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A New Light on Alchemy

Fools' gold, Dr Faustus - traditional images of a Renaissance black art. But was there more to it than that? Zbigniew Szydlo and Richard Brzezinski offer an intriguing rehabilitation.

In June 1897 the French journal La Nature reported that the United States Assay Office had, on April 16th, purchased the first ever gold ingot manufactured from silver.. Six months later, an article in a popular newspaper related that the inventor, Dr. Stephen H. Emmens, was 'producing enough gold to bring him at the Assay Office a profit of $150 a week'. Emmens, an American of British descent, bragged that he had finally mastered the alchemists' art and could produce gold commercially. He let slip that his 'Argentaurum' process worked by the action of high pressure and intense cold on silver, but was eventually exposed as a fraud when he claimed that his process was endorsed by a leading physicist, Sir William Crookes. By 1901 Emmens was nowhere to be traced.

Three centuries earlier, in 1590s Prague, an unknown alchemist of Arabic origin made a flamboyant appearance in a city with a reputation as the alchemical capital of Europe. After courting merchants and bankers, he invited twenty-four of the wealthiest to a banquet, during which he promised to multiply gold. He obtained 100 gold marks from each guest, and placed the coins in a large crucible with a mixture of acids, mercury, lead, salt, eggshells and horse dung. But, as he prepared to operate the bellows of his furnace, there was a tremendous explosion which left the guests spluttering in a fog of fumes. By the time the smoke had cleared, the alchemist had vanished, along with the 2,400 gold marks.

Such stories of fraudsters form the modern stereotype of the alchemist, and alchemy is widely seen as little more than the art of changing base metals into gold. With hindsight we know the alchemists were wasting their time: it is impossible to 'transmute' elements by chemical means, and nothing short of bombardment by neutrons in a nuclear reactor will produce gold from lead, and then only in microscopic amounts.

Although modern chemists are pre- pared to admit that the alchemists invented many of the chemical processes in use today, alchemy is still often condemned as mumbo-jumbo, and at worst, bundled in with astrology and necromancy as an occult pseudo-science. No wonder then that alchemy was dismissed in 1831 by Thomas Thomson as the 'rude and disgraceful' beginnings of chemistry. But is this view of alchemy justified?

When we hear that some of the greats of science, Sir Isaac Newton (1642- 1727) and Robert Boyle (1627-91 – of Boyle's law fame) had a keen interest in alchemy, perhaps it is time to think again. When we examine more closely the obscure texts of alchemy and venture behind the baffling terminology and mystical allusion, we see revealed a long and ancient line of philosophers and experimenters searching for secrets far more precious the gold.

The origins of alchemy go back at least four millennia to ancient Mesopotamia, India, China and Egypt and the first reasoned attempts to make sense of the diversity of nature. Aristotle, the tutor of Alexander the Great, brought many of these ideas together when he proposed that all worldly substances were made up of four elements: air, earth, fire and water. A fifth element, the ether or quintessence (from Latin quinta essentia, fifth essence) was the stuff of the heavens.

A refinement to this picture was made by Arab alchemists in the eighth century AD, in particular by Jabir ibn Hayyan, known in Europe as Geber. He proposed that all metals were formed of mercury and sulphur mixed in various proportions.

White metals had very little sulphur, and yellow metals like gold, had more. It seemed like common sense, and was an open invitation for attempts at gold-making.
Increasingly alchemy gained a mystical side – perhaps from frustration at failed experiments. Into it came a strange concoction of Christian, Gnostic and neo-Platonic ideas. Adepts began to believe that experiments would only work when they were in a state of spiritual elevation achieved through prayer.
Central to the mysteries of alchemy was the belief that ancient texts contained forgotten secrets of nature. The most definitive of these texts was the Tabula Smaragdina or Emerald Tablet, which, according to legend, had been discovered by Alexander the Great in the Egyptian tomb of Hermes Trismegistos ('thrice-great'), the Greek counterpart of the Egyptian god of wisdom and magic, Thoth. The Emerald Tablet was inscribed with thirteen axioms. Unfortunately, they were rather difficult to understand. The riddle-like language of the fourth is typical: 'Its father is the sun, its mother the moon; the wind carries it in its belly, its nurse is the earth'. This cryptic style was emulated by the alchemists, who christened themselves 'sons of Hermes' or Hermetic philosophers.

It is impossible here to go into the full world picture the alchemists had developed by the sixteenth century; but the key to it was panvitalism – the idea that the universe and everything in it was alive: animals, plants and minerals. Animals had the shortest lives but most complicated structures; minerals, the longest lives and simplest forms – that they were alive seemed logical after observations of volcanoes erupting, and crystals growing.
Minerals were believed to grow from seeds – the equivalent of plant seeds and human semen. These grew deep in the earth and rose to the surface, maturing as they moved. Depending on the path taken, they developed into different types of rocks. If a young mineral rose quickly along a poor route it emerged in a 'corrupt' form, such as lava; if it rose slowly along a pure and perfect vein it matured into gold. Even until the early twentieth century, English farmers were convinced that stones were growing in the ground and rising up like weeds that periodically needed to be removed.
When a true alchemist, as opposed to a quack, was attempting to make gold he was not merely lusting for wealth: gold, because of its rarity, lack of reactivity, and glowing lustre was the mineral world in its ultimate state of perfection. By discovering how to make gold, the alchemist would, it was thought, also have the means of perfecting the plant and animal worlds. In order to produce gold in the laboratory, alchemists attempted to replicate and speed up the natural processes thought to take place deep in the earth. Their main goal was to discover the mysterious substance through which gold travelled on its way to the surface – this material they knew as the Philosopher's Stone. When found, the Stone would be the means of bringing perfection to the human world, giving health and eternal salvation to the fortunate alchemist. In effect, the search for the Philosopher's Stone was much like the quest for the Holy Grail.
The Philosopher's Stone was a major goal of alchemy, but to claim it was the only one is like saying the Grand Unified Theory is the sole aim of physics, or Fermat's Last Theorem was the same to mathematics. Alchemp bad the general aim of making sense of nature in all its complexity. To be sure, there were other concrete goals: the alkahest or universal sol- vent which could dissolve all substances, and the universal medicine or Elixir of Life, which would cure all diseases and was related to the Philosopher's Stone. More bizarre, and verging on the occult was palingenesis – the reincarnation of plants and animals from their ashes; and attempts to generate miniature human beings (homunculi) from semen incubated in rotting horse dung.
Alchemy had already been given a sizeable kick in the direction of a practical science by the extraordinary Swiss physician Paracelsus – or to give his full name, Philippus Theophrastus Aureolus Bombastus von Hohenheim (1493-1541). After travels to the east, and work as a military surgeon, Paracelsus declared that most traditional medicines were useless, so he devised his own, with spectacular results.

When appointed physician to the city of Basel in 1527, he celebrated by publicly burning the works of Galen and Avicenna, the established authorities on medicine. The only way to learn anything about nature, said Paracelsus, was to go out and observe it at first hand. Only the Bible was infallible, everything else was open to question. Paracelsus disputed Aristotle's four elements theory because fire was nowhere mentioned in Genesis. Borrowing from Geber's theory of metals, he decided that there were three fundamental substances: sulphur, mercury and salt – though he defined them in a broader sense than the modern materials of these names. Paracelsus' revolutionary ideas spawned a new school of medical alchemists. Many of them were attracted to Prague and the liberal court of the German emperor, Rudolf B, who sponsored a bustling community of proto-scientists and artists.

Among Rudolf s alchemical protégés, and shining out above them was a Polish doctor, Michal Sedziwój (latinised as Sendivogius). Recognised by his contemporaries as one of the greats of early European natural philosophy, he has now slipped back into obscurity. Sendivogius was to signal the next remarkable transformation of alchemy.

Michael Sendivogius (1556-1636) has suffered more than most from the poor reputation of alchemy. Until recently, his life was known only in legendary accounts, replete with tales of spectacular transmutations, imprisonment by jealous rulers and improbable escapes from dungeons and burning towers. In the contemporary record Sendivogius emerges as a very different man. Born in Sacz, Poland, his name appears on the registers of Altdorf and Leipzig universities and in 1591 he matriculated from Vienna University. After serving as a courtier and doctor of medicine at Rudolf s court in Prague, he returned to Poland where he was taken into the confidence of King Zygmunt III. He became involved in the Polish metal- lurgical industry, and helped set up several factories in the Czestochowa and Silesia regions. He travelled regularly to the German empire on secret diplomatic missions, taking the opportunity to maintain contact with leading academics such as Johann Hartmann, Europe's first professor of chemistry (appointed in 1609).

Sendivogius' most influential book was published in Prague in 1604 as De lapide philosophorum (On the Philosophers' Stone), but was soon retitled Novum lumen chymicum (A New Light of Alchemy). Over the next two centuries it was to go through at least fifty-six editions in Latin, German, French, English, Russian and Dutch. Sir Isaac Newton owned a copy, now in the British Library, which has marginal notes in his handwriting, and corners turned down to mark passages. The great French chemist, Antoine Laurent Lavoisier, also had a copy – now at Cornell University and marked with his bookplate. What was it about this work that gave it such a distinguished following?

As was common with alchemical tracts, the author of A New Light of Alchemy concealed his name in an anagram: Divi Leschi Genus Amo – 'I love the divine race of the Lechites' (i.e. Poles). Yet the book is surprisingly easy to read and is largely devoid of mystical terminology, quite unlike the opaque writings of Paracelsus. The book is a remarkable expose of the world-view of Renaissance alchemy, which Sendivogius states had developed greatly beyond the wisdom of the ancients.

In his preface to the first English edition (1650), the translator, John French, a successful doctor of medicine, could hardly have praised Sendivogius' book more highly:

> In that treatise of his thou shalt see the mystery of Deity, and Nature unfolded ... So that if anyone should ask me, What one book did most conduce to the knowledge of God and the Creature, and the mysteries thereof; I should speake contrary to my judgement, if I should not, next to the Sacred Writ, say Sandivogius.

Alongside his explanation of the workings of nature, much of which went back to traditional alchemical ideas, Sendivogius had put something quite new:

Man was created of the Earth, and lives by vertue of the Aire; for there is in the Aire a secret fond of life.... whose invisible congealed spirit is better than the whole earth.

For the first time Sendivogius revealed that air is a mixture, not a single fundamental substance as proposed by Aristotle. This was a great step. The implications to alchemy were momentous.

By the mid-sixteenth century, the alchemists were convinced there was a 'universal spirit' – a vapour or soul – pervading all matter. It was in this that the life-substance of all entities (including minerals) was believed to be located. Before Sendivogius nobody had managed to identify this universal spirit with a real substance. Sendivogius' 'aerial food of life' seemed to be the true Elixir of Life – sought after by alchemists for centuries.

Sendivogius saw the 'aerial food' percolating through all life, by way of an innocent-looking, colourless, crystalline solid: saltpetre (nitre or potassium nitrate). By observing over time the main source of saltpetre – farmyard soils – Sendivogius became convinced that the 'food of life' was condensing out of the air and growing into living saltpetre crystals. Saltpetre's life-giving power was visible in fertilizers and dynamically demonstrated in gunpowder, of which it was the key ingredient. Saltpetre also seemed to have other miraculous properties: it was used in medicines and freezing mixtures and in the manufacture of the acid, aqua regia (the 'queen of waters') which could dissolve gold.

'Aerial nitre' – what modern chemists would call oxygen – seemed to he the key to nature; in its gaseous form, it made all animal life possible; condensed into solid form, as saltpetre (or nitre), it gave life to plants and minerals. It was, in Sendivogius' words: 'Our water that wets not our hands, without which no mortal can live, and without which nothing grows or is generated in the world'. To the great satisfaction of the Hermetic philosophers, Sendivogius' aerial nitre also seemed to be the solution to the fourth riddle of the Emerald Tablet – 'the wind carries it in its belly, its nurse is the earth'. Sendivogius' aerial nitre theory was a landmark breakthrough in the understanding of nature. Alchemy was never to be the same again.

The study of the nature of air quickly became a major topic of scientific enquiry. Research was, however, soon interrupted by the horrors of the Thirty Years' War of 1618-s8, and Sendivogius himself was brought to the verge of bankruptcy. But a number of. central European scientists fled to the relative safety of England, and through contacts like Robert Fludd (1574-1637) and Sir Kenelm Digby (1603-65), the Sendivogian theory received a wide audience in England. Thanks to the so- called 'Invisible College' interest in air survived the English Civil Wars and Cromwell's Commonwealth. By the 1660s air and its properties had grown into a key field of research at Oxford University. The chief experimenters included Robert Hooke (1635-1703), John Mayow (1641-79), and, of course, Robert Boyle. Although they made no mention of the anonymous man who had inspired their research, the influence of Sendivogius is clear in their writings, and it would be appropriate to call them the 'Oxford Sendivogians'.

Even with these great minds at work, the composition of air was to defy the investigators for nearly two centuries. Air contains one-fifth oxygen and four-fifths nitrogen, but the smaller quantities of carbon dioxide and water vapour make its chemical behaviour highly complex and difficult to understand. The subject was confused for many decades by the German 'Phlogiston' theory of about 1700, which was a radical departure from Sendivogian views. But Sendivogius' influence was still in evidence in 1732, when one of the earliest (and greatest) teachers of chemistry, the Flemish author, Herman Boerhaave, restated the importance of Sendivogius' discovery:

> Air possesses a certain occult virtue which cannot be explained by any of those properties previously investigated. That in this virtue the secret food of life lies hidden, as Sendivogius clearly said, some chemists have asserted. But what it really is, how it acts, and what exactly brings it about is still obscure. Happy the man who will discover it!

And happy he was. When Joseph Priestley isolated 'dephlogistigated air' in 1774, he tried breathing some of it. He found that his 'breast felt peculiarly light and easy for some time afterwards'. He went on:

Who can tell, but that, in time, this air may become a fashionable article in luxury. Hitherto only two mice and myself have had the privilege of breathing it ... Nothing I ever did has surprised me more, or is more satisfactory.
In fact, Priestley was probably not the first person to breathe pure oxygen. In 1621 an unusual event took place in London. A vessel rowed by twelve oarsmen sailed from Westminster to Greenwich under water. The voyage was witnessed by James I and thousands of Londoners. This, the first recorded submarine, was constructed by the Dutch inventor and alchemist Cornelis **Drebbe**l (1572-1633), one of the great lost figures of Renaissance science. Drebbel had become internationally famous after building a perpetual motion machine (which, in fact, was solar-powered); and from about 1604, he worked for James I, building a variety of automata, refrigerators, barometric devices, and probably the first microscope seen in England (1621).
Much of the interest in Drebbel's submarine lay not in its construction and

military potential – but in an air-freshening technique that Drebbel had devised, and kept a close secret. The great Robert Boyle described Drebbel's vessel in his New Experiments Physico-Mechanicall, Touching the spring of the Air, and its effects (Oxford, 1660). Boyle was especially curious about a 'Chymicall liquor, which he [Drebbel] accounted the chiefe Secret of his submarine Navigation'. Boyle interviewed Drebbel's son-in-law, and discovered that when the air in the submarine became stuffy, Drebbel 'would by unstopping a vessel full of this liquor, speedily restore it to the troubled Air such a proportion of Vitall parts, as would make it againe, for a good while, fit for respiration'. Although Boyle describes Drebbel's secret substance as a 'liquor', several other writers of the period insist it was a gas. But could it have been oxygen?
In his Treatise on the Elements of Nature (1608), Drebbel gives a clue to how he might have manufactured oxygen. In a passage on the origin of thunder, he writes: 'Thus is the body of the saltpetre broken up and decomposed by the power of the fire and so changed in the nature of the air'. This suggests he was aware that heating saltpetre causes it to give off a gas – and realised that this gas was the same substance that allows humans to breathe.
Modern scientists have not been comfortable with the idea that Drebbel isolated oxygen over 150 years before Lavoisier. The idea of a gas did not yet exist (the term was coined by van Helmont in the 1640s); and formal techniques for experimenting with gases were only developed around 1700 by the Englishman, Stephen Hales. Even so, behind the complex medieval terminology of spirits, vapours and exhalations, it is clear that the alchemists understood more about gases than we give them credit for. It had been known for centuries that breathing or burning things in an enclosed space reduces the quality of air, and glass apparatus had made big advances by about AD 1150 when pure alcohoI was first obtained in Italy by distilling wine. In practice, there is no reason why Drebbel could not have used oxygen in his submarine, even if he did not understand the full chemical significance of what he had done.
It is likely that Drebbel learnt how to produce oxygen from Sendivogius. Drebbel belonged to a scientific and artistic élite that was already by the sixteenth century, cosmopolitan. Such men travelled Europe seeking wealthy patrons and most of them knew each other. Drebbel visited Rudolfs court at Prague in 1594 and again in 1610-11, and it was here that he may have met Sendivogius, and found out how to manufacture the 'secret food of life' by heating saltpetre.
But if Sendivogius discovered how to make oxygen in around 1600 and Drebbel used it in a practical way in 1620 why is it that nobody knows about it today? How is it that Priestley, Scheele and Lavoisier got all the credit in the 1770s? In part the answer is that the alchemists were highly secretive and believed only the worthy should be enlightened. They wrote in an obscure style so that only the 'sons of Hermes', who were prepared to spend years in study, would be able to understand their texts. Making such knowledge public, they said, was 'casting pearls before swine'. There was also the danger that the knowledge would fall into the wrong hands and be used for evil ends.

Despite its essentially honest objectives, alchemy was, even in its own time, viewed with contempt and regarded as little removed from magic and astrology. It was banned by universities, popes and kings, and Ben Jonson lampooned it furiously in The Alchemist (1610). The respected figures of medicine generally ignored the subject. The Imperial Count Palatine Michael Maier (1569-1622) was different.

Maier had known Sendivogius since they had studied together at Altdorf University in 1594, and got to know him better when he was employed as doctor at the Imperial court from 1609 until 1611. Maier had initially been highly sceptical about alchemy, but through Sendivogius he became a committed alchemist and one of its most ardent champions. Along with Sendivogius, Maier seems to have played a key role in the formation of secret philosophical societies, the details of which are only now beginning to emerge. In his 1617 book Atalanta Fugiens, Maier wrote that alchemy was the 'noblest of the scholarly disciplines, directly after theology, for its subject matter is the investigation of the greatest secrets of God's creation'.

Alchemy was also accorded respect by Robert Boyle, the archetypal enemy of Aristotelian beliefs, and often described as the world’s first true scientist. Boyle believed in the possibility of transmuting base metals into gold, and was influential in obtaining Parliamentary repeal of the Act against gold multipliers in 1689. Sir Isaac Newton was another closet alchemist. In spite of his pioneering work in the 'respectable' sciences – mechanics, optics and calculus – it has recently emerged that Newton spent the bulk of his career secretly attempting to decipher the mysterious texts of alchemy.

There was another problem that prevented Sendivogius' theories from becoming common knowledge: the church. Hermetic philosophy was knowledge about nature in addition to that in the Bible. To have openly identified a 'spirit of life' that corresponded to a real substance was risking censure. Copernicus had dared publish his theory only on his death bed; Galileo published and got into serious trouble with the Inquisition; Darwin dreaded the church's reaction, and refused to discuss his ideas in public. Sendivogius got over the problem by publishing anonymously, but then took little credit for his discovery.

Today, the identification of a 'food of life' in air by a now obscure Polish alchemist may appear to be of only trivial interest, yet the repercussions on the progress of science were profound. Sendivogius shone a bright new light on alchemy, away from attempts at gold-making towards the investigation of air. By doing so, he set in motion an explosion of proto- scientific enquiry which was to end when Lavoisier identified and named oxygen in 1779. With that event, chemistry in its modern form was born.

Sendivogius still does not hold the historical status and respect he deserves; neither does alchemy. In an unscientific age, the alchemy of the hermetic philosophers was the closest there was to a science, But alchemy was more than just a predecessor to chemistry – it was a 'living chemistry' – the study of which encompassed the entirety of nature. Lavoisier has been called the father of chemistry. It is perhaps time that alchemy was acknowledged as the mother of chemistry, rather than just a wayward cousin.

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