Rediscovery of the Elements

VISITING THE LAND OF THE CURIES.

Part 5. Finding Lavoisier

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



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The first issue of the Rediscovery of the Elements series appeared in the 2001 Spring issue of *The HEXAGON of Alpha Chi Sigma* and since then, 57 articles appeared 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 the Rediscovery website:

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 was written, starting in 2017. So far, 15 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 four parts of the Paris story appear as follows; there were no more installments written 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)

Part 4. You are invited to see the Earth turn (Fall 2025)



Figure 1. Turgot's Plan de Paris, for sale in the bookshop of the Louvre in Paris, gives exquisite detail of all features of Paris during the early 1700s.

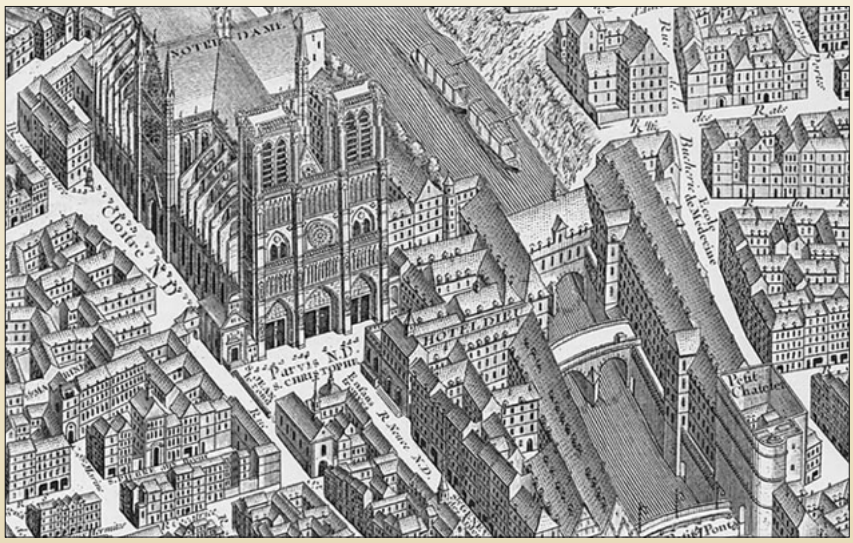


Figure 2. An example close-up of the Turgot's Plan: The Notre Dame area. The detail of Turgot's map is astonishing, with each street and building ("hotel" in French) specifically identified. North is not at the top of the Turgot map, but instead towards the lower bottom left. (Hence, the view of all Turgot map sections is southeast, in the upstream direction of the Seine).

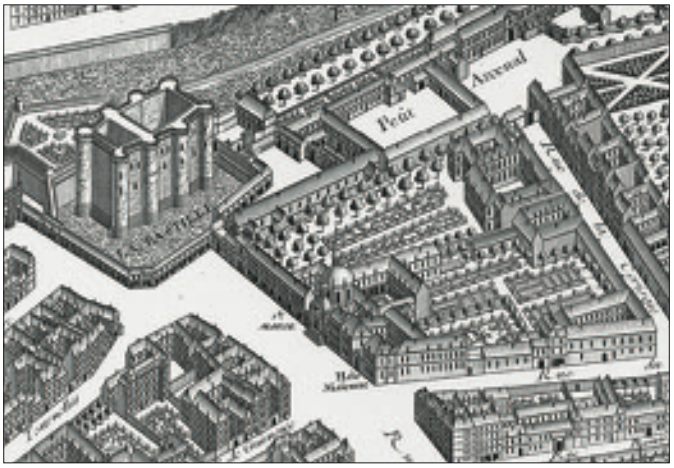


Figure 3. Close inspection of Turgot's Plan reveals the sites of the Bastille and le Petit Arsenal. Lavoisier conducted his later research in his Arsenal laboratory, located in the upper right corner of this figure. Locating the historic site of the Arsenal is facilitated by the Bastille, which no longer exists but which is now prominently commemorated as the famous Place de la Bastille, a busy traffic circle today surrounded by historic plaques.



Figure 4. The St. Merri Church (l'Église de St. Merri), where Lavoisier was christened. The Fontaine Stravinsky (Stravinsky Fountain) is in the foreground. The church is only meters west of Rue Pecquay, Lavoisier's birthplace. A full description of Lavoisier's sites found in the authors' searches of Paris can be found in their REDISCOVERY project.[1]

Jim and Jenny follow Turgot's maps, ending up at the Musée des Arts et Métiers

Continuing our Rediscovery tour of Paris, our next business was to explore the life of Antoine Lavoisier, the "father of modern chemistry." We told Jill Daniels, our Paris guide, "We know he had a full life working in Paris, finalizing his research at his laboratory at le Petit Arsenal." Jill, intimately familiar with Paris' sights, was not aware of any public memorials dedicated to Lavoisier. She searched in her copy of Hénocq's *Les Plaques Commémoratives des Rues de Paris*, but found nothing. "But you have the various addresses of his homes and activities," Jill told us, "so perhaps you could use a historical map to locate these sites while you're here. Let me introduce you to le Plan de Turgot, a detailed drawing of a 'bird's-eye view' ("oeil de vue d'oiseau") of Paris published in 1739. I'll accompany you to the Louvre, where they sell copies."

Hence, the day after our Panthéon trip (*HEXAGON, Fall 2025*), our trio took a trip to the famous Louvre Museum. In the bookshop of the museum, on the wall was a detailed drawing of the entire city of Paris, the famous Plan de Turgot. This map, measuring 2.49 meters high and 3.13 meters wide (ca. 8 x 10 feet), presented incredible detail, displaying every street, with all the buildings, houses, fences, and even trees. Jill told us, the *Plan* was commissioned by Michel-Étienne Turgot, "tête de la municipalité de Paris" ("head of the municipality of Paris"), who wanted to include "en élévation églises, édifices, fontaines, places, monuments publics pendant deux ans (1734–1736)" ("the full height of churches, buildings, fountains, places, public monuments during the period of two years 1734–1736"). The map resembled a huge Middle Eastern tapestry, inked like a huge burnt sienna lithograph. (Figure 1). The map had an isometric perspective, the same technique used today by engineers to draw three-dimensional renditions of complex machinery at an angle. It was truly a work of art, displaying a complex network of nerves—streets—with synapses—the buildings—with a huge artery coursing through it—the Seine River. Jill said, "Not only can you see fences, trees, courtyards, terraces, and parks, but perhaps more, the streets are all named, frequently the same as today's, allowing precision navigation in your explorations."

Jenny said, "Look at that building on the island, in the middle of the river. That looks like Notre Dame." (Figure 2).

"It is," said Jill, as she pointed out, "and there's the Sorbonne. And there's the Louvre. And the Bastille, which is now gone."

"I'll take it!" I exclaimed. I glanced at the price tag. "I notice the prices are now in both francs and Euros."

"Yes, they will change over completely to Euros from francs next year, in 2002."

Moments later, we unrolled our purchase on a table in the Louvre lunch room. The map was smaller than the original—(1.00 x 0.75 meters, or 40 x 30 inches) but had all the same full detail. One by one, using the street identifications, we could locate the various important locations on a modern map where Lavoisier once lived and worked. And most importantly, "Here is le Petite Arsenal," I tapped the map, "it's plainly identified! Just next to the famous Bastille! The *famous* Bastille! According to my literature research, his famous and most productive laboratory was at the southern end of le Petite Arsenal, up towards the top of the map." (Figure 3).

"Both the Bastille and le Petite Arsenal are now gone," said Jill. "But the location of the Bastille, once a famous prison, is well-known. It's now 'la Place de la Bastille,' a busy traffic circle. In the center of the circle is la Colonne de Juillet, the "July Column," commemorating the July Revolution. There's a Metro station there, unless you want to walk."

"We could take a look!" I turned to Jill, "Do you think it's possible there is some sort of monument or plaque there? Even though it is not mentioned in your book?"

"I told you what I thought about that—there is simply too much to see and know about in Paris, to have it all in one bound volume. The proud Parisians know they've got a lot to see in Paris, but there's so much they don't know where it all is."

"Let's try it!" cried Jenny. "As you once said, we never want to have to say, 'I wish we had visited such-and-such a place, we'll never know what we might have found.'"

Jill said, "All you have to do is go to la Place de la Bastille, then head southward, maybe 200, 300, 400 meters. And look everywhere."

Jenny said, "Every street."

"In fact," said Jill, "on your current city map, here's a street called 'Rue de l'Arsenal,' reaching southwest of the Bastille. That looks like a good place to focus on." She leaned back in her chair and laughed. "Well, I know what you folks are going to do today! I wish I could go with you—I have a tour scheduled in a couple of hours … After your searches, you probably want to plan on visiting le Musée des Arts et Métiers—the Museum of 'art and measurements': a museum



Figure 5. This magnificent bronze monument of Lavoisier, sculpted by Louis Ernest Barrias and inaugurated 27 July 1900, once stood on the Place de la Madeleine in back of the Église de la Madeleine. The inscription on the plinth reads (in part)"Antoine Laurent Lavoisier 1743–1894. Fondateur de la chemie moderne [Founder of modern chemistry]…" The statue was taken down and melted for bronze by the Germans in 1940. (Popular Science Monthly, ***1900***, 58, *115 (December):* Wikimedia Commons*).*



Figure 6. Place de la Bastille with its prominent Colonne de Juillet (Column of July). Bastille Day is celebrated on July 14.



Figure 7. On Boulevard Bourdon, 250 meters south of the Place de la Bastille, is this inconspicuous building, the Mairie de Paris, the local City Hall. Lavoisier's plaque can be seen two meters high on the wall, in the lower center of the figure.



Figure 8. The plaque on the Mairie de Paris, identifying Lavoisier's site. See text for translation. It was in this laboratory that Lavoisier established the Law of Conservation of Mass and recognized the true elements, launching a revolution in chemistry.

of technology, science, and industry)—where I *do* know there is a smashing display on Lavoisier."

I rolled up the map and poked it into my pack. "There are so many places to check out along the way that we will miss if we take the Metro. It's a long walk, but we already walked all the way to the Latin quarter to find the Curies, so we can do this!"

"Let's go!" cried Jenny, as she gave Jill a long hug. Jill hugged back, but no kisses on the cheeks—she was not a Parisian, but a Brit.

"Don't forget to look below your feet when you get to la Place de la Bastille. The cobblestones were taken from the prison when it was taken down."

"Au revoir!"

"Au revoir!"

Searching Paris for Lavoisier. During the 3-kilometer hike to the Bastille area, we found the various homes and other sites that pertained to Lavoisier[1], but no plaques or statues. Usually, the original sites had been removed and replaced by modern buildings. One exception was the St. Merri Church where Lavoisier was christened (Figure 4). Sadly, the most famous statue of all had been missing for almost a century (Figure 5).

After a long trek, we arrived at la Place de la Bastille (Figure 6), from which we could get our bearings for a final search of le Petit Arsenal. South of the Bastille site, we found the Rue de l'Arsenal and walked the entire length of it, about 400 meters … and found nothing.

"Oh, well," I said, "I guess we expected too much."

"Let's go over a street," said Jenny. There's a landing dock, a canal, coming in from the Seine—just to the east."

"Okay," I said. We started northward on the street parallel to Rue de l'Arsenal. "Boulevard Bourdon, I see," looking at the street sign. On the canal was a sign inscribed, "Port de l'Arsenal."

We walked back toward the Bastille, about 200 meters. "Our first cross street," I read the street sign, "Rue Bassompierre, I see. … Not on Turgot's map."

"JIMMY! Looky!"

"Where?"

"That big red brick building! There's a plaque!" (Figure 7).

We bounded over, and there it was: a marble plaque embedded on the outside wall of an office building. The plaque bore a gold-embossed inscription (Figure 8).

"It says Lavoisier!" cried Jenny. "Read it, Jimmy! What does it say?"

I traced the words with my finger, and translated:

"Here was located
THE BUILDING OF THE ADMINISTRATION OF POWDER
where worked and lived from 1776 to 1792
Antoine-Laurent LAVOISIER
Administrator of powder and saltpeter
who established there his chemistry laboratory"

"This is it!" cried Jenny, immediately starting to take photographs. "Why powder?"

"By 'powder' they mean 'gunpowder.'"

"And saltpeter?" she asked, in between her shots.

"For the manufacture of gunpowder, which requires charcoal, sulfur, and saltpeter. France was blockaded by Great Britain. They couldn't get their saltpeter from the Far East, so they had to make their own. They set up 'saltpeter refineries' where they piled up manure and garbage and soaked it with urine. The nitrogen compounds were oxidized to nitrates, which were leached off and collected."

"Ye gads. Must have stunk like Pawpaw's pig farm in Wichita Falls, Texas."

"No doubt. Actually, when we visit other localities in France in the future, we'll be dealing with saltpeter refineries in Dijon, southeast of France. That was the birthplace of Bernard Courtois, who moved to Paris, where he discovered iodine."

"What is this building used for, anyway?"

My gaze moved to the front door, several steps to the left. The entrance was identified over the transom by 'Mairie de Paris/Direction de la Jeunesse et des Sports/Direction des Affaires Scolaires.'

"It's Paris City Hall building," I said. "Directorate of Youth and Sports, and Management of School Affairs."

Jenny had finished taking photographs. I moved over and took in the scene, relishing the moment of discovery. It was difficult to imagine what it looked like over two centuries ago (Figure 9). "Here is where Lavoisier proved water was not an element, but a compound. Where he showed that air was not just a medium of combustion, but was a *reactant*. He was a genius. He didn't really discover oxygen, but he was the first to understand exactly what it was."[2]

"Does anybody else in the U.S. know this plaque is here?"

"I never found anybody who did. I actually talked to the nephew of Marguerite Perey [discoverer of francium in the Paris Curie laboratory] when we visited Oak Ridge, and he simply referred me to Hénocq's book."

"Jimmy … We're lucky again. Let's go find the museum of art and measurements."



Figure 9. This is a print of the Grand Arsenal and the gunpowder warehouse, dated from the end of the 18th century, engraving by Simon Mathurin Lantara (1729–1778), taken from the Hotel Carnavalet museum. The Grand Arsenal was on the Seine River, ca. 400 meters south of le Petit Arsenal, which is beyond the buildings in this print.



Figure 10. Le Musée des Arts et Métiers, where the exhibits of Lavoisier are located.

Lavoisier's exhibit in le Musée des Arts et Métiers. We walked to le Musée, 1.9 kilometers to the northwest. Along the way, we visited the Hotel Carnavalet museum, where we viewed models and historic prints of the Bastille and Arsenal areas. Arriving at the Arts and Métiers museum (Figure 10), there were crowds of students assembled for a tour of the museum (Figure 11). Inside the museum, indeed, we were not disappointed with the complete and full description of Lavoisier's work, including his instruments in a mockup laboratory (Figures 12–15). One especially captivating exhibit was a video (Figure 16) of Lavoisier's experiment showing that a mixture of hydrogen and oxygen, when sparked with an electrode, yielded water—proving that water was not one of the ancient elements (fire, earth, water, and air). Instead, water was a compound created by the combination of two gaseous reactants which Lavoisier recognized as elements—and named —(hydro-gen, water former, and oxy-gen, acid former).

Lavoisier was also involved in the creation of the metric system in the late 1700s. An interesting exhibit was the "decimal clock" which was designed to include time as well as length, weight, and volume in the metric system (Figure 17). The accompanying placard informed us that the French also concocted a "Revolutionary calendar" starting in "An I" ("Year One"), with 12 months named after nature, such as "frimaire" ("cold"), "nivose" ("snowy"), "floreal" ("flower"), and "thermidor" ("heat"). This calendar was dropped in 1805 by order of Napoleon I, along with the decimal clock.



RIGHT: Figure 11. The Musée is quite popular; these Parisian students are waiting for their school tour. A complete exhibit devoted to Lavoisier's Petit Arsenal laboratory is inside.



Figure 12. This is a mockup of Lavoisier's laboratory at le Petit Arsenal, which Lavoisier used in his chemical and calorimetric experiments. The conspicuous tall wheel balances were used by Lavoisier to weigh the hydrogen and oxygen to show that mass is conserved in the hydrogen + oxygen reaction.



Figure 13. Lavoisier, from his wealth as a tax-farmer, was able to procure some high-quality, expensive equipment for his scientific measurements. He was obsessed with precise weight measurements, which he used with skill to take advantage of the Law of Conservation of Mass. The Russian scientist Mikhail Lomonosov had propounded this concept previously, but not realizing that air was not just an inert medium but also a reactant, could not exploit the idea. Lavoisier "rediscovered" the law and used it skillfully to his advantage in his chemical studies involving solids, liquids, and gases.



Figure 14. This is the globe in which Lavoisier demonstrated inflammable air (hydrogen) and vital air (oxygen) unite to form water. To the left, partially hidden, is a Tschirnhausen lens he used in his experiments on diamonds at the Jardin de l'Infante beside the Louvre, where he demonstrated that diamond was carbon.

"If Lavoisier was so important and was a genius, why was he guillotined?" asked Jenny.

"Because he was a government agent, a tax-collector, he was accused of tax fraud and selling adulterated tobacco. There was a great deal of resentment engendered against the government which led to the Revolution. A story goes, perhaps apocryphal, the prosecutor at the trial announced, 'The Republic has no need of scientists…'"

"What a loss!"

"Joseph-Louis Lagrange, the famous mathematician, made a famous quotation, 'It took only an instant to cut off his head, but another like it might not appear for another 100 years.'"

"Can we visit Lavoisier's grave?"

"Unfortunately, not. He was dumped in a common grave at Errancis Cemetery. That's about one and a half kilometers north of Place de la Concorde, where he was guillotined.



Figure 15. Lavoisier's delicate equipment included high-quality brass stopcocks to deliver accurate amounts of gases.

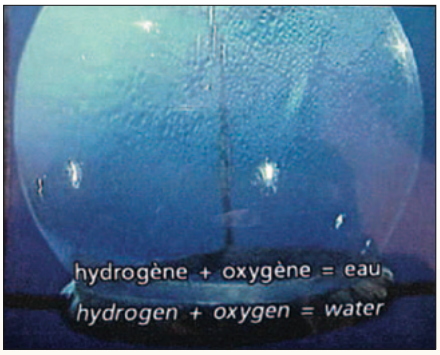


Figure 16. A detailed two-minute video demonstrates the vigorous reaction of hydrogen and oxygen, triggered by a spark introduced by an external generator. Heat is liberated inside the globe as hydrogen and oxygen react. As the globe cools, water condenses out. The water is weighed and found to have the same combined weight as the original hydrogen and oxygen. This video was taken by the authors' camera and was taken home to UNT to show to many years of introductory chemistry classes. Today, a YouTube is available on the Museum site, and is identical to the video photographed by the authors two decades ago: www.youtube.com/watch?v=DmYEz_CH9mk

Ironically, his execution was soon followed by that of Maximilien Robespierre, a key participant in the Revolution. He also was 'buried' at Errancis."

"But what about the trial? Wasn't his service to the country recognized and deemed important?"

"Not at all. At the trial, even with his record of serving and improving the city and its environment, it was claimed that there was a 'conspiracy against the French people' and 'justice must prevail.' All his science contributions and civic contributions were simply ignored. In fact, a detailed report praising his service was offered at the trial but was not even opened."

"Were a lot of scientists caught up in this 'round-up'?"

"Scientists, per se, no. A recent complete biography of Lavoisier by Poirier states that



Figure 17. Lavoisier was a member of the committee to create the metric system in 1791, a decimal system which included the meter, gram, and litre. The original system also utilized a decimal duration of time, which was introduced in 1793. In the metric clock, there were 10 "hours" in a day, with each divided into 100 "minutes," while each minute was divided into 100 "seconds." The meter, gram, and litre were adopted enthusiastically and are used today internationally, while the decimal time was soon abandoned.

'seven scientists perished as victims of their political opinions and not as men of science.'"[3] This was out of a total of some 17,000 persons who were executed during the 1793–1794 Reign of Terror. Most of the scientists laid low and waited out the crisis."

"For example, Vauquelin, whose statue we saw in front of the Moissan Museum (see *HEXAGON*, issue, year). He discovered chromium and beryllium."

"Yes, a couple of years after the 'Reign of Terror.' Remember. Klaproth? The chemist-biographer Thomson said this German chemist was the creator of the art of analytical chemistry. (see *HEXAGON*, Spring, 2022) The French counterpart, in Thomson's opinion, was Vauquelin, a close second to Klaproth.[4] Klaproth concentrated on mineralogical analyses, but Vauquelin also extended his research into organic chemistry, discovering asparagine (the first amino acid) in asparagus and malic acid in apples, and other organic substances."

"Hopefully, we can continue to trust our science and we won't ever have to face the threat of irrational 'conspiracy theories' again."

"Yes … As Poirier poignantly stated, France rapidly realized that indeed they needed scientists: 'The imagination and enthusiasm of these men would work wonders' during the post-Revolution troubled times.'"[3]

Next: More French discoveries: halogens —iodine and bromine.

GE Note. This is the last entry in the series that I received, and I leave the final line of this essay the way Jim did: to be continued. One last picture that Jenny took is featured on the cover, telling the story of running off with your companion and finding success, purpose, and rediscovery in a second life.

I salute the end of 25 years of the privilege and pleasure I have had publishing their work.



Jenny and Jim Marshall in front of their collection of elements.

References

1. A full detail of the authors' explorations in Paris, including figures with full descriptions and detailed maps, is available at: chem.unt/~jimm/REDISCOVERY%206-10-2021. The authors found past homes, schools, and work sites associated with Lavoisier, as well as several museums and others that included statues, busts, and exhibits.
2. The reader is referred to *Oxygen*, the 2001 play by Roald Hoffmann and Carl Djerassi, which discusses the contributions of Lavoisier, Priestley, and Scheele—the three contenders for the discovery of oxygen—and describes the complex process of scientific discovery.
3. J.-P. Poirier, *Lavoisier*, [English translation]. **1996**, 385–387, University of Pennsylvania Press.
4. T. Thomson, *The History of Chemistry*, **1975**, Vol II, 211–215 [reprint of 1830 edition, H. Colburn and R. Bentley, London].