Rediscovery of the Elements

VISITING THE LAND OF THE CURIES.

Part 4. Fluorine: You are invited to see the Earth turn

GE Note: *Dedicated to the memory of Jim and Jenny Marshall.*



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Figure 1. The author's GPS (Global Positioning System) notes the latitude and longitude while the authors walk south on the Avenue de l'Observatoire towards the Royal Observatory. The Arago medallions, named after François Arago, lie along the meridian extending north from the observatory. The longitude (2° 20.2′) was originally considered as the Prime Meridian (the Greenwich Prime Meridian was adopted internationally in the mid-1800s). In their studies of elemental discoveries in the New World, Jim and Jenny were later confused with the written longitude reports of Alexander von Humboldt in the Americas in the late 1700s—until they recognized he was using the Paris meridian as zero longitude. The Arago plaques lead north from the observatory, even passing by the Louvre, defining the fictional "Rose Line" in The da Vinci Code.

In the 2001 Spring issue of *The HEXAGON of Alpha Chi Sigma*, the first issue of the Rediscovery of the Elements series appeared, and since then, 57 articles have run to cover the entire project, culminating in the 2016 Summer issue, shortly after the unfortunate passing of Jenny in 2014. Jim passed away in early 2025. These articles can be found on their website at: *www.chem.unt.edu/~jimm/REDISCOVERY.*

Many curious readers have queried, "Why did you take on this grand project? What was it like to actually be the first to revisit all of these sites of discovery of the elements?" In an attempt to answer these questions, a new series of articles has been written, starting in 2017. So far, 14 articles have appeared (these may be found at *alphachisigmahexagon.com*). Within this new series, a critically important site has been Paris, which was, among other things, the location of Lavoisier's revolutionary studies recognizing the true elements. The first three parts of the Paris story appear as follows; there is one installment remaining after this one.

Part 1. Tous le monde est en grève! "Everyone is on strike" (Summer 2022)
Part 2. Inside the Museum (Fall 2023)
Part 3. The Most Dangerous Element (Summer 2024)

Jim and Jenny visit the Panthéon after leaving the Henri Moissan Museum …

Exiting le Faculté de Pharmacie, where we visited the Moissan museum describing the discovery of elemental fluorine, we passed by the statue of Vauquelin and turned right, south on Avenue de l'Observatoire.

Jill, our multilingual British guide, was taking us at a brisk clip down the Avenue. "I'm taking you first down the Avenue to the Royal Observatory itself, about half a kilometer away. There is history there that will then lead us to the Panthéon."

"Tell us about it," said Jenny.

"Well, the observatory was built in the 1600s with great fanfare. It was intended to support the maritime trade, to aid in navigation. The first director was Giovanni Cassini."

"Cassini!" I exclaimed. "Any relation to the Cassini division in the rings of Saturn?"

"That's the one," said Jill. "The construction of the observatory actually predates the Greenwich Observatory in the U.K." She pointed to a plaque embedded in the sidewalk leading south (Figure 1). Here is one of the Arago medallions, leading north from the observatory. These were laid down in 1994. [N.B. These medallions figured prominently later in *The Da Vinci Code*, a 2006 movie, based on the 2003 novel by Dan Brown]. Originally, the Paris Meridian was taken internationally as the zero longitude, not Greenwich. Most of the work of the Paris observatory is now at the Meudon Observatory on the western outskirts of the city."

"I know about that place," I said. "That's where Pierre Jules Janssen was. The first one to observe helium spectroscopically. We have that on our list of places to visit."

Jill continued, "In 1851, Foucault built one of the first of his eponymous pendulums. He advertised it as demonstrating that the earth rotates, instead of the heavens moving around the earth. He said: 'Vous êtes invités à venir voir tourner la terre.' That is, 'You are invited to watch the earth turn.' He first set it up in the Royal Observatory, later moved to the Panthéon. But here we are at the observatory."

An imposing stone building with a dome lay at the south end of the Avenue de

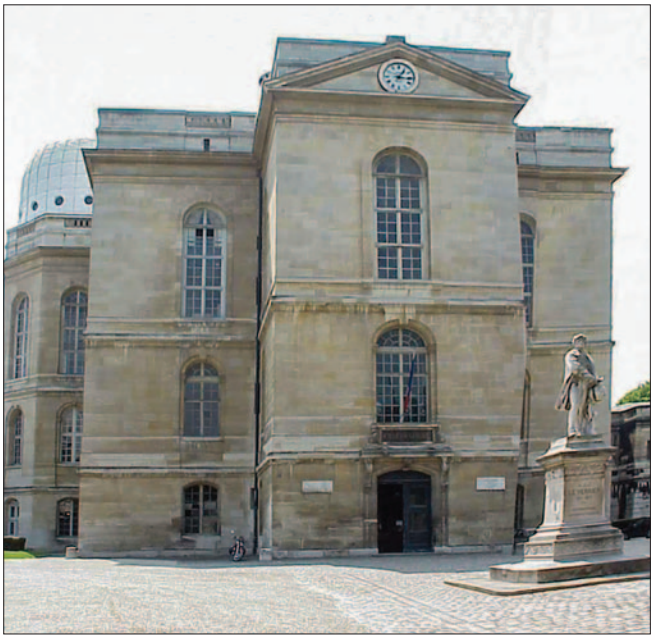


Figure 2. The Paris Observatory was built 1667-1672 (the Greenwich Observatory in England was built in 1676).



Figure 4. The Panthéon was built 1758-1790. After the Revolution, the building has served as a mausoleum for important French citizens.



Figure 3. A plaque on the observatory wall—the first determination of the speed of light was made at this observatory in 1676.



Figure 5. The weighty bob swings in a 16-second period from a 67-meter line. This demonstration was important because it was the first direct evidence that the firmament with its sun, moon, and stars doesn't rotate above us, but instead the Earth moves beneath us.

l'Observatoire (Figure 2). A statue stood outside, of Urbain Le Verrier. "I know him," I said, "he predicted the existence of Neptune from perturbations of the orbit of Uranus."

"And there's a plaque!" cried Jenny. "On the wall (Figure 3). Read it, Jimmy."

"'The Danish astronomer Olaus Römer 1644–1710 discovered the speed of light at the Paris Observatory in 1676.' Now—how in the world did he do that?"

Jill said, "He observed discrepancies in the times of eclipses of Jupiter's moons when Jupiter was either near or far from the Earth."

"Can we go in?"

"No, it's closed. We can turn now to go to the Panthéon. It's a little over a kilometer that way, to the north."

Huffing and puffing, Jenny and I both admired Jill's endurance. "I thought we were in good shape," I said, "but you're just barely breathing."

Jill smiled, "I walk many kilometers, every day. I have to, to lead several tours a day."

"And you organize all of them?"

"Yes. Specially designed, every one."

Finally, we arrived at the Panthéon (Figure 4). Jill said, "This is the grand mausoleum. Many important French people are here—not only the Curies, but Victor Hugo, Rousseau, Voltaire, many others."

We entered, "It's as big as a cathedral!" exclaimed Jenny.

"It's like a huge cavern," I said. "Listen to the echoes."

In the center was the famous Foucault's pendulum. A heavy bob spindle was suspended on a cable from the very top of the dome. It was making mighty swings back and forth across the floor, ranging from one side of an inscribed circle to the other (Figure 5).

Whoosh! Whoosh!

"It's taking forever to make a swing," said Jenny. "Reminds me of Poe's '*The Pit and the*



Figure 6. A recreation of the "shed" of Marie and Pierre Curie where radium and polonium were discovered.

Pendulum.'" She studied her watch for a moment. "Sixteen seconds for a complete cycle. That's a lot longer than my Granddaddy's clock in West Texas."

"Longer pendulum. Jenny, you were good in physics. Remember the equation for pendulum oscillatory motion?"

"Vaguely."

"2π times the square root of the length in meters divided by the gravitational acceleration, 9.81 meters per second squared, ($T = 2\pi(L/g)^{1/2}$). T is for time, a full period, full left and right swing." I looked up; the cable stretched all the way into the dome, far above. "I wonder how long the cable is."

Jill was reading the informational plaque. "Sixty-seven meters. That's over 200 feet!"

"Yes," said Jenny, always good at math, "gravitational acceleration is about 10, let's see…" She closed her eyes: "67 divided by 10 is 6.7. Let's see, the square root would be a little over 2.5. … Let's just take 2.5, double to 5, and multiply by pi, 3.14." She closed her eyes and in a moment, opened them and said, "Yep, about 15 or 16 seconds or so."

Jill stood amazed, "A cowgirl who can do celestial mechanics! Amazing! … But what is fascinating is watching the plane of the bob's movement rotate. Watch the perimeter of the circle. Note where the bob touches the perimeter of the circle. We have to wait for a while."

"I'm waiting," said Jenny. "It's now passing over … the '19' marker."… Whoosh! …"Almost exactly."

Jill said, "Now just watch."

After a minute, Jenny said, "I'm still waiting."

"Be patient."

Then, after 5 minutes, Jenny said, "Hey! It's moving! It was touching the "19" marker a little while ago. But now it's moved around—just a tiny bit."

Jill laughed. "It hasn't moved. "The Earth moved! This is historically the first direct evidence that the Earth is rotating."

Jenny said, "I thought they knew that a long time ago."

"They knew it ever since they realized the Earth was a sphere—since the days of Columbus, but there was no direct proof. Your perception—and that of all earlier peoples—would be that you're stationary and the Biblical firmament—a dome securing the sun, moon, heavens—is moving across the sky above you, a complete cycle every day. To a casual observer, there would be no reason not to believe that in fact the heavens are moving, and that we are perfectly still. So…before this experiment, there was no definite proof that it was the earth's motion that created this illusion of the movement of the heavens, even though ancient astronomers had suggested this centuries ago. And Foucault first demonstrated only a century and a half ago! Just like atoms…ever since Dalton in the early 1800s, scientists believed that the chemical world acted like there were such things as atoms, but until we actually saw them in the middle of the 20th century, it was—and for that matter, not believed by absolutely everyone—example: Ernst Mach only 100 years ago."

"And the pendulum moves a complete circle every day!" said Jenny.



Figure 7. The sarcophagi of Marie and Pierre Curie in the crypt of the Panthéon.



Figure 8. There are no elaborate inscriptions for the famous Curie couples; their history speaks for itself.

"At the North or South Pole, yes, because the Earth rotates beneath it 360 degrees a day. But it's a bit more complicated than that. It doesn't move at all at the equator. And at intermediate latitudes, it moves between 0 and 360 degrees."

"Sounds like a job for trigonometry," said Jenny.

"Precisely. Sine of the latitude. The sine of 90° at the poles, 1. The sine of 0°, Equator, 0."

"What's the latitude of Paris?"

"I know that, we just read it off our GPS. About 49°."

Jenny closed her eyes. She was not only good at algebra and arithmetic—adept left-brainer—but also proficient at geometry—a natural right-brainer. I knew what she was doing—conjuring an image of a right triangle and approximating the ratio of the appropriate two legs of it. She muttered, "Let's see…sine 30° equals one-half…sine of 45° with two equal legs, is 0.707 as I recall…sine 49° would be slightly more, maybe three-quarters, call it 0.75." She opened her eyes. "It would move three-quarters in one day, or it would take a day and a third to make a complete circle."

Jill was studying the plaque. "Incredible! This says a complete circle in 32.7 hours. Why, you said one and a third days; that's 32 hours!

You're a genius!"

I grinned, "She's a computer wizard. Makes up web pages. Teaches it at school."

"What a pair," Jill shook her head. "I like working with you folks. Do you want to see the crypts?"

"Yes!" Jenny clapped her hands.

Down the stairs we went. It was dark and solemn. A huge mock laboratory was set up with cardboard facsimiles of Pierre and Marie Curie (Figure 6). Nearby was the Curie crypt, with huge stone sarcophagi, stretching from our knees to far above our heads. In the tan stone were engraved nothing more than their names and dates. Marie's sarcophagus was stacked unceremoniously on top of Pierre's (Figure 7).

Jill said, "They were originally buried in Sceaux, Paris suburb south of here."

"Where the parents of Pierre lived," I said.

Jill said, "But then their remains were brought up here in a special ceremony in April 1995."

"Just a couple of years ago," Jenny touched the stone lightly with her fingertips. "Just like Egyptian pharaohs. They're in here."

She read the engravings (Figure 8):

"MARIE CURIE-SKLODOWSKA
1867–1934"

"PIERRE CURIE
1859–1906"

"She outlived him by almost 30 years," Jenny murmured. "Worked all that time without him."

"They omitted the slash on the 'L' in Sklodowska," I said. "It's Polish, and is not pronounced like the English letter 'l' but the English letter 'w.' Like 'Skwa-DOHV-ska.'"

Jenny looked around the crypt. "Is that all? No more inscriptions? Why aren't there epitaphs?"

Jill shrugged.

"Well, there certainly will be one on our gravestone," said Jenny. She stared off into space. "It will say: 'In order to discover new continents, one must lose sight of the shore.'" She looked at me. "What do you think of that?"

"Yes," I said, "this is our Personal Legend."

"Personal Legend? What's that?" asked Jill.

"Paulo Coelho. He adopted the term from alchemy. Used it in *The Alchemist*. Means fulfilling a lifelong quest. Coelho said that when you really wanted something, the whole universe conspires in helping you do it."

"We are part of the universe," said Jill.

Jenny replied reverently, "This room is our universe, at this moment."

Next: Searching for Lavoisier.