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NEWTON'S VICE

Some say alchemy inspired our greatest scientist.

We've all grown up with the story of the apple plunking Isaac Newton on the head, giving him a fruitful idea about gravity. Though it probably did not hit him, that fabled apple almost certainly did fall: Newton himself repeated the story several times. It was not, however, his only source of inspiration for the idea of gravity.

Newton was a pillar of the scientific revolution, arguably the greatest scientific thinker our species has ever produced, but he was also an alchemist. According to some scholars, his pursuit of the secrecy-shrouded, somewhat disreputable teachings of alchemy contributed to his discovery of the workings of gravity. Alchemy also shaped his thinking about the structure of micromatter, a subject for which he is less famous, but on which he came remarkably close to the mark. Such notions have never delighted the world of science.

Like most alchemists (and a few wizards of Harry Potter's world), for many years Newton engaged in the "Great Work"-the search for the mythical substance known as the philosophers' stone, said to transform base metals into gold. Like the more pious and intellectual alchemists, however, Newton was interested not in riches but in perfection.

According to tradition that stretches back to the ancient Egyptians, Arabs and Greeks, the philosophers' stone perfects all matter it touches. If that matter is a metal, the philosophers' stone turns it into gold. If that matter is a human being, however, a little taste of the philosophers' stone (more often thought to be a liquid or a powder than a stone) will work as a cure-all, and maybe even as the elixir of life, an equally fabulous substance said to restore youth and prolong life indefinitely. For the most devout alchemists in a highly religious age, the Great Work amounted to nothing less than a quest for the agent--and possibly even the process itself--through which God worked in the world.

The philosophers' stone was also said to have strange powers of attraction; it was this power, say some scholars, that Newton transmuted into the science of gravitational force acting at a distance.

an search of Newton the alchemist, I have come to his alma mater, Trinity College of Cambridge University. At my feet, a wasp bumbles around the sweet ridges of a half-eaten apple. Perched on a low wall strung with tourists, I see a tiny lawn that erupts into one small apple tree. Beyond, the grass presses up against a gabled building slung between the stone lace of a gothic chapel and the triumphal archway in a stone wall known as Trinity's "Great Entrance."

I blink and imagine myself back three centuries, to April 1686. The wall rears high, and the tree shrinks and disappears as the lawn bursts into a garden planted with geometric beds of herbs. Between two buttresses bracing the chapel bulges a wooden shed; when the door opens, smoke and pungent odors trickle out. Inside, Newton hunches alone over a furnace that has been burning day and night for many weeks.

He has dark eyes, a long, thin nose and an expression that some read as affable and others as obstinate; either way, his face is too young for the gray hair that crowns it. He is notoriously absentminded: when he remembers dinner at all, he heads for the grand dining hall wearing his church-going surplice over fallen stockings. He is meticulous, however, with his glowing crucibles and bubbling retorts filled with mercury, lead, antimony and sulfur.

This is a man who, by age 43, had already invented calculus, broken white light into its component colors and built a telescope whose design is so good it is still in use today. In 1687 he produced a book that profoundly changed the way we see the world, a book that will always stand as a crowning achievement of the human mind, the hilosphiae naturalis principia mathematica, known universally as the Principia. This work not only gave us the three laws of motion that still bear his name; it defined gravity, and provided precise mathematical equations by which it could be measured. It was heralded across Europe as revolutionary. Nonetheless, though Newton's mathematical arguments astonished the few who could follow them, his hypothesis of gravity roused dismay and even disgust.

Natural philosophy (as science was then called) had declared an absolute separation between matter and spirit, and limited its attentions to the material world. Respectable natural philosophers were supposed to discover and describe rational physical causes for natural phenomena. While Gottfried Wilhelm Leibniz and Christiaan Huygens, the reigning kings of the scientific community, admired Newton's math, they sniffed that his so-called "force" of attraction was no more than a traitorous return to explaining the natural world by means of "occult qualities."

The doubters were closer to the truth than they knew. Practitioners of alchemy proudly billed it as an occult art whose secrets could be unveiled only by a deserving elite. In the privacy of his walled garden, Newton strove to become one of those proud few; his obsession with alchemy was an incandescent love affair that burned for nearly 30 of the most scientifically productive years of his life. By the time he died in 1727, he had spent untold hours experimenting over his furnaces. He had also amassed one of the finest private alchemical libraries ever collected and had written well over a million words on the subject.

Neither the science nor the alchemy could have been predicted. Isaac Newton was born in a manor house in the village of Woolsthorpe on Christmas Day 1642, three months after the death of his father, a farmer who signed his name (also Isaac Newton) with an X. Tiny enough to fit inside a quart pot, young Isaac was not expected to survive. He did, of course, his life beginning the very year that Galileo's ended.

Across millennia, European thinkers had built up a conception of the cosmos as a gorgeous edifice streaming with light and filled with orderly ranks of angels, planets and stars dancing in perfect circles for the glory of God. Almost exactly 100 years before Newton's birth, Copernicus had shoved Earth from the center of this cosmic stage with the revolutionary proposal that our planet revolves around the sun rather than vice versa. And only 33 years before his birth, Kepler had destroyed the ancient belief in the heavens' perfect circular motion by showing that the planets move in elliptical orbits; a year later, 1610, Galileo demolished the notion of the heavens' perfect state of being by glimpsing moon craters and sun spots through his telescope. At the time of Newton's birth, an architectural plan of the cosmos thousands of years in the making had been shattered, but no new system had replaced it.

Newton grew up ignorant of the tremors shivering through the intellectual world. Not until he reached Cambridge did he run across the work of the French philosopher and mathematician Rene Descartes. The year that Newton turned 2, Descartes had finally proposed a new understanding of physical reality in his Principia Philosophiae. During Newton's childhood, the educated classes in Europe were busy grasping the notion that the world was one vast machine built from tiny, uniform particles in motion. When Newton discovered this system, now called Cartesian mechanical philosophy, it launched his genius. As Wordsworth later put it, Newton's mind went "for ever Voyaging thro' strange seas of Thought, alone."

Newton came to Descartes with a flexible mind at a time when Descartes' ideas were still radical new theories rather than revered doctrine: there was a lot of room for genius to move in. And move Newton did, teaching himself enough math to not only follow Descartes but to pinpoint the flaws in his arguments. Much of Newton's ensuing work, including the pointedly mathematical title of his own magnum opus, bears the marks of a competitive need to surpass the Frenchman.

At Trinity, Newton's cat grew fat on food he forgot to eat; in pursuit of truth, Newton often disregarded danger as well as dinner. Experimenting with optics, he once stuck a bodkin, or large blunt needle, as far back between his eye socket and his eyeball as he could (the picture he drew in his lab book is intensely disturbing); he also stared into the sun until he nearly blinded himself.

Voltaire later reported respectfully that Newton said he solved problems "by thinking on them continuously"; the Master of Trinity College worried that he might "kill himself with study." Instead, eight years after he arrived at Cambridge, the university appointed him, in 1669, at age 26, Lucasian Professor of Mathematics, still one of the most prestigious posts in the scientific world (it's currently held by Stephen Hawking).

The new Professor Newton had made his career as a natural philosopher, but the Cartesian system that so entranced him posed as many riddles as it solved, and Newton knew it. For devout men like Newton, a major problem with Descartes' system was that it left no room for God: in his zeal to separate matter from spirit, Descartes had decreed God an absentee landlord who had built the clockwork cosmos and then absconded to gaze on his handiwork from afar.

For those not ready to banish divinity, alchemy offered an alluring alternative. The alchemical world was more like a plant or animal than a machine. "This earth resembles a great animal," Newton himself would one day write in a manuscript now in the Smithsonian's Dibner Library; it breathes in "Nature's universal agent, her secret fire" and exhales gross air. All matter, whether animal, vegetable or mineral, said the alchemists, was growing, mating, reproducing, aging, decaying and dying, only to be born anew in an endless chain of life.

The year that he became Professor Newton, the small-town-scientist-newly-made-good took his second trip to London. He bought two furnaces, glassware, chemicals and a six-volume anthology of alchemical writings called the Theatrum Chemicum. Then he sped back to Cambridge and went to work.

At an absurdly small table for six in Trinity College's palatial Wren Library, I run my fingers down pages Newton himself dog-eared and decorated with notes: pages that babble in English and Latin about shining red oils, magical compounds of sulfur and mercury, and alchemical retellings of the Genesis creation story.

Ancient symbolic links between gods, planets and metals led alchemists to couch their recipes as myth, and to read all myths as covert alchemical recipes: Jupiter was a code name for tin, as well as the name of the king of the gods and the largest of planets. Saturn could mean lead, Venus copper, Mars iron, and Mercury mercury. Diana might mean the moon, or silver, or both, while the sun indicated gold. Page after hallucinatory page, dragons, doves, eagles and lions fight and fly and devour each other, all the while changing colors, as the solvent in one experiment that Newton described takes on "a dark red or yellow color w[Th] black & blue spots," glimmering with the entire rainbow all at once.

Newton apparently believed that all this hothouse imagery encoded in different ways one true chemical process that would produce the philosophers' stone. In an effort to translate the poetic chaos into practical laboratory terms, he collected and compared all the alchemical writings he could lay his hands on, probing alchemical literature to a degree unequaled by anyone before or since. He indexed it; what began as an 8-page document with 115 headings eventually swelled to more than 100 pages with 879 headings listing 5,000 references.

In the lab Newton used the same symbolism he spent so much time trying to decode in other people's writings. "I made Jupiter fly on the wings of the eagle!" he exclaimed in May 1684; in this case it seems fairly certain that he was talking in code about some process of vaporizing tin. But a lot of his lab notes remain impossible to decipher with any reasonable certainty. "Dissolve volatile green lion in the central salt of Venus and distill," the man who invented calculus jotted in another notebook. "This spirit is the green lion the blood of the green lion Venus, the Babylonian Dragon that kills everything with its poison, but conquered by being assuaged by the Doves of Diana, it is the Bond of Mercury."

He was still Isaac Newton, however, and as his biographer Richard Wasteful wrote, when he walked into the lab he "did not leave his special gifts at the door"; instead, he submitted alchemy's mysteries to precise quantitative analysis. The scientist who had measured colored rings of light in hundredths of an inch now divided an ounce into 480 grains and worked with such minute amounts of chemicals on a mirror, using the point of a knife.

In modern terminology, he spent much of his time at the furnace refining ores, making alloys, converting substances from one state to another (from solid to gas to solid again, for example), or separating the elements of one compound and then recombining them with other substances. If what he thought he was doing is murky, what he hoped to achieve is murkier still. If he composed any general treatise describing a unified theory of alchemical science--a Principia chemical--it has not survived. Scholars have had to reconstruct his alchemical theories and research from notes now scattered in libraries from Jerusalem to Los Angeles.

The link some scholars see between Newton's alchemy and the universal law of gravitation lurks in the philosophers' stone's hypothetical power to draw into itself the alchemists' life-giving universal spirit. In the Manuscripts Reading Room of the new British Library in north London, I stumble awestruck through the cramped scribble Newton used to fill a small brown book with notes on the philosophers' stone from the alchemist Basil Valentine. "He that learnt to know exactly this golden seed in this Magnet," Newton wrote, "he hat the true root of life."

Both in lab and library, Newton focused his research on the dull gray substance that he called antimony, but we call antimonial ore, or stibnite; Newton identified it with the mysterious material his favorite alchemical authorities termed "green lion" or "Magnesia" (Latin for "magnet"). This ore had long been precious to alchemists for its use in refining gold to a very pure state, but Newton was much more interested in its supposed powers of attraction.

Though not quite the philosophers' stone, antimony was said to attract the universal spirit or "active principle." Newton wanted to isolate at "the heart of the lion" the specific metallic form of this universal spirit, something the alchemists called "philosophic mercury" (not to be confused with the common element). To do so, he spent a lot of time carefully refining antimonial ore to produce the metallic element in a rare form, showing silvery crystalline veins radiating around a central point. For years this "star regulus" lay at the heart of his alchemical research. He was experimenting with it just before plunging into the Principia; when he interrupted his work in 1686, it was to experiment with the star regulus of antimony once again.

Newton did not find the universal law of gravitation in alchemy. He did find in his occult research, however, the key notion of an "active principle" that could work at a distance, a provocative concept that lay well beyond natural philosophy's approved channels of thought. This is not to say that gravity itself is occult; it is a regular, mathematically predictable phenomenon by which two masses attract each other. In contrast, the philosophers' stone is a mass that mysteriously attracts spirit. It took all of Newton's mechanical and mathematical genius, as well as prompts from other, more conventional minds, to transmute this arcane principle of attraction at a distance into a quantified science.

Unpublished scraps fluttering around the edges of the Principia hint that he originally meant his magnum opus to explain particle as well as celestial physics. The modern concept of atomic elements still lay over a century in the future, but atomism-the idea that matter is built from tiny particles-had been around since the Greeks, and was fundamental to Cartesian mechanical philosophy. "Nature is exceedingly simple and conformable to herself," he wrote in a conclusion that was cut before publishing. "Whatever reasoning holds for greater motions, should hold for lesser ones as well." Planets, he knew, depend on the attractive force of gravity for their orbital motion, and smaller but still sensible bodies depend on attractions and repulsions too. Newton went on to speculate that the tiniest building blocks of matter depend on analogous, "as yet unobserved" forces.

Detectable bodies, he conjectured, were made of relatively large particles joined together in tenuous nets, an image he borrowed from alchemy; "vulgar" or "mechanical" chemistry involved rearrangements at this level. These particles were in turn made of smaller particles, and those particles, of still smaller particles, on down to the smallest, indivisible building blocks of matter. "Any body can be transformed into another, of whatever kind," he wrote in the first edition of the Principia. All transmutation took, he thought, was dissolving matter into its ultimate parts and restructuring them, something that could only be done, he wrote elsewhere, by alchemy's "more subtile, secret & noble way of working."

In hindsight, Newton's nested system of micromatter is not a bad abstraction of molecular, atomic and subatomic structures bound by forces of attraction and repulsion. Living more than two centuries before the building of high-energy accelerators, however, he had no hope of finding what he was looking for. But Newton didn't know that, and as soon as he finished the Principia, he scuttled back into the alchemical lab to unlock the secrets of micromatter.

This time, after six years of frenzied work, he very nearly did kill himself with study. In June 1693 he was hard at work, vaporizing mercury and lead. At about this time, he thought he had succeeded in making the philosophers' stone: "Thus you may multiply each stone 4 times & no more," he dashed with excitement, "for they will then become oyels shining in y[e] dark & fit for magicall uses."

In September the bubble burst for good, and Newton suddenly withdrew from the world. In a fit of paranoia, which he later termed "a distemper that much seized his head," he hurled angry, disjointed letters at the philosopher John Locke and the diarist Samuel Pepys, accusing them of trying "to embroil me w[th] woemen," and breaking off the friendships.

He was under enough emotional and mental stress to explain a nervous breakdown, but he may also have poisoned himself with his alchemy, becoming "mad as a hatter," because it was exposure to the mercury used in processing felt that made hatters so proverbially loopy.

By the spring of 1694, Newton had emerged from the storm shaken but sane. Once more, he returned to his lab, but as suddenly as he had begun his alchemical work, he broke it off. Less than two months after his last dated experiments in 1696, he abruptly packed his bags and moved to London to become the Warden and then Master of the Royal Mint. In a deliciously ironic career move for a retired alchemist, he made himself a wealthy man presiding over a complete recoinage of the kingdom's gold and silver. Though he kept lightly in touch with alchemical circles in London, he never again seriously pursued the Great Work himself. Having briefly believed he had touched the sun, his disillusionment seems to have run deep.

When Newton took up alchemy, his fascination was no unique quirk. In the 17th century, chemistry and alchemy were not yet distinct. Newton, in fact, was led to the subject through the writings of Robert Boyle, whose own flirtations with alchemy have been pushed into the shadows in favor of his reputation as the father of modern chemistry.

Alchemy's days as a serious subject were numbered, however. When Newton died in 1727, his executors asked Dr. Thomas Pellet to determine which of his papers were publishable. Time and again Pellet scrawled across sheaves of Newton's alchemical papers: "Not fit to be printed."

As time passed, this need to guard Newton from the taint of his alchemy strengthened. While editing Newton's "complete" works in the late 18th century, Bishop Samuel Horsley passed over his million alchemical words in silence. By 1855, Sir David Brewster, Newton's first major biographer, could not contain his horror. "We cannot understand how a mind of such power," he raged, "could stoop to be even the copyist of the most contemptible alchemical poetry, and the annotator of a work, the obvious production of a fool and a knave." Then he, too, subsided into silence.

Ironically, it was what Newton did not find, rather than what he did, that has vindicated his alchemical research. For though he could not demonstrate the structure of micromatter or achieve transmutation, 20th-century physicists have done both.

In 1901, British scientists Ernest Rutherford and Frederick Soddy found that radioactive decay could passively cause one element to change into another. Watching this process, the two stood transfixed until Soddy blurted out, "Rutherford, this is transmutation!" In 1919 Rutherford was able to announce that he had forced transmutation by bombarding nitrogen nuclei with alpha particles to produce oxygen; in 1937 he titled his last book The Newer Alchemy.

In the wake of these discoveries, interest in Newton's alchemy has risen steadily. As late as the 1880s, the University Library of Cambridge refused to accept his alchemical papers, even as a gift, deeming them "of no scientific value." By the 1970s Newton's alchemy had become the subject of serious scholarly research by Betty Jo Dobbs and Karin Figala. Though many still balked at the notion, some historians of science had begun to see links between Newton's alchemical dreams and the development of modern science.

Traces of Newton's life are not hard to find. His favorite London coffeehouse has morphed into the Devereux, a Dickensian pub full of lawyers, but in his honor, I order black coffee. In Jermyn Street, I finger fine-tailored shirts for sale in the building that was once his home. At the Tower of London, I walk the outer walls, which housed the mint he ruled with more of an iron hand than a golden touch. Up in Cambridge, Trinity once displayed his furnace-filled lab to visitors, but it is long gone, replaced by a scion of the infamous apple tree. Beyond his books, I despair of finding any trace of Newton's obsession with alchemy.

Then, on my last afternoon in London, I duck into the quiet of Westminster Abbey. Facing the western doors, a baroque monument of Newton swirls upward; on a panel beneath his languidly reclining bare feet, naked cherubs in bas-relief toy with his great discoveries. At the far right side, I finally find what I am looking for and smile: one of the imps blows into a fiery furnace. Guidebooks suggest that this is an assay furnace, representing Newton's years at the mint, but the discreet alchemist who designed and built brick furnaces just like it would surely have appreciated this tribute to his labors over the fire.

PHOTO (COLOR): Alchemists used strange words and symbols to describe reactions. Here the green lion (representing the mysterious material called Magnesia) devours the sun.

PHOTO (COLOR): Newton uses a prism to break sunlight down into its component colors. this achievement alone would have made him famous.

PHOTO (COLOR): A scion of the original apple tree (legend has it) frames Woolsthope, the manor house where Newton was born in 1642.

PHOTO (COLOR): An alchemist searches for the secrets of life in this 17th-century painting.

PHOTO (COLOR): A seminal work of science, the Principia, may owe a debt to the dark art.

PHOTO (COLOR): This image of Newton at age 46, copied from a painting by Sir Godfrey Kneller, is the earliest known portrait.

PHOTO (COLOR): Opposites (male and female, day and night) are united under a star representing the philosophers' stone in a 16th-century manuscript.

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By Jennifer Lee Carrell

Jennifer Lee Carrell of Tucson has written for Smithsonian on fire-fighter training and Shakespeare's popularity in the Wild West.

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