seeks to explain the origin of elements in the universe.

"Lithium has one of the most complex stories," Fields said. "The oxygen you're breathing, the carbon in your DNA, the iron in your blood — that came later, out of stars. But lithium comes straight out of the Big Bang."

Big Bang nucleosynthesis, as it's called, first produced hydrogen, the simplest, lightest and most abundant element — 75% of the newborn universe by mass. Helium formed next and accounts for most of the remaining mass. Lithium was created last, in minuscule amounts — one lithium atom for every 2 billion hydrogen atoms. Heavy elements, like gold, are generally the universe's rarest. Lithium is an outlier — the third-lightest element and yet "barely there," Fields said.

Lithium is unusual among the elements in other ways. It's the only one we know of where a significant amount is made in all three element-producing processes: the Big Bang itself, within stars and when cosmic rays strike and fragment disparate particles in space. These collisions, called cosmic ray spallation, result in discombobulated atoms reassembling themselves with varying numbers of protons and neutrons, like an intergalactic Mr. Potato Head. (Beryllium, found in emeralds, is also produced this way.)

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*"For the first 100 million years or so after the Big Bang, only hydrogen, helium and lithium existed in the vast, unblemished fabric of space before the first stars ignited like furnaces in the dark to forge all other matter."*

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Because they're created from swirling clouds of matter in the cosmos, all stars are born with lithium. But the sources of lithium in the universe have, since the late 1980s, presented astronomers with an odd problem. As Fields told me, astronomers studying the abundance of elements after the Big Bang have created complex calculations that account for the expansion of the universe, nuclear reactions and the behavior of subatomic particles like photons and neutrinos. The math pencils out for hydrogen and helium — the measurements match the predictions. Not so with lithium — only a third or less of the expected amount of lithium is observable in the universe. "We call 'em like we see 'em in astrophysics," Fields said, "so we called this the lithium problem."

So where did it all go? Astronomers have tried to answer this by training their telescopes on the oldest stars. Ann Boesgaard, an astronomy professor emerita at the University of Hawaii and a pioneer in galactic chemical evolution, studies distant stars in the galaxy, some more than 11 billion years old. “Because of the light travel time,” she said, “the farther away you stare, the nearer you are to the beginning of the universe.” Like fossils, the stars should tell the story of how elements built up over time. But the amount of lithium Boesgaard has measured in those stars is still only 60% of the amount astronomers predict was present at the beginning of the universe.

Lithium, Boesgaard explained, is an extremely fragile element with a poorly bound nucleus. When it gets too hot, it is destroyed. Inside stars, convective currents churn their contents into different temperature zones, pulling lithium toward the hotter center. “At 2.5 million degrees Kelvin, it’s curtains for lithium atoms,” she said. At that temperature, lithium undergoes nuclear reactions and is converted into helium. Perhaps the discrepancy between the observed and expected amount of lithium in the universe is because so much of it is getting eaten up inside stars. But how quickly? “We’re looking at the oldest stars and we still can’t find it,” Boesgaard said.

Closer to home, our star seems to support this hypothesis. Katharina Lodders, a cosmochemist at Washington University in St. Louis, analyzes ancient meteorites to understand elemental abundance in our solar system when the sun was born about 4.6 billion years ago. She compares their composition to that of the sun, which accounts for over 99% of the mass of our solar system and therefore should reflect its proportion of elements. The distribution of almost every element in these meteorites matches the sun.

But not lithium. Astronomers studying the sun through spectroscopy find much less than they would expect. The sun’s convection currents must be dragging the lithium atoms deeper into itself and destroying them. “The sun and other stars tell us what they’re made of,” Lodders told me. “You just have to read the messages hidden in the light.”

## Act II: Man Meets Lithium, Immediately Tries To Set It On Fire

The story of how humans discovered lithium goes back to the late 18th century and a Brazilian scientist, statesman and poet named José Bonifácio de Andrada e Silva who was hopscotching around Europe on a sort of early study abroad program. While touring an iron mine on the Swedish isle of Utö, he picked up some curious rocks in the waste pile and determined they were new minerals. He called them petalite and spodumene.

Nothing much was heard of Silva's curious discovery until almost 20 years later when Johan August Arfwedson, a promising employee in the laboratory of Jöns Jacob Berzelius, one of the founders of modern chemistry and the man who coined words such as "polymer" and "catalyst," started analyzing another petalite sample from Utö. Arfwedson used the methods of the times to separate out the mineral's silica and aluminum, which together accounted for about 97% of its mass. Next, he mixed some of the pulverized rock with barium carbonate and heated it until he obtained a salt. Trying to determine the salt's base, Arfwedson ruled out potassium, magnesium and then sodium. He repeated his analysis twice before he concluded he'd found "a definite fixed alkali, whose nature had not been previously known."

Because the element was discovered in a mineral, Arfwedson and Berzelius named it "lithia," after the Greek word "lithos," for stone. Arfwedson went on to identify lithium in two other minerals, lepidolite and spodumene, which had it in particularly high concentrations. Arfwedson tried in vain to isolate lithium to create a pure sample of the element, but lithium is highly reactive and readily forms compounds from which it isn't easily separated. A slender, well-dressed man known for his precision and orderliness, Arfwedson eventually turned away from the inscrutable lithium and all but abandoned chemistry altogether to attend to an iron forge outside Stockholm, where he died in 1841.

Finally, in 1855, two chemists — Robert Bunsen and Augustus Matthiessen — were able to isolate lithium in a quantity large enough to study its properties. They did this by passing an electric current through molten lithium chloride. At last, mankind could look upon the lightest metal in its pure form.

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What Bunsen and Matthiessen observed was a silvery-white alkali metal about as dense as pine wood. Pure lithium is soft enough that if you had a lump of it in your kitchen, you could cut it with a knife. You wouldn't want to, though. Lithium is so reactive with the nitrogen, oxygen and hydrogen in air that it would tarnish black before your eyes and may then combust. If you put it in water, it would fizz and may catch fire and explode. For these reasons, lithium is never found in its pure state in nature. It is always in a compound. It constitutes 0.002% of the Earth's crust, making it slightly more prevalent than lead.

Even before lithium was isolated and understood, chemists were recommending its compounds for medical use. In 1843, a British surgeon named Alexander Ure was investigating cures for gout and urinary stones. Ure put a large bladder stone in a solution of lithium carbonate he obtained from the mineral lepidolite and watched the stone shrink over five hours. He envisioned treating patients with urinary stones by injecting the solution directly into the bladder. The trouble was, lithium was still in short supply. Ure had to wait until 1859 before he could get enough lithium carbonate to try to treat a 56-year-old man with a large bladder stone. Roughly every other day over several weeks, he injected lithium carbonate into the man's bladder. The stone didn't shrink and the patient eventually died — it's not clear why — but Ure still claimed the experiment was a success because it seemed the stone at least became more brittle.

Meanwhile, many 19th-century doctors subscribed to the popular belief that an excess of uric acid, which constitutes most bladder stones, was responsible for ailments as diverse as heart disease, asthma and tuberculosis. The British doctor Sir Alfred Baring Garrod suggested lithium as a treatment, due to its ability to dissolve uric acid. Toward the end of the century, a doctor in Denmark even tried treating depressed patients with lithium carbonate, thinking that their afflictions were also caused by too much uric acid. By the end of the century, physicians throughout Europe and the U.S. had begun to prescribe lithium, by then widely available, for all manner of ills. The Australian Broadcasting Corporation recently called lithium the "turmeric of the late 1800s."[1]

Over time, lithium lost its luster as a panacea. It wasn't until the middle of the next century that its role in psychiatry would be solidified by an unlikely doctor in another hemisphere.

## Act III: A Miracle For Melancholy, If Not For Several Guinea Pigs

As early as the second century, physicians like Soranus of Ephesus prescribed bathing in alkali mineral springs to cure mania and melancholia. We now know that many of these mineral baths contain lithium, which perhaps contributed to their therapeutic effects.

The treatment of “taking the waters” extended into the United States as well. Lithia Springs in Georgia is home to mineral springs that have long been a sacred center of healing for the Cherokee tribes. By the end of the 19th century, Lithia Springs’ Sweetwater Park Hotel was a destination for the likes of Mark Twain, the Vanderbilts and Presidents Cleveland, Taft, McKinley and Theodore Roosevelt. Seeking to extend its reach, the hotel’s owner began bottling the spring water and shipping it across the country, even to the White House.

The therapeutic benefits of such lithium microdosing are disputed, but the medical value of lithium was unequivocally proven when a doctor in rural Australia made an accidental discovery that would change the world of psychiatry.

John Cade was born in 1912 in a country hospital near Melbourne. His father served as an army medic during World War I and returned from Gallipoli and France with severe PTSD, whereupon he took up a position as a doctor in Victoria’s Department of Mental Hygiene. As Walter A. Brown writes in his book, “Lithium: A Doctor, A Drug, And A Breakthrough,” the young Cade and his two brothers grew up on the grounds of a mental asylum, interacting with patients who had severe mental illness.

Cade studied medicine at the University of Melbourne and specialized in pediatrics and psychiatry. In 1936, he was appointed a medical officer at the same mental hospital where he had grown up. He began conducting research into patient diets, antibody levels and the differences between men and women diagnosed with what is now called schizophrenia.

In 1940, his research was interrupted. Australia had declared war on Germany and Cade joined the Australian Imperial Force, sailing to Malaya in 1941 to defend the British colony from Japanese invasion. In the ensuing battles, the Japanese outmaneuvered the Commonwealth troops and Cade was among 50,000 British and Australian soldiers captured as prisoners of war.

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Cade spent the next three and a half years in a prison camp battling malnutrition and poor health. He studied the effects of vitamin deficiency among his fellow prisoners and even conducted autopsies on soldiers with mental illness, noting many of them had physical manifestations of their disorders in their brains. By the time he was liberated, in 1945, Cade was eager to get back to work. "The old brain box is simmering with ideas," he wrote to his wife on the journey home. In 1946, he took a job as director of the Bundoora Repatriation Mental Hospital, where his research began in earnest.

The first thing Cade wanted to study in the 200 patients at the hospital was the idea that people experiencing manic-depressive illness are producing an abnormal amount of some naturally occurring substance. The best place to look for this substance, he reasoned, was in the patients' urine. So Cade began collecting samples from his patients, which he stored in jars on the top shelf of his family's refrigerator. To determine if the urine was toxic, he injected varying amounts of it into the abdomens of guinea pigs that he raised behind his house. Some urine from manic patients, he found, would kill a guinea pig in much smaller quantities than urine from non-manic patients.

1. The craze continued. In 1929, a soft drink hit the shelves called Bib-Label Lithiated Lemon-Lime Soda, which included lithium citrate as one of its seven ingredients. The drink was eventually renamed 7Up and it was made with lithium citrate until 1950.

Cade thought the components of urine that may be causing his patients' illnesses were urea and uric acid. He successfully dissolved both using lithium compounds, which he then injected into the guinea pigs. When he did, he noticed the guinea pigs became tranquilized, so much so that he could roll the restive creatures on their backs as they "merely lay there and gazed placidly back at him."

Scientists looking back on Cade's research assume that the guinea pigs were manifesting the early symptoms of lithium poisoning. Cade didn't know. So he decided to conduct therapeutic trials of lithium in his manic-depressive patients. To test the safety and to determine the correct dose, he first administered it to himself. Feeling no ill effects, he started his first manic patient on lithium in the spring of 1948.

Within five days, it was clear that this patient, a man of 51 who had been the most troublesome in his ward, was improving. He was tidier, more settled, less disinhibited and less distractible. Three months later he was able to leave the hospital with instructions to take 300mg of lithium carbonate twice daily. In the next year, Cade treated nine more patients with lithium citrate and lithium carbonate. He published a paper on his study in The Medical Journal of Australia, alerting the world to a promising new treatment for an intractable condition in the surprising form of a simple, ancient element.

"He really did this on his own, in isolation, in a little backwoods Australian hospital," Brown told me. "He had no grant. He had no research training. But he was curious, and he was a great observer."

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Two years later, Cade's original patient, who had been in and out of the mental hospital since his initial release, died of lithium poisoning from the doses Cade had prescribed.[2] Perhaps due to this and other reports of patients dying from lithium toxicity, Cade stopped prescribing it; when he became superintendent of a mental hospital in Melbourne, he banned the use of lithium there. But other doctors, including Morgens Schou in Denmark, picked up the torch and continued lithium research, eventually cementing its place among the best and simplest treatments in psychiatry.

Decades later, we now know lithium uniquely treats symptoms of manic depression, or bipolar disorder. It alleviates mania — temporary periods of hyperactivity, euphoria and delusions. Unlike other treatments, it prevents future episodes of mania and perhaps also depressive periods. For unknown reasons, it also dramatically reduces suicide risk. People with bipolar disorder commit suicide at rates 10-30 times the rest of the population. Controlled clinical trials have found that patients taking lithium are 10 times less likely to attempt suicide. No other treatment for bipolar disorder has the same effect.

"Lithium's ability to fully alleviate the symptoms of a devastating condition makes it one of the best treatments in medicine," Brown wrote in his book. "Not patentable and inexpensive, lithium has never been marketed and no single company is motivated to promote it. But lithium's advantages over its patented, profitable, and well-advertised competitors are becoming more apparent."

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In the first two decades of its use in this country, lithium saved the U.S. economy $145 billion in hospitalization costs, according to a 1994 paper published in Science magazine. Research in Texas, Greece, Lithuania and elsewhere has found that naturally occurring lithium in drinking water is associated with lower rates of suicide and violent crime, prompting some scientists to advocate adding it to municipal water supplies, much like fluoride is sometimes added to strengthen teeth.

But still even today, it's unclear what this silvery-white metal is doing in the brains of people who take it. The mystery lends a certain magic to lithium. Although some patients experience side effects including weight gain, brain fog, brittle hair, increased thirst, poor memory and lethargy, and still others stop taking lithium because they miss the joyful exuberance of their manic states, many people with bipolar disorder can't imagine life without it. As the writer Jaime Lowe put it in the title of her powerful personal essay in The New York Times Magazine, "I Don't Believe in God, But I Believe in Lithium."

## Act IV: Batteries That Keep Going And Going And Only Sometimes Burst Into Flame

Thomas Edison died in 1931 with a tin of lithium on his desk. One of the final projects in the great inventor's life was experimenting with new chemistries in what he called “storage batteries.” The perfect battery — one that was cheap, rechargeable and packed with power — was an elusive quarry.

Batteries go back to 1800. That year, the Italian scientist Alessandro Volta stacked plates of zinc and copper, separated by cloth soaked in brine, and found that he could generate a steady electric current between them. It was the world’s first “battery,” and it’s where we get the term “voltaic cell.”

The first rechargeable batteries were invented decades later. In 1859, the French physicist Gaston Planté devised a rechargeable battery using lead electrodes in sulfuric acid, a basic formula that, with some improvements, is still used to start cars, boats, lawnmowers and other engines.

Edison scorned the idea of using lead. “If Nature had intended to use lead in batteries for powering vehicles,” he insisted, “she would not have made it so heavy.” He tinkered with batteries made of nickel and iron in a solution of potassium hydroxide. He found that his battery’s capacity improved by 10% when he added lithium hydroxide to the electrolyte mix, an encouraging development for a valuable new market: electric vehicles. In 1897, the bestselling car in the U.S. was the electric Columbia Motor Carriage. Back then, electric vehicles were outcompeting their counterparts powered by petrol and steam. New York City even had a short-lived electric taxicab service called the Electrobat.

By 1914, Henry Ford and Edison were dreaming up a low-cost electric vehicle. But Edison struggled to create a battery light enough and energy-dense enough to power a vehicle over long distances. If he had succeeded, it’s possible to imagine an entirely different course for automotive history. Eventually, however, the internal combustion engine won out, ushering in more than a century of fossil-fuel-powered transport with devastating consequences for the planet.

In the years that followed, lithium took on leading roles in various fields. Because it can withstand high temperatures and is water resistant, grease containing lithium salts was adopted for use in aircraft engines; today, it dominates nearly three-quarters of lubricating needs across all industries. It is a valuable material in metallurgy, where it is alloyed with aluminum to make airplane fuselages, bikes and high-speed trains. When blended with magnesium, lithium can create armor plating.

Because it lowers thermal expansion, lithium is a useful ingredient in ovenproof ceramics and in the glass-ceramic surfaces on induction cooktops. It is employed as an absorption material in air conditioners and humidity control systems. The lithium-6 isotope is used in the core of nuclear weapons, its reactivity escalating the power of a thermonuclear explosion. It's in fireworks too, burning a brilliant red.

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*"Small, lightweight lithium-ion batteries made portable technology possible."*

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After the 1973 oil crisis, however, scientists picked up where Edison left off, exploring lithium's potential energy. At that time, Exxon began pouring money into developing batteries as an alternative to hydrocarbons. Among the scientists employed in the company's New Jersey research labs was a British-born American named M. Stanley Whittingham who thought the obvious key to creating powerful, lightweight batteries lay in the lightest metal on the periodic table: lithium.

2. Around this time, the U.S. Food and Drug Administration pulled lithium-chloride from American grocery shelves. Marketed as a healthy, sodium-free alternative to table salt, lithium chloride had been leaving diners with weakness, nausea, tremors and blurred vision — all symptoms of lithium poisoning. After several deaths, the F.D.A. banned the addition of lithium to food and drinks.

As Steve LeVine wrote in "The Powerhouse: Inside the Invention of a Battery to Save the World," Whittingham was still a post-doc at Stanford University when he found that he could move lithium atoms from one electrode to another, at room temperature, without much damage to either electrode. It was the first example of a rechargeable lithium-ion battery. In 1977, Whittingham put that technology to use in a thin, coin-sized battery that could fit into a solar-powered watch. When he and his team tried to scale up the batteries' size, however, they ran into the problem of lithium's reactivity — his batteries kept igniting in the laboratories in a process called "thermal runaway," a phenomenon that still starts dangerous fires, forces airplanes into emergency landings and requires postal workers to ask if any lithium batteries are in packages being mailed.

An Oxford scientist named John Goodenough expanded on Whittingham's work. In 1980, he found that when he paired lithium with cobalt oxide, the resulting battery was safer and had a much higher voltage, enabling it to power larger devices. This chemistry is still used in most lithium-ion batteries today, especially in electronics. By the late 1980s, a Canadian company called Moli Energy was producing lithium-ion batteries with pure lithium metal as the anode, the negatively charged electrode in a battery that releases electrons to be absorbed by the positively charged cathode. Moli's battery was powerful — but dangerous.

"Everyone knows the holy grail of batteries is lithium metal," said Venkat Srinivasan, a battery scientist at Argonne National Laboratory. "That's the best nature has given us. The problem with lithium is it reacts with everything."

When one of Moli's batteries caught fire in a Japanese cell phone, Moli recalled them all. The company went into bankruptcy, and lithium-ion battery engineers went back to the drawing board, this time using lithium in the battery's cathode.

A few years later, Japanese scientist Akira Yoshino propelled the research forward into a safe, powerful, market-ready battery for consumer electronics. Yoshino used Goodenough's lithium cobalt oxide cathode with an anode of petroleum coke, which is made of graphite crystals, where the lithium ions could nestle safely when discharged. He coated these materials onto paper-thin sheets separated by a layer of electrolyte goop. These sheets were rolled together inside a metal canister to create the first successful mass-produced lithium-ion battery. It was a third smaller and lighter than standard batteries — and even more powerful.

The three lithium-ion battery pioneers — Whittingham, Goodenough and Yoshino — were awarded the Nobel Prize in Chemistry in 2019 for their work in "making possible a fossil-fuel-free society."

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Small, lightweight lithium-ion batteries made portable technology possible, starting with Sony's camcorders in 1991. Then came cordless phones, laptops, cell phones and tablets. Lithium-ion batteries have become cheap and reliable enough that we've dreamed up other uses for them. Now we find them in power tools, vacuums, electric toothbrushes, headphones and kitchen mixers. An iPhone 15 has about 1 gram of lithium in its battery. An average electric vehicle battery, on the other hand, contains 8 kilograms (almost 18 pounds) of lithium. Just as lithium-ion batteries now dominate global lithium consumption, electric vehicles dominate the battery market.

Battery chemistry has shifted over time. Lithium iron phosphate batteries are cheap, safe and readily used in shorter-range cars, especially in China. In 2000, Mike Thackeray, a chemist from South Africa, patented a lithium battery involving nickel cobalt manganese oxide. That formula powered the Nissan Leaf and became so successful that now half of EVs sold worldwide use it.

Battery innovators aren't slowing down; lithium-ion battery recipes are always being refined. Engineers are looking for alternatives to cobalt, for example, which is expensive and often mined with child labor in the Democratic Republic of Congo. The lithium-ion battery field is open to constant tinkering. "Nature just doesn't give you nickel cobalt manganese oxide," Srinivasan explained. "There's all this architecture and very careful manipulation that happens in lithium battery work."

Research continues into cheaper, safer, more energy-dense lithium-ion battery chemistries. In the near term, silicon shows promise as an anode in a cheap, powerful, fast-charging battery. On paper, lithium-air batteries, a lightweight chemistry using pure lithium as an anode and oxygen as a cathode, offer energy densities close to gasoline's. Many researchers are trying to overcome the safety hurdles of going back to the "holy grail" — pure lithium metal in the anodes of solid-state batteries. Lithium metal tends to form needle-like "dendrites" in batteries, which can short them out and create fire hazards. This may be avoidable, but if they're ever to reach mass production, they will have to be perfect, every time.

Other non-lithium batteries with materials such as iron, sodium and zinc have benefits for specific applications. But the chemical structure of lithium is unique. No other element is as light and as willing to share an electron, which is what creates energy. New technologies will emerge, but lithium has enamored us with its potential.

Srinivasan imagines a near future in which we have diverse arrays of batteries everywhere. Batteries could harvest electrons from lamps on our desks, for example, from treadmills at our gyms, from intermittent energy sources like the sun and wind and tides. Batteries could emerge that can store grid-scale energy for days, weeks, months or even seasons. Battery evangelists seek batteries with lifespans of 30 or 50 years or longer, batteries that can find ways to repair themselves — batteries, in other words, that are almost like organisms, with lithium as the blood beating within them.

### Act V: The Future Is Electric, But Still Massively Complicated

Today, lithium is everywhere. It's in the watches on our wrists, in the phones in our pockets, the tablets in our bags. It's in our medicine cabinets, our casserole dishes, even inside our bodies in medical devices like pacemakers and defibrillators. It's in our kids' toys, our hedge trimmers, our flashlights. It's in our bikes, scooters, cars and buses. Without lithium, our constantly connected, mobile lives would be impossible. It's little wonder people are calling lithium "white gold."

But like actual gold, and like "black gold" of the fossil-fuel era, the race is on to find new sources and greater quantities of a substance that we depend upon for all that we've come to expect and all that is yet to come. Anyone who imagines a future of electric passenger planes, long-duration grid storage and air taxis is conjuring a dream founded on lithium. Where will it all come from, and at what cost?

Before 1988, the U.S. had been the world's chief producer of lithium for about 30 years, thanks to spodumene blasted out of the Kings Mountain mine in North Carolina. American lithium went around the world. Then Chile began producing it cheaper by pumping brine out of vast underground seas and evaporating it to harvest the lithium salts. Today, Chile and Australia produce most of the world's lithium. Less than 1% of global lithium now comes from the U.S., all from a single brine operation in Silver Peak, Nevada.

That's about to change. The U.S. Geological Survey estimates the U.S. has 14 million metric tons of lithium deposits scattered across the country. We're going to need it — the Biden administration is aiming to halve carbon emissions and is pushing for half of new vehicles to be electric by 2030. Consequently, lithium's price is climbing. In 2022 alone, the price of it went up 400%. It's stabilized since, but researchers estimate lithium demand will increase five-fold by 2030.

The U.S. is scrambling to secure an independent lithium supply chain from mine to refinement to battery factories so it doesn't have to rely on competitors like China. The next decade could see an explosion of lithium production in this country. As of March, in the western U.S., there are 130 lithium mining proposals awaiting approval, with 83 in Nevada alone.

Chief among them is a new mine poised to begin production in the coming years in a clay deposit at Thacker Pass, in northern Nevada, the largest known lithium source in the U.S. The mine is owned by Vancouver-based Lithium Americas and partly funded by a $650 million investment from General Motors, plus a record-setting $2.26 billion loan from the U.S. Department of Energy.

Now under construction, the mine is not without controversy. It sits on land considered sacred to members of the Fort McDermitt Paiute and Shoshone Tribe. In 1865, the 1st Nevada Cavalry raided a Paiute campsite there and killed at least 31 people. At that time, white settlers were expanding westward in search of gold. Today, some tribal members worry that their sovereignty is being trampled in the name of unfettered eco-capitalism. Most identified lithium resources in the U.S. are within 35 miles of a Native American reservation.

Environmentalists are warning of other dangers, too. In 2022, the U.S. Fish and Wildlife Service listed as endangered a rare flower called Tiehm's buckwheat that only grows in southwestern Nevada on the site of another proposed lithium mine at Rhyolite Ridge. The U.S. Bureau of Land Management is conducting an environmental impact assessment on the project, but the mine is expected to go ahead. Meanwhile, in the vicinity of the Thacker Pass mine, the U.S. Fish and Wildlife Service is monitoring another species that may warrant protection: the Kings River pyrg snail, a species that has only been found in 13 localized springs and is as small as the tip of a ball-point pen.

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*“Without lithium, our constantly connected, mobile lives would be impossible. It’s little wonder people are calling lithium ‘white gold.’”*

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The debate around lithium mining divides people in unexpected ways and forces us to examine our priorities. Is it more important to ensure the supply of a material that will help wean us off fossil fuels? Or is it more important to protect biodiversity in an age of mass extinction? Is it cultural genocide, as some say, to put a mine on land sacred to tribes? Or might these mines offer those communities secure, high-paying jobs, tax income and a stake in the profits of an element that has to be mined somewhere?

Unlike fossil fuels, lithium-ion batteries have the potential to be recycled. Because it is made up of elements, when a battery comes to the end of its life, it can theoretically be disassembled and repurposed. Around the world, companies are cropping up to recycle batteries, saving money and lowering the urgency for new mining.

Innovations in extraction could mitigate the intensive water use of lithium production, too. A startup called Lilac Solutions is pioneering a type of ceramic bead that absorbs lithium out of brine without the conventional need for a vast evaporation pond. The company says its process uses much less water than conventional lithium extraction. The brine is simply pumped from its source, mixed with the beads, and then returned. Lilac soon hopes to start extracting lithium from Utah’s Great Salt Lake.

Could there be unforeseen downstream effects of our rapacious appetite for lithium? Some scientists worry that the more we extract lithium from minerals and underground brines, the more it disperses into our drinking and irrigation water. More lithium in drinking water may lead to fewer suicides and less violent crime, but at a certain level, a medicine becomes a poison. Globally, there are still no recommendations on a safe amount of it in drinking water; a study of almost 200 pregnant women in Argentina found that drinking water with elevated lithium levels may impair thyroid function and is associated with smaller newborns. Even less is known about the impact of lithium in agriculture, although a paper published this year noted that lithium may inhibit plant growth and decrease soil nutrients.

There are technological concerns around lithium, too. Just as our full-scale embrace of the internal combustion engine facilitated our addiction to fossil fuels, the buildup of lithium battery technologies could inhibit the growth of competing chemistries. Lithium-ion batteries have a significant head start in research, financing and manufacturing at places like Tesla's Gigafactory in Nevada. Some argue that the government should be subsidizing other battery technologies — hydrogen fuel cells, for example — so that competition remains robust and we don't paint ourselves into a corner with lithium.

We've only been aware of lithium for a little over 200 years and yet it's had a profound impact on the human story. As this simple, lightweight, reactive metal increasingly powers our lives, do we run the risk of despoiling the very planet we're trying to protect?

Long before cell phones and climate anxiety and the Tesla Model Y, long before dinosaurs and the first creatures that climbed out of the ocean to walk on land, long before the Earth formed from swirling masses of cosmic matter heavy enough to coalesce, back, way back, to the infant universe, to the dawn of matter itself, there were just three types of atoms — three elements in the blank canvas of space. One of them was lithium. It was light, fragile and extremely reactive, its one outer electron tenuously held in place.

Everything we have done with lithium, all its wondrous applications in energy, industry and psychiatry, somehow hinges on this basic structure, a sort of magic around which we're increasingly engineering our future. Lightness is usually associated with abundance on the periodic table — almost 99% of the mass of the universe is just the lightest two elements. Lithium, however, is the third lightest element and still mysteriously scarce. "It's peculiar," Fields, the astronomer, told me. "It's special. There's very little of it, but it has this pivotal role in the universe."

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Published by the Berggruen Institute