



Exploded myth? Revisionist historians hope to change alchemists' image as delusional buffoons.

HISTORY OF SCIENCE

# The Alchemical Revolution

As cryptic manuscripts and centuries-old labware yield their secrets, scholars are coming to realize that medieval “chymists” were real scientists after all

For possibly the first time in 2 millennia, a chemist has used an ancient formula to transmute silver into gold. The secret, a solution called “divine water,” was in an ancient Greco-Egyptian metalworking manuscript originally written on papyrus and preserved in a mummy wrapping. Following the recipe exactly (lime, sulfur, and the “urine of a youth” combined and heated “until the liquid looks like blood”), Lawrence Principe mixed chemicals under a fume hood, heated the solution over a Bunsen burner, dropped in a silver Canadian Maple Leaf coin, and watched, pleased, as the coin turned yellow.

It wasn't real gold, of course. Principe, who holds dual Ph.D.s in organic chemistry and history of science, says the layer of gold-tinted oxidation on the coin's surface might be useful for making metal ornaments look more expensive. But if the metal's color could be changed, a 3rd century thinker might have surmised, then why not its other properties? Could any base metal be transmuted entirely into gold?

Those were reasonable questions for the

time, Principe believes. “Science doesn't progress ever forward in one grand, royal road,” he says. “It's a twisted, thorny labyrinth with multiple pathways.” Yet alchemy is certainly a thorn in the side of historians: an unwelcome reminder of science's foray into magic.

Principe and a growing number of other science historians, however, hold that alche-



Garage alchemy. Working at home, William Newman replicated a chymist's possible glimpse of atomic theory.

mists—“chymists” is their preferred, less-loaded term—were serious scientists who kept careful lab notes and followed the scientific method as well as any modern researcher. He tests that hypothesis by recreating their experiments in a sunny storage closet repurposed as a small lab at Johns Hopkins University in Baltimore, Maryland. If the alchemists saw what they claimed, he says, then it's high time for an “alchemical revolution” to restore them to scientific respectability.

In the view of these advocates, alchemists have been unjustly ranked with witches and mountebank performers, when in fact they were educated men with limited tools for inquiring into the nature of the universe. The mystical stories that shroud their writings suggest that they were busy recording spiritual visions. But the truth is more complex: As concerned as modern patent applicants about having their secrets stolen, chymists often coded their protocols behind a tapestry of arcane metaphors, allegories, and drawings. Their royal patrons encouraged such obscurity, worrying that successful transmutation of metal into gold would devalue their currency. And too much clarity could prove fatal at a time when falsely claiming success at transmutation might be punishable by death.

If the lives of the chymists weren't hard enough, in the late 17th century as the European Enlightenment took the stage, a rising class of scientific professionals began a deliberate campaign to smear the entire discipline. In a talk to Leiden University professors in 1718, the Dutch physician Herman Boerhaave apologized in advance about his topic. “I must talk about chemistry!” he said. “About chemistry! A subject disagreeable, vulgar, laborious, [and] far from the affairs of intelligent people.” Well-known scientists such as Isaac Newton and Robert Boyle dabbled in chymistry at their peril; their work was often hidden from other scholars or suppressed, only to resurface in the 20th century. While chemistry eventually regained its good name, alchemy remained a *bête noire* among historians of science for centuries. Until recently, peer-reviewed journals refused to publish papers on the topic.

“The way alchemy was presented in the early 1980s was a parody, partially created in the 18th century and added to by people who didn't read the sources and tried to recraft the sources into their own ideas,” Principe says. “But what was the daily activity of an alchemist? When he got up each morning and went into his workshop, what was actually in the flasks that he held? What was he thinking

CREDITS (TOP TO BOTTOM): THE ALCHEMIST'S EXPERIMENT TAKES FIRE, 1687/HENDRICK HEERSCHOP; DUTCH/OIL ON CANVAS LAID DOWN ON BOARD/GIFT OF FISHER SCIENTIFIC INTERNATIONAL/COURTESY OF THE CHEMICAL HERITAGE FOUNDATION COLLECTIONS/PHOTOGRAPH BY GREGORY TOBIAS; ISTOCKPHOTO; COURTESY OF BILL NEWMAN

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about?” That’s the question Principe says he’s been working on for 30 years, “and I’m still trying to answer it. It’s maybe a bit obsessive.”

Obsession is what it takes: Even after cutting through all the symbolic coding, recreating experiments is difficult. “We talk about lots of these processes as though they were easy, while they actually involve a lot of tacit knowledge,” says William Newman, a historian at Indiana University, Bloomington, who also works on chymistry re-creations—some of them with a furnace in his own garage. Considering that even the best post-Renaissance experimenters distilled phosphorus from urine, melted silver from whatever coins they might be carrying, and used inexact heat sources, their results were difficult, if not impossible, for them to reproduce. “You have to back-engineer to understand how the theory integrates with the practice,” Newman says. “There’s no better way to do that than to do the experiments themselves.”

Principe’s current pet project is to understand the glow of the Bologna stone: a legendary rock that, when placed in a fire, was one of the first recorded examples of natural phosphorescence. By chance, a 17th century cobbler who had put a piece of barite in his fire stumbled upon the perfect combination of factors to light it, but re-creating the process stumped centuries of chymists. Following clues from a manuscript by the 17th century natural philosopher (and alchemist) Wilhelm Homberg, Principe went to Italy and retrieved bits of barite from a field that is now a skeet-shooting range outside Bologna. In a replica he built of Homberg’s oven, and measuring parameters such as temperature, pressure, and gas exchange, he’s gotten them to glow faintly—just as described 300 years ago. “As I read Homberg’s description, both of the stones and how you work with them, I never understood it at a really deep level until I had done it myself,” Principe says.

Re-creating experiments, the historians say, helps describe how the mysteries that teased early chymists gave rise to modern science. For example, Newman traces atomic theory directly back to the early 17th century German chymist Daniel Sennert. The

existence of atoms had been proposed on metaphysical grounds centuries earlier, but Sennert was the first to infer it experimentally. While researching transmutation, he found that silver could be re-isolated after being dissolved in nitric acid—evidence, Sennert concluded, that metals are made up of irreducible “corpuscles.”

“A lot of scientific laws that were formulated as late as the 19th century were actually in play much earlier than we had imagined,” says archaeologist Marcos Martín-Torres of University College London. “We easily dismiss things chymists did as superstitious, but when you look further into it, they have a lot more ingenuity than we credit them for.”

For instance, as early as the 14th century, many alchemists believed that their experiments would work only if their crucibles were made in the Hesse region of Germany. While excavating labs in Austria, Martín-Torres dug up broken shards of such crucibles and analyzed their chemical makeup using scanning electron microscopy, x-ray diffraction, and other imaging techniques. It turned out there was truth behind the lore: In a 2006 paper in *Nature*, Martín-Torres revealed that Hessian potters in the 15th century knew how to make a highly heat-resistant ceramic component now called mullite. The secret, later lost and not rediscovered until the 1920s, enabled chymists to conduct technically demanding experiments.

Martín-Torres also analyzed traces of the chemicals the crucibles had held. For the most part, he says, the results agree with the chymists’ notes. “They never discovered transmutation, but they discovered modern experimental science instead,” he says—and with it tangible byproducts such as

cosmetics, pigments, and medicines.

These new realizations have brought a swarm of students to the field and inspired a growing number of international conferences on alchemy. “I can’t even keep up with the literature now,” Principe says. History is being rewritten as scholars unearth neglected manuscripts, outing a growing number of early scientists as closet alchemists.

On one such foray, Principe recently struck a glimmer of gold. He found buried in a Russian military archive an unpublished chymistry textbook by Homberg, the official chemist of the French Royal Academy. The manuscript had been hidden since 1716; Principe spent 7 years tracking it down. In it, Homberg claimed to have discovered the philosopher’s stone: the fabled element that would transmute base metals into gold.

“He was an alchemist!” Principe says with glee. Homberg had covertly searched for the secret of transmutation with the Duc d’Orleans and described his successful method in his textbook, much to the chagrin of the nascent academy. “The academy is funded by the crown; they’re publicly the most visible intellectuals

in France. You don’t want them dealing with something that has this bad reputation,” says Principe, who is currently writing a biography of Homberg. “That’s probably why his final manuscript was never published.”

So what happens if Principe manages to re-create Homberg’s last protocol right down to the pièce de résistance? “If I do, you can visit me in my lavish villa somewhere and ask me about it,” he told an audience at the 2011 meeting of AAAS (publisher of *Science*). “I won’t tell you about it, but I can offer you a glass of wine and we can talk about something else.”

—SARA REARDON

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Podcast interview  
with author  
Sara Reardon.



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