

“We’ll get the lead out of the iron meteorite. You measure its isotopic composition and you stick it into the equation. And you’ll be famous, because you will have measured the age of the Earth.” —*Harrison Brown*

I said, “Good, I will do that.” And he said, “It will be duck soup, Patterson.”

## Duck Soup and Lead

Oral History — Clair C. Patterson

*Clair C. “Pat” Patterson, who first measured the age of the Earth (4.6 billion years) and whose work on the ubiquitous high levels of lead played a significant role in the passage of the Clean Air Act of 1970 and in the removal of lead from a number of substances including gasoline, died December 5, 1995.*

*He had come to Caltech as a research fellow in 1952, eventually becoming a senior research associate, and finally accepting a professorship (he didn’t believe tenure should be a scientist’s goal, just one of his many iconoclastic views) only in 1989, three years before he retired. He was awarded the \$150,000 Tyler Prize for Environmental Achievement in 1995.*

*The following article is adapted from interviews conducted in March 1995 by Shirley Cohen for the Caltech Archives Oral History Project. It has been edited and condensed, and some portions, for want of space, have had to be omitted completely. Patterson begins his story with his childhood in Mitchellville, Iowa, in the farmland outside Des Moines, where he was born in 1922. His father was a rural mail carrier; his mother, who was a member of the school board, gave him his first chemistry set. He earned his AB in chemistry in 1943 at Grinnell College, where he also met his wife Lorna (Laurie). A year later he got his MS, also in chemistry, from the University of Iowa, which is where we join the story.*

**Left:** Clair Patterson was photographed at Caltech’s 1993 Commencement by Yigal Erel, his last graduate student, who was awarded his PhD at that ceremony.

**Right:** Laurie and Clair Patterson at their own graduation from Grinnell College in 1943.



Clair Patterson: I got a master’s degree in nine months. Then there was a chemistry professor at the University of Iowa who said, “Patterson, you’ve got to go to the University of Chicago and work on the atomic bomb.”

Shirley Cohen: But he wouldn’t have known about the atomic bomb then?

CP: Yes, because that’s where he went.

SC: I thought it was such a big secret.

CP: Oh, it was only a secret to chimpanzees who didn’t know what they were doing. He was going to the University of Chicago to work on the atomic bomb, and he wanted to take me along. I had become a spectroscopist. I had done research in molecular spectra at the University of Iowa for my nine-months, whiz-bang, master’s degree. While I was there I got into atomic spectra a little bit. So now, at the University of Chicago I was doing atomic-emission spectroscopy. They were analyzing the various products of the uranium when it disintegrated.

*{Here Laurie Patterson fills in some gaps: “Pat and I left Iowa City to work on the Manhattan Project in the spring of 1944, soon after we were married. We lived in an apartment hotel across the street from the Museum of Science and Industry in Chicago. Pat became more and more unhappy at being in the city, doing work we both felt would let the ‘genie out of the bottle’ much too soon. We went to Iowa for a weekend late in the summer of 1944 in order for Pat to enlist in the army. (He had been rejected because of nearsightedness during our senior year in college, when all but 19 men of our graduating class left Grinnell to go into the services.) The physical requirements had been lowered, and he felt he would be accepted at this time. He set this in motion with his draft board; I enlisted in the Waves. Three days later his draft board reported that they could not draft him*

because of his high security rating and he must return to the University of Chicago. Fortunately, I had not turned in the final papers and was not yet formally a Wave. We returned and were asked to meet with the colonel in charge of the Manhattan Project at 5th Army Headquarters. He suggested that he send us to Oak Ridge, where there were many young people. Pat felt he was the only young male on the streets of Chicago and that he was a 'draft dodger.'"}

So we went down to Oak Ridge, and that's where we spent another year and a half or two years, working at the uranium 235 electromagnetic separation plant. At Oak Ridge I got into mass spectrometers. You see, the isotope of uranium that they wanted was uranium 235, which is what you made the nuclear bomb out of. But 99.9 percent of the original uranium was uranium 238, and you couldn't make a bomb out of that. But the little tiny bit that was  $U^{235}$  had a different mass, and you could separate them using a mass spectrometer.

SC: Is this where you met Harrison Brown?

CP: No, he was there, but I didn't meet him until after the war. Harold Urey wasn't there but he had done the theoretical work at Columbia that the Oak Ridge diffusion plant was based on. (There were both electromagnetic separation and diffusion separation at Oak Ridge.) That's where Urey got his ideas about isotopic fractionation being a function of temperatures. This was the



The Pattersons enjoyed escaping to the Cumberlands from nearby Oak Ridge, Tennessee (1945).

insight that enabled him to develop the concept that led to what we call paleotemperatures—the measurement of temperatures 200 million years ago. This is Sam Epstein's stuff. {Epstein is now the William E. Leonhard Professor of Geology, Emeritus.}

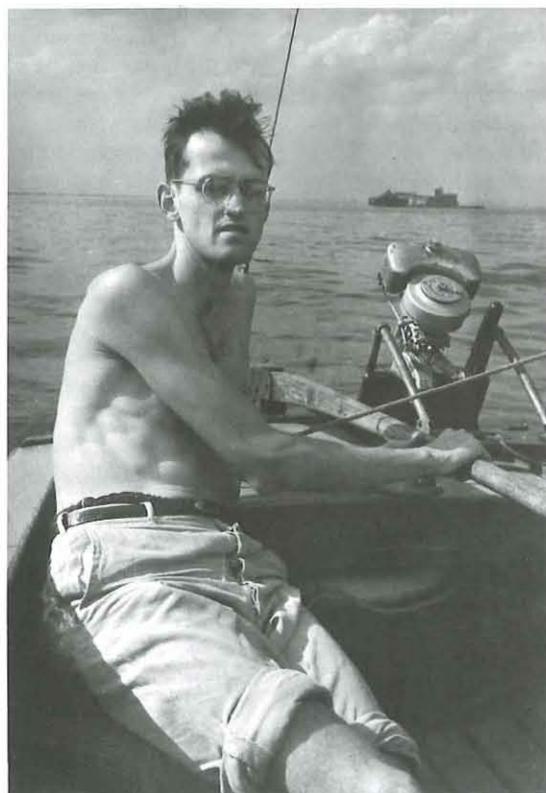
These guys during the war developed these concepts, you see, and they kept them on the shelf. They knew that they were working as engineers on a hideous weapon of warfare. They were the same types as my mentor at the University of Iowa who told me, "Patterson, we are saving democracy for the world against fascism." These professors, who were no longer at the university but working on the bomb project, told young people like me that this was the thing to do—this hideous crime we were committing was a necessary thing.

I didn't think this way then, only later. But during that time I learned a lot of new ideas and concepts and patterns of thinking. So when the war ended, I said, "I want to go back to the university. I love the University of Chicago. I'm going to go there and I'm going to get my PhD in science and study some of this important stuff."

Harold Urey, Harrison Brown, and all these guys flocked back to the University of Chicago. And all these ideas that had been cooking around in their minds during the war then came to fruition as goals. This had nothing to do with making the atomic bomb. These were scientific concepts that dealt with atomic physics and chemistry.

So when I went to the University of Chicago, Brown found out about me {Brown became Patterson's research adviser} and said, "Hey Pat, you're familiar with mass spectrometers. Now, there's this other youngster, George Tilton. What we're going to do is learn how to measure the geologic ages of a common mineral that's about the size of a head of a pin. It's called zircon." Little tiny zircon crystals occur as a minute trace constituent of common ordinary igneous rocks.

The University of Chicago wasn't all work and no play. Here Patterson sails on Lake Michigan in 1947.





**The laboratory proved too small to contain Harrison Brown, who eventually became professor of science and government as well as professor of geochemistry.**

When those rocks crystallize and form from magma, a lot of different crystals form in there, and among them are tiny bits and pieces of zircon. They have uranium but no lead. And as they sit there, the uranium decays to lead, and you can do uranium-lead measurements. However, the amounts of uranium in there are only a few parts per million, and that's decayed to even smaller parts of lead.

What Brown wanted Tilton and me to do was to develop mass spectrometric techniques to measure amounts of uranium and study the isotopic compositions of amounts of lead that were a thousand times smaller than anything anyone had ever looked at before.

Three different methods had been developed for measuring ages: the uranium-lead age, the potassium-argon age, and the strontium-rubidium age. I didn't work on the latter two, only on the

If we only knew what the isotopic composition of primordial lead was in the Earth at the time it was formed, we could take that number and stick it into this marvelous equation that the atomic physicists had worked out. And you could turn the crank and blip—out would come the age of the Earth.

uranium-lead. I was the lead man, and Tilton was the uranium man.

Tilton only had to measure concentrations. I had to measure isotopic compositions, and that is different. And Brown said, "Well, Pat, here's the deal. Once you do that, then here's what you do." Brown had worked out this concept that the lead in iron meteorites was the kind of lead that was in the solar system when it was first formed, and that it was preserved in iron meteorites without change from the uranium decay, because there is no uranium in iron meteorites. Now, this is crucial

because when other parts of the solar disk of the planets were forming—for example, the Earth—they took in both lead and uranium. Therefore the lead in the Earth today is a mixture of two things: the primordial lead that was there in the beginning, and the lead that has been created by uranium decay since the Earth was formed.

There are two isotopes of uranium that decayed to two different isotopes of lead, and there's also thorium, which decays to another isotope of lead. So you have three different isotopes of lead. And the whole thing gets mixed up. You've got all these separate age equations for the different isotopes of uranium and different isotopes of lead that were formed. And it was not known what the isotopic composition of lead was in proportion to these different isotopes in the Earth when it was first formed. If we only knew what the isotopic composition of primordial lead was in the Earth at the time it was formed, we could take that number and stick it into this marvelous equation that the atomic physicists had worked out. And you could turn the crank and blip—out would come the age of the Earth.

So Brown said, "Pat, after you figure out how to do the isotopic composition of these zircons, you will then know how to get the lead—you will have it all set up. You just go in and get an iron meteorite—I'll get it for you. We'll get the lead out of the iron meteorite. You measure its isotopic composition and you stick it into the equation. And you'll be famous, because you will have measured the age of the Earth."

I said, "Good, I will do that." And he said, "It will be duck soup, Patterson."

SC: Did he ever work in the lab with you?

CP: No. He came in one time. He was trying to show us something. It blew up in his face. He had to stick his head under the water faucet. He was better out of the lab.

It was a very fruitful type of pioneering work. But I hadn't yet gotten to the measurement of the age of the Earth and studying the lead in iron meteorites, which Harrison had told me was duck soup five years earlier.



Patterson uses a distillation apparatus to purify reagents in his Caltech lab in 1957. He didn't trust the purity of commercial chemicals, so he redistilled them.

I became aware of the contamination problem because I kept getting the wrong answer for lead in these zircons. We knew what the amount of lead should be because we knew the age of the rock from which it came and because of George Tilton's measurement of the amount of tiny bits of uranium in there. We could calculate how much lead there should be and what its isotopic composition should be. And it kept coming up with the wrong number, so I had to figure out why—to go to all these sources for different possibilities. That's how I found out all about this contamination—that there was lead coming from everywhere. And in the process of finding this out, I learned how to analyze very low concentrations of lead in everything—in common ordinary things like hair, clothing—that people had never thought about.

SC: I'd like to talk a little bit more about your interaction with Harrison Brown over the years that you were his student.

CP: Well, I got my PhD at the University of Chicago after five or six years of work there. George Tilton and I published a paper on how to determine the ages of the tiny zircon crystals in the rocks. This was very important because it is one of the three major methods that were subsequently used to delineate the geologic history of the Earth. It was a very fruitful type of pioneering work. But I hadn't yet gotten to the measurement of the age of the Earth and studying the lead in iron meteorites, which Harrison had told me was duck soup five years earlier.

When I was finishing my PhD, I said, "Well, Harrison, I really would like to continue this work and measure the age of the Earth and get the lead out of the meteorite, but I need to work as a post-doc here at Chicago to do that." And he said, "OK, Pat, go ahead." The Atomic Energy Commission had financed George's and my work for

**Right: Patterson and his family in 1955—Charles, Cameron, Claire, and, in front, Susan.**  
**Below: 1957—Patterson loads a sample for analysis in the mass spectrometer.**



the five previous years, and since they had financed us for work that led up to this, I wrote a new proposal. They turned it down. They said they weren't interested in measuring the age of the Earth.

I cried on Harrison's shoulder. He said, "Pat, that's all right. I'll rewrite your proposal in my name." And you know, he's very good at explaining things to people in a nonscientific way. So he rewrote the darn thing. Boom. I was awarded a postdoc fellowship. I did about half the work in one year in getting lead out of meteorites to do this, and then Harrison got offered a big job here at Caltech in the geology department. And he brought me along with him.

SC: And you just said yes?

CP: Yes, of course. Because I wanted to continue this work. After he came, he got more money out of the Atomic Energy Commission to build a mass spectrometer here, to build me a laboratory to work in. And in that laboratory I isolated iron-meteorite lead. But I didn't have a mass spectrometer built yet, so I flew back to the University of Chicago and used their new one to measure this stuff. It was wonderful. And that was the data that I used to publish this paper delineating the measurement of the age of the Earth. This was in

1953. It was the first measurement of the age of the Earth to be published.

It was not understood by the geological scientific community at all—how this was done or anything about its meaning or significance. It was a dozen years before this number got into the geology textbooks. Before then the age of the Earth was very vague—some billions of years. Then when the correct number began to appear in the geology textbooks, they never said how it was determined, only that it was due to uranium-lead geochronological measurements.

But what was said was incorrect, of course. It wasn't until maybe 10 or 15 years later that a few of my colleagues were able to really do this correctly. You must recognize that this number that I had measured related to the time of the coalescing of this planet out of the solar disk. Now, that is a finite period of time. But do you have a billion years for this to take place—which is a substantial fraction of the time that's passed since the Earth was formed—or was it just a very short time? Well, they were working on that. And I didn't give two hoots for that. My attitude was: "I don't want to work on that stuff anymore. What I want to work on is the evolution of the Earth—what happened to the Earth itself during the time it was coalescing."

Now, the reason I could do that was that we could use lead isotopes as measures. But the isotopic composition of the lead was changing—it was dynamic, because uranium was decaying all the time, and there were three radioactive progenitors of three different isotopes in this lead that were being added all the time the Earth was there. These parts were moving around all over the place, and uranium and thorium were being separated from each other and from lead, due to the different chemical properties in these different components that were moving around. Some had sulfur, some had oxygen, some had silicon. And these different components would grab onto different chemical

strengths of the lead, uranium, and thorium, and segregate them in different parts, so that the proportions of lead and uranium and thorium would change for millions and hundreds of millions of years at different areas. The lead within would have a different isotopic composition. And you could track this.

So, today, you could look at the lead in rocks and begin to put together a picture of how they had been chemically related in past times. And you could get other people's work to help you interpret what that chemistry meant in terms of position in the Earth. And then we could get times. So that's what I was interested in, what I started out doing. I said to hell with this damn stuff about cosmology of the sun to the planets. There were other people who were very interested in that, so they worked their hearts out to prove I was wrong.

SC: They didn't like your number?

CP: No, no. They wanted to make discoveries. And in order to make discoveries, you can't just prove somebody's right. You want to prove that somebody's wrong.

SC: But meanwhile, you were getting grants to do this.

CP: No, Harrison was getting them. Let's get back to Harrison. In all this time, I was trying to shift back to using lead isotopes. Now, in order to do that, believe it or not, Harrison got money from the Atomic Energy Commission to do this kind of work at Caltech. He was talking about, oh, how my work was related to uranium, of course. He went through all these calculations, and he told the Atomic Energy Commission how there was enough uranium in ordinary igneous rock, that if you ground that rock up and then leached it with hydrochloric acid, you would get enough uranium to use in an atomic generator that would be equivalent in energy to 10,000 tons of coal. In other words, 10,000 tons of coal would equal the amount of energy of the uranium in one ton of granite.

SC: And they bought that?

CP: They bought that! It was that kind of sales pitch he used. Now listen, you know what I would say. I would say, "Well, I want to know how this chunk of North America evolved and then got thrown around and came over here, and how this other chunk came up later. And we want to know when this chunk came up and when that chunk came up, and how they were related to each other, what their ancestry was." And the Atomic Energy Commission would say to me, "To hell with you, Patterson! We don't care about that stuff at all."

SC: You have to know how to do it.

CP: Yes, but that's the way I would write my proposals. And I never got funded. Harrison would get them funded for me. I stopped interacting with him when he moved over to Baxter Hall (*as of 1967 Brown held a joint appointment as professor of science and government and professor of geochemistry*) and I had to start getting my own money, which I failed at, of course. But Brown protected me.

There was an important phase here in Brown's helping me get money. He shifted from the Atomic Energy Commission after about four or five years; he had a new idea. I was studying sediments. In order to figure out what was happening in the past, I would have to get oceanic sediments. You see, the rocks would erode (they'd have lead in them), and then they would form sediments, and you could measure the age of the sediments. I wanted to sample all the continents of different times, and the oceans were a mixing reservoir. And we would look at this mixture in the sediments as a function of time.

And Harrison said—he was a brilliant guy politically—"Oh, heck, the oil companies should be interested in this." Why? "Well, the isotopic composition of the lead is a tracer that helps identify the stage, or the age, to characterize the time or the type of the sediment that you have." So he convinced the oil companies that they should finance my research because it would assist them in identifying oil deposits. You know, when you drill a core, you're looking at bands in a rock. And if you measure the lead isotopes in there, it can give you more information than you had before. It could help characterize the type of sediment, so it could help you locate and identify oil deposits and reservoirs here and there. So they started. It was a national consortium of oil companies that had this big research fund that they doled out to help them do this stuff. Harrison got money from them

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1971

every year, huge amounts, to fund the operation of my laboratory, which had nothing whatsoever to do with oil in any way, shape, or form.

SC: That's called basic research.

CP: And then a very bad thing happened. We found from measuring lead in these sediments how much lead had been passing through the oceans and depositing in these sediments. Now, there are two kinds of lead: there's a soluble lead that's in the water, and then there's lead in particles. These particles are what the sediments are made out of. However, a small fraction of sediments are made out of residues of organisms that are living in the water—like zooplankton poop. And they fall down through four miles of water!

When the zooplankton residues got into the sediments down there, there'd be a chemical reconstitution, what we call "formation of autogenic minerals." It would be a rearrangement of that

stuff over a few thousand years into lattices of minerals. You could get the lead out of those minerals by just taking a piece of sediment and treating it very gently with a little diluted acid. But you wouldn't get the lead in the clay particles that had migrated out from the rivers and then fallen down and formed the bulk of the sediments. You wouldn't touch that lead. You'd only get this little tiny amount of lead that had been in the zooplankton, because that soluble lead collects on the outside of their little bodies.

The drilling project was a Scripps (*Institution of Oceanography*) operation, a gigantic one. I don't know whether this was paid for by the government or by the oil companies, or both. They would lower drills down through four miles of water, and then they would bring these cores back up. The cores were down at Scripps, and we got segments of that stuff. They came from all over the Pacific. There was a pattern scattered throughout the basin of the Pacific, so we could see what was coming from China, what was coming from North America, what was coming from South America at different times. Different stuff came at different times, depending on the climate. Now, this isn't over thousands of years, or even hundreds of thousands of years. I mean, we're talking about millions of years.

In addition to dating this stuff, Ed Goldberg at Scripps and a guy by the name of Gustaf Arrhenius (who's the grandson of the famous Swedish chemist Arrhenius) had worked out this autogenic mineral business. They didn't study lead, but they knew that this mineral was made of reconstituted plankton poop. They had identified this mineral, which nobody had done before. I knew that when I leached it with acid, I'd been taking their mineral and getting the lead out, which came from the soluble lead.

When we measured that, using the ages of the sediments, we had a measurement of the rate of the past flow of lead through the oceans all over—and this was millions of years ago. So we knew the quantity, the rate per square centimeter of sediment surface (the bottom of the ocean), grams per square centimeter per year. We knew how much was flowing through there.

Then I got some data from the rivers. There were these idiots who were measuring lead in river waters who didn't know anything about how to measure lead. And I knew that because I had previously worked out how to do the measurements for meteorites. But I took their data for river water, and I multiplied by all the rivers how much river water there is in the oceans each year. And I came out with a number for lead that was a hundred times greater than the amount that we had measured that was flowing through the oceans in the past. I thought, something is wrong here. Are these guys wrong? Or is there really that much lead coming into the oceans today?

At that time we were working out methods for

We collected the snow and brought it back here and we analyzed it and found huge concentrations of lead increasing since the 1700s until now—a 200- or 300-fold increase in the concentrations of lead.

taking what we call a profile. A ship would sit there and it would lower something and grab some water, hoist it up, and then it would lower it deeper and hoist it up. We'd collect water up and down for vertical miles, and we'd measure it.

SC: Did you have somebody on the ship doing this? You weren't on the boat yourself?

CP: Yes I was! And I got sicker than a dog!

Now, in these profiles, you look at how the concentration changes with depth. We found a huge increase in the upper portions of the oceans, which decreased to lower concentrations with depth. Now, why is that? Why should the lead be so high? The waters don't mix that rapidly. And the waters up near the top are much younger than the waters lower down. It takes a long, long time for them to mix.

So I made some calculations. What about the lead in gasoline? We extrapolated from our profiles how much lead was in the upper part of all the world's oceans, and it could easily be accounted for by the amount of lead that was put into gasoline and burned and put in the atmosphere. We had more tons put in the atmosphere from the tetraethyl lead added to gasoline than we could see in the upper part of the world's oceans. And that's what caused the problem. The oil companies were financing my work. We're in serious trouble.

SC: Even Harrison Brown would have trouble with that one.

CP: Oh, he did! And that's when he disassociated himself from me. He stopped getting money from the oil companies, and I had to start getting it myself. I needed money because since I got this idea about lead coming from gasoline, I wanted to look at the record. Where do you see that record? You see it in the snow that never melts in the

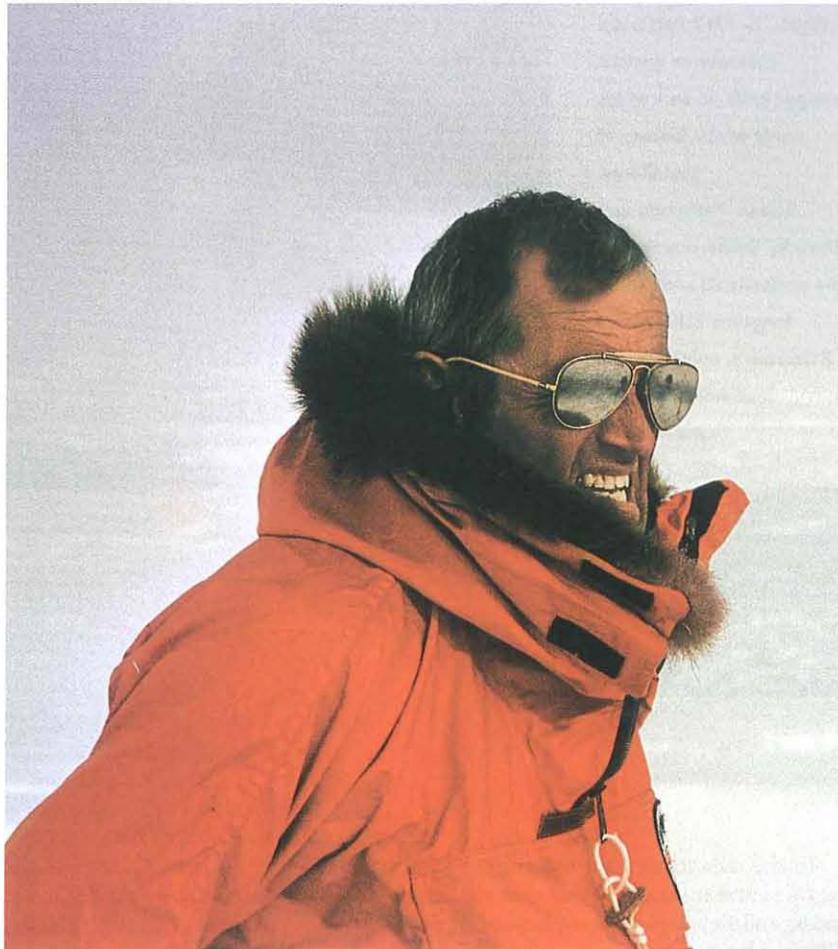
polar regions. It comes out of the air that has lead in it. Lead is in the snowflakes. It goes down and you have a layer there. Next year you have another layer.

I started working at the North Pole. We had to collect the concentrations of lead in the snow there; it was a thousand times lower than the concentrations of lead in the "pure" laboratory water in most laboratories. I had to measure concentrations that they couldn't measure. In other words, these scientists were using the purest water in the laboratories as a baseline, and they couldn't go below that level. I had to see variations with time, and the techniques for doing that at these levels were not at all developed. I required a two-foot cubic block of snow. And then we had to dig shafts down 200 or 300 meters to get these blocks of ice over a period of time to see what was happening. We sawed even larger blocks out of the walls of a tunnel, while wearing acid-clean plastic gloves and suits and using clean saws. We collected the snow and brought it back here and we analyzed it and found huge concentrations of lead increasing since the 1700s until now—a 200- or 300-fold increase in the concentrations of lead.

About the same time I had proposed a concept that I call biopurification, which has to do with what the natural level of lead should be in people. You start out by looking at the calcium in our bodies and asking where it comes from. You track it back—you look at the food that we eat, you look at the organisms that made that food, and you keep going down the food chain until you come to plants. Then you go down to the soil, and you go from there to the rocks that the soil came from. It so happens that there are calcium-like trace metals such as barium but in very small abundances—a tiny, tiny, infinitesimal trace. Barium is like calcium but it's chemically different. For one thing, it's a very massive atom. It has different chemical properties than calcium—not grossly different, just enough different so that barium is poisonous as hell. When we evolved through all these millions of years of evolution,



**On their Antarctic expedition in 1966, Patterson and his crew sawed large blocks of snow from shafts 300 feet deep and from tunnels, then shipped them back to Caltech to analyze. They found an enormous increase in concentrations of lead since the Industrial Revolution.**



nature devised an exclusion mechanism for handling this. Each one of the organisms in this food chain has to have calcium, but nature evolved a process for the exclusion of barium when they take up calcium. There are certain kinds of proteins that grab hold of the calcium and pull it, and they don't do that efficiently for barium. So there's an enormous reduction of the barium-to-calcium ratio.

Lead comes in with the calcium too. And it's distributed in the body much like calcium (not on a molecular basis—there are different proteins) but in a general, morphological distribution. Ninety-nine percent of it is in our bones.

I knew what the lead/calcium ratio is in average people today. (The people who measured this couldn't measure lead properly in bones, but I used their data anyway.) So I had the ratio going from rocks to food to people. And do you know, the ratio of lead to calcium in people was about the same as that in rocks?

Now, I compared that with barium. I got this data from my old, evil, atomic-bomb people; they measured barium in our food and in our bodies because they were measuring radioactive barium. And you know what? The barium-to-calcium

ratio in rocks dropped in our food and in us by a factor of a hundred. The barium ratio shows that lead should be a hundred times less than it actually is in us today. We are being poisoned by lead. And guess where it is coming from? Look at the ocean—that's coming from tetraethyl lead.

Others thought this was a pile of crap! They said, "Patterson, would you please start worrying about science instead of this health crap. What a waste! Here you are; you measured the age of the Earth, and you're worrying about tetraethyl lead and this stupid stuff about lead in bones." But I was right. When we finally actually measured the lead ratio—it took about 25 years to do this accurately—it turned out to be a factor of a thousand instead of a hundred. I was off—the wrong way.

*{In the last 15 years Patterson came back to work on the "lead content of people," using the barium/lead/calcium ratios to analyze the bones of current cadavers and those of ancient buried bones. After accounting for the absorption of lead from soil moisture in the buried bones, Patterson arrived at a "natural" lead level in human bones that was a thousand times less than the level in our bones today.}*

**Right:** In 1972 Patterson examines an ancient copper knife as part of his study of the history of metallurgy.

**Below:** Patterson and Dorothy Settle, member of the professional staff and a longtime colleague of Patterson's, point out the lead solder on tuna cans in 1980.



In the meantime I started going to the poles to get ice, and measuring lead coming out of volcanoes, and developing complicated devices for getting seawater.

SC: What was your motivation at this point? Were you thinking in an environmental sense?

CP: No, I was not! Science, science, science! I wanted to know what this natural level of lead is. I didn't care two hoots about verifying what the contamination was. I was forced to measure the contamination in order to arrive at the natural level. But there were friends and colleagues who were environmentalists, and they used my work. My work was used to get the lead out of gasoline. As a matter of fact, I wrote a paper on this biopurification concept where I said that we have a hundred times more lead than we should have. And that's when I really got shot down by the oil companies.

I got some money from the National Science Foundation for quite a while. And then I shifted to the National Institutes of Health and the Department of Health, Education, and Welfare and that sort of stuff. And then there was the International Geophysical Year. I had colleagues who were not working with lead, but who were working with other things that were related to lead. And we put in proposals together to get support for sample-collection procedures, the costs afield, and then I could add my laboratory and my salary and my visiting colleagues.

SC: So it was a lot of cooperation with a lot of people.

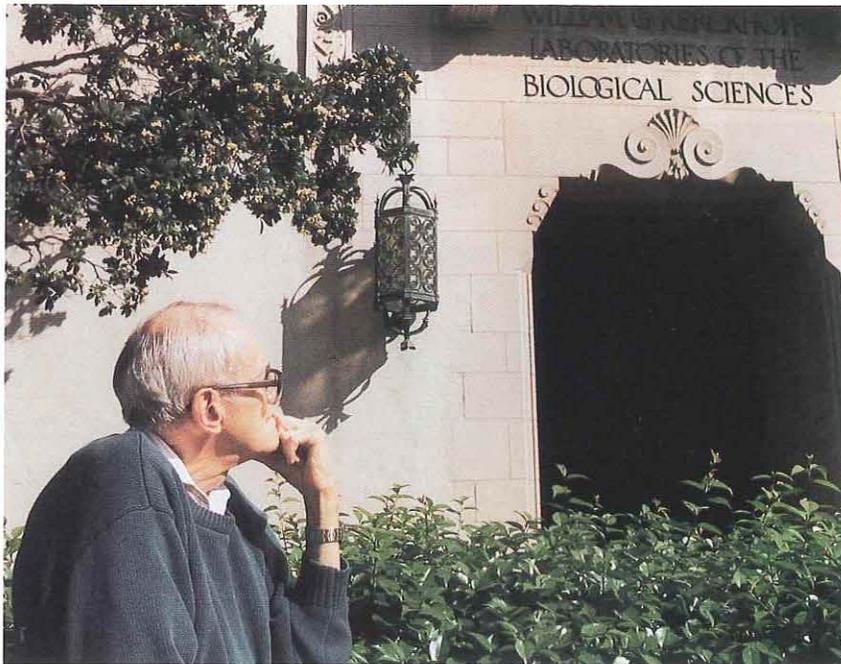
CP: Yes. Then they could use my findings as a glowing example of what was being done by these cooperative research projects. Because other people couldn't measure these numbers, they had to come to my laboratory from all over the world to find out how to do that.

We continued measuring the lead, not just in oceans, volcanoes, and the poles, but also the land areas—plants, animals, high mountains. And finally we got a picture that confirmed and clearly showed that Earth's entire biosphere was heavily contaminated with industrial lead emitted into the atmosphere from smelters and from automobile exhaust. Urban areas were further polluted by other sources of lead being moved around—solder in tin cans and so on.

At the same time, I had been investigating the history of the production of lead. I went back 9,000 years to when metallurgy began; lead came into the picture two-thirds of the way along. And then I showed how lead was related to the development of coinage in metal. I made quantitative calculations based upon data that were available from historical records of production of lead. I worked out ways to estimate from ancient data how much lead had been mined by the Greeks and Romans. I had to figure out the rate of production indirectly, about five different ways, including figuring out the half-life of coins.

I got this curve for the production of lead, which I published about 20 years ago. Some of my colleagues that I'd been teaching how to analyze lead in polar snows got together to work on this. I had dug shafts in the snow back to around the Industrial Revolution but I wasn't able to go back 2,000 years to the time of the Romans and Greeks, so I couldn't measure the lead concentrations then. But these French and Australian colleagues used new techniques that we had devel-

The Institute has a whole lot of things wrong with it—everything has something wrong with it. But because this Institute existed, I existed.



1995

oped in my laboratory to do that. *{This work was published in 1994.}* Guess what their curve was as a function of time? It fell right on top of my lead-production curve.

Do you think I was proud? No! You know what I said? “This proves that for 2,000 years we have been unable to understand the evil that we are doing to ourselves and the biosphere.” Because, you see, this lead was coming out of the Greek and Roman smelters into the atmosphere, going around the Earth, part of it working its way up, and was incorporated in the snow that fell at the North Pole.

Many of my colleagues immediately jumped on *{the evidence of the increased level of lead in human bones}*—not the people working with me but scientists who were concerned about the environment and about people being hurt by all this. They wanted to use this information, and they

did, to reduce the effects of lead on people and the environment today.

But I myself asked—what is the meaning of this? How did we think? What led us to poison the Earth’s biosphere with lead? I therefore shifted to trying to figure out how we thought, and this is where I evolved this new concept of human consciousness in terms of pathways, neuronal circuitries, that are used within the brain to think in two different modes.

*{It was, in particular, his work on Roman lead production —“the relationships between social interactions and the metallurgical technologies”— that led Patterson in this direction. His concept involved what he called a utilitarian, or problem-solving, type of thinking, and nonutilitarian thinking, which includes religion, art, philosophy, history, and science, in which “you’re trying to understand; the individual brain becomes aware of something and it asks why?” He viewed the latter as less hard-wired in the brain than utilitarian thinking, although it would have had an evolutionary role in conferring advantage on tribes who thought this way.}*

SC: You must have some good feeling for Caltech for allowing you to live this way?

CP: Oh yes. The Institute has a whole lot of things wrong with it—everything has something wrong with it. But because this Institute existed, I existed.

SC: You don’t think there would have been anywhere else where you could have lived this life?

CP: No. I would have been a molecular biologist at the University of Ohio, fighting, unhappy, quarreling, and not being able to accomplish anything. Caltech provided this environment inadvertently—it didn’t do it intentionally. It was just there. It was a magnificent opportunity. □