



Historical Article

Isaac Newton and Alchemy

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Abstract. Isaac Newton dedicated a good part of his activity to alchemical experiments. This article tries to discuss the motivations that drove Newton to spend so much of his time in the laboratory: the search for a unitary vision of the forces acting in the macrocosm and in the microcosm, the belief on a hidden *prisca sapientia* in the occult philosophy to be rediscovered with a scientific approach and the dispute with materialistic philosophy.

Keywords. Newton, Alchemy, transmutation, cosmology, physics.

1. THE SPIRITUAL SIDE OF ALCHEMY

In the popular imagination the idea of alchemy is mostly bound to current definitions that can be found in dictionaries or encyclopedias. For instance, the *Webster's New World Dictionary of American Language* reports that alchemy is:

The chemistry of Middle Ages, the chief aims of which were to change the baser metals into gold and to discover the elixir of perpetual youth or Seemingly miraculous change of one thing into another.

Alternatively, one can find that metaphorically alchemy can be intended as synonymous with subtle artifice or deception. If the story were as simple as this, alchemy would be reduced to a kind of philosophy or pseudo-science definitely passed away, albeit still of interest for a historical reappraisal.

However, in that case it would be quite hard to explain how alchemy could have lasted for more than two millenia.¹ In like manner it is quite surprising that the novel *The Alchemist*, written in the 1980s by Paulo Coelho, had such an extraordinary success to sell more than 100 million copies, with translations in 65 different languages.² Yet, the novel is about an entirely alchemical journey. The story is about Santiago, an Andalusian shepherd boy. After a recurring prophetic dream Santiago meets Melchizedek, the mysterious king of Salem, who reveals that a treasure is waiting for him at the feet of the pyramids in Egypt and gives him two magical stones, Urim and Tummim, that will show him the path to reach the treasure. [At the beginning of the story we find one of the key features of alchemy, the revelation]. Santiago

sells the flock and leaves to Africa, but is soon victim of a robbery and plunges into the deepest misery, remaining with only the two magic stones; it is the black phase of the opus alchemicum. But Santiago succeeds in recovering a good economic condition by hard working for a crystal merchant until he gets in the condition to resume his journey through the desert. Santiago makes three important meetings, the first with Fatima, an Arab girl with whom he falls in love. But he must leave Fatima to continue his journey in search for the treasure. The second meeting is with an Englishman who has studied alchemy and is travelling to meet a famous Alchemist, 200 hundred years old. Santiago learns some alchemy from the Englishman and finally meets the Alchemist who becomes his guide for part of the remaining travel. Finally, and after many adventures, Santiago gets to the Pyramids and finds the treasure, but this is not the philosopher's stone that transmutes metals into gold. What Santiago will discover is the World Language which is in all things and, understanding the nature, with this language he will realize his personal legend. The alchemical journey is thus the attainment of knowledge and a journey of purification and self-fulfillment:

Also the Alchemist, indeed, though understanding the World Language, though knowing how to transform lead in gold, lived in the desert. Without a need to demonstrate to anybody his science and his art. While continuing on the way toward his Personal Legend, the boy had learned all needed to know and had experienced every thing he might have dreamed of.

To better investigate this point let us try to read a brief passage from a treatise on alchemy:³

It is possible to create the medicine with different compounds, however it is a single matter and does not require any other extraneous thing, apart from some white and red ferment. Pure and natural, the Opus has no other manifestation; at right times different colours will appear. The first days it will be necessary to get up early and see if the vineyard is in flower; the following days it is necessary to see if it has changed into raven's head. Later it will change in different colours and among them one must look for the intense white because this is what we expect without error: our king, the elixir or the simple powder, soft to the touch, which has as many names as the things of the world ...

If, apart from the hermetic language typical of alchemy,⁴ we simply dwell on the surface of such a description of alchemical procedures, it is apparent that alchemy is an antiquated, faded practice. However, when we consider that this excerpt is taken from the *Tractatus in arte Alchemiae* (Treatise in Alchemical art) attributed to Saint

Thomas Aquinas, one of the Saints of the Church and a leading philosopher of the Middle Ages, a reflection is in order. In fact, in Thomas' conception: *Laboratorium est Oratorium* (The Laboratory is an Oratory), which means that the exploration of natural elements that can be looked after in the crucible of the alchemical laboratory is only a pathway to a more substantial knowledge of the truth that is guaranteed by religion. For Thomas alchemy was a moral and religious activity rather than simply a practical or scientific activity and this has been also the attitude of many other philosophers of the Middle Ages and of the Renaissance. Outside this context it would be quite impossible to figure out that a description of the search for the Philosopher Stone, usually taken as a foolish attempt of charlatans and visionaries, can be found in another treatise, *De Lapide Philosophico* (On the Philosopher Stone),³ attributed again to Thomas:

I also attempted to transform in gold our red Sulphur, after boiling it in aqua fortis on low flame; when this water became red, I distilled it in the alembic and at the bottom of the retort a pure rubedo of the Sulphur remained which I freezed with the aforesaid white stone to make it red. Then I threw part of it over much copper and I obtained very pure gold. However, about this procedure I can only speak quite generally and in obscure word, neither I will reveal it here, in order that anybody wishing to operate will do it not before a full comprehension of the methods of sublimation, distillation, freezing, and of the shapes of the containers and quantity and quality of the flames.

For Thomas Aquinas (1225-1274) alchemy was not a prosaic search for the philosopher stone but a quest of a divine spirit that, in a unified vision, permeates all nature in its material and spiritual manifestations.

2. ISAAC NEWTON, THE ALCHEMIST

A similar attitude toward alchemy has continued a long time after the Middle Ages and is expressed in the following way by Isaac Newton in a letter of his *Correspondences*:

For alchemy does not trade with metals as ignorant vulgars think, which error has made them distress that noble science; but she has also material veins of whose nature God created handmaidens to conceive and bring forth its creatures... This philosophy is not of that kind which tends to vanity and deceit but rather to profit and to edification inducing first the knowledge of God and secondly the way to find out true medicines in the creatures ... the scope is to glorify God in his wonderful works, to teach a man how to live well ... This philosophy both speculative and active is not only to be found in the volume of nature but also in the sacred scrip-

tures, as in Genesis, Job, Psalms, Isaiah and others. In the knowledge of this philosophy God made Solomon the greatest philosopher in the world.

Isaac Newton has been the founder of modern science and an advocate of the scientific rigour who expressed his working method by the motto *hypotheses non fingo*. Newton was very meticulous in his researches and rarely completely satisfied with the obtained results. Speaking of himself he said:

I do not know what I may appear to the world, but to myself I seem to have been only like a boy playing on the seashore, and diverting myself in now and then finding a smoother pebble or a prettier shell than ordinary, whilst the great ocean of truth lay all undiscovered before me.

Yet, Newton dedicated his time almost exclusively to alchemy for some 25 years, in the same period when he completed his *Philosophiae Naturalis Principia Mathematica*.⁵⁻⁸ Initially, and for several years, he studied with great accuracy all had been published on alchemy, and unpublished works as well, making annotations and résumés and transcribing several texts (see Figure 1). Then he established and equipped his own alchemical laboratory and started to carry experiments. When Newton died, in his library, among others, 169 books were found, 138 on alchemy and 31 on chemistry. Actually, he always tried to consider separately experiments on chemistry and on alchemy. But many other books on alchemy may have been lost when Newton moved from Cambridge to London and, possibly, others were lost during a fire that occurred in his laboratory. Newton never published any-

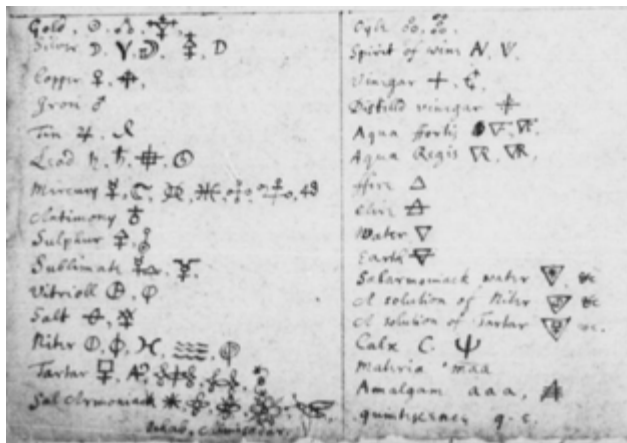


Figure 1. An autograph note by Newton with the alchemical symbols in the *Liber Mercuriorum Corporum*. Partly taken from “The Chymistry of Isaac Newton”. Reproduced by permission of the Provost and Scholars of King’s College.

thing on alchemy but he left notes and writings on alchemy for almost one million of words, a patrimony that has remained unexplored for a long time.

The absolute commitment of Newton to alchemical experiments has been described by his assistant Humphrey Newton:⁹

He very rarely went to Bed, till 2 or 3 of the clock, sometimes not till 5 or 6, lying about 4 or 5 hours, especially at spring & ffall of the Leaf, at which Times he usd to employ about 6 weeks in his Elaboratory, the ffire scarcely going out either Night or Day, he siting up one Night, as I did another till he had finished his Chymical Experiments, in the Performances of which he was the most accurate, strict, exact: What his Aim might be, I was not able to penetrate into but his Paine, his Diligence at those sett times, made me think, he aimd at something beyond the Reach of humane Art & Industry.

...
About 6 weeks at Spring & 6 at the ffall the fire in the Elaboratory scarcely went out, which was well furnished with chymical Materials, as Bodyes, Receivers, ffends, Crucibles &c, which was made very little use of, the Crucibles excepted, in which he {fused} his Metals: He would sometimes, thò very seldom, look into an old mouldy Book, which lay in his Elaboratory, I think it was titled, - Agricola de Metallis, The transmuting of Metals, being his Chief Design, for which Purpose Antimony was a great Ingredient. Near his Elaboratory was his Garden, which was kept in Order by a Gardiner I scarcely ever saw him do any thing (as pruning &c) at it himself. When he has sometimes taken a Turn or two, has made a sudden stand, turnd himself about, run up the stairs, like another Archimedes, with an E’ϋρηκα, fall to write on his Desk standing, without giving himself the Leasure to draw a Chair to sit down in.

By the end of the 1670s and again around 1690s, Newton got into a deep crisis from nervous breakdown and depression touching the madness as it is evident from several letters that he wrote in those periods. The causes of these crisis are not really clear. Certainly Newton was a brilliant man but his family and affective events were rather poor and may have been at the origin of these crisis.

For the purpose of the present discussion it is of interest that a lock of Newton’s hair has been analyzed and a high concentration of mercury, in particular, and lead has been found.^{10,11} From this result it has been hypothesized the Newton’s illness was caused by mercury poisoning. But this inference does not seem certain since the reported symptoms do not seem to correspond to mercury poisoning. The high level of metals in the hair, however, once again demonstrates that Newton spent a considerable time in the alchemical laboratory. To such an extent that John Maynard Keynes, the famous economist which at an auction bought a good part of the alchemical writings by Newton stated that:

Newton was not the first of the age of reason. He was the last of the magicians, the last of the Babylonians and Sumerians, the last great mind which looked out on the visible and intellectual world with the same eyes of those who began to build our intellectual inheritance rather less than 10,000 years ago.

3. THE ALCHEMY MEETS THE MECHANICS

Newton applied to all his alchemical experiments with the same rigour as in his scientific experiments in mathematics, mechanics and optics and, as already noted above, his writings and notes in alchemy are quite consistent. David Brewster, one of the first biographers of Newton, accurately examined all his alchemical writings and, to his disappointment, had to observe that these investigations looked at variance with the idealized picture of Newton as a great scientist:⁹

In so far as Newton inquiries were limited to the transmutation and multiplication of metals, and even to the discovery of the universal tincture, we may find some apology for his researches; but we cannot understand how a mind of such power, and so nobly occupied with abstractions of geometry, and the study of the material world, 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.

Although Brewster was still convinced that the purpose of Newton, and of his other great contemporaries interested in alchemy, was to rescue alchemy from the condition of a *process commencing in fraud and terminating in mysticism*:

The alchemy of Boyle, Newton and Locke cannot be thus characterized. The ambition neither of wealth nor of praise prompted their study, and we may safely say that a love of truth alone, a desire to make new discoveries in chemistry, and a wish to test the extraordinary pretensions of their predecessors and their contemporaries were the only motives by which they were actuated,

in practice, the alchemical writings were finally considered not fit for publication and were not included in Newton's *Opera Omnia*, as obscuring his fame as a scientist, to remain neglected until the twentieth century.

The reasons why Newton never published anything on his researches on alchemy may be various. In a letter to John Conduit he states that:

They who search after the Philosopher's Stone by their own rules [are] obliged to a strict and religious life,

which complies with the common attitude of alchemists that the secrets of the Great Work should not be

revealed to non adepts. In a letter to the President of the Royal Academy, Henry Oldenburg, Newton likewise recommends that Boyle should not make the results of his alchemical researches available to the vulgar because:

It may be an inlet to something more noble, not to be communicated without immense damage to the world if there should be any verity in the hermetic writers, therefore I question not but the great wisdom of the noble author will sway him to high silence till he shall be resolved of what consequences the thing may be either by his own experience, or the judgment of some other ... that is of a true hermetic philosopher ... there being other things beside the transmutation of metals (if those great pretenders brag not which none but they understand).

Apart from this general belief in secrecy, it is more likely that Newton had been unable to sort from his alchemical experiments the answers he was actually looking for and probably wanted to include in the *Principia*. So, the real question is about the actual motivations that made Newton so deeply interested in Alchemy. A hint to the problem can be found in the same Newton's writings. In the preface to one of the editions of the *Principia* Newton writes:

I wish that we could derive the rest of the phenomena of Nature by the same kind of reasoning from mechanical principle ... For if Nature be simple and pretty comfortable to herself, causes will operate in the same kind of way in all phenomena, so that the motion of smaller bodies depend upon certain smaller forces just as the motion of larger bodies are ruled by the greater force of gravity. It remains therefore that we inquire by means of fitting experiments whether there are forces of this kind in nature, then what are their properties, quantities and effects.

After discovering the laws of gravitation governing the motion of the celestial bodies and of the planets, Newton conceived the idea that the principles active in the macrocosm could have an equivalent in the microcosm:

So far I have explained the system of this visible world, as regards the larger movements that we can easily observe. But any reasoning is valid for larger motions must be valid also for the smaller ones. The first rely on larger forces of attraction of larger bodies, and I think that the latter are dependent on smaller forces, for now not observed, between microscopic particles.

Newton's attempt was to discover this equivalent in the crucible of the alchemist. In essence, Newton was interested in a synthesis of all knowledge, a unified theory of the principles governing the universe. On the one

hand this interest derived from the profound religious beliefs of Newton, as described by Yates:¹²

As a deeply religious man, ... Newton was profoundly occupied by the search for One, for the One God, and for the divine Unity in nature. Newton's marvellous physical and mathematical exploration of nature had not entirely satisfied him. Perhaps he entertained, or half-entertained, a hope that the "Rosicrucian" alchemical way through nature might led him even higher.

In his search for a unified theory of the universe Newton may have been attracted by the central concept of alchemy of a *prima materia*, a concept originally attributed to the Greek philosophers and to Aristotle, in particular, of a starting material at the origin of all the materials of the world (a kind of *anima mundi*). A pictorial representation of a kind of alchemical cosmogony in the frame of the four elements (earth, water, air, fire) or alternatively of the *tria prima* (salt, mercury, sulphur) is shown in Figure 2. According to a definition attributed to Arnaldo de Villanova, there is in nature a certain pure matter that art (*i.e.* Alchemy) can discover and bring to perfection such that it can convert to itself all the imperfect bodies of nature by contact. In the Emblem XXXVI

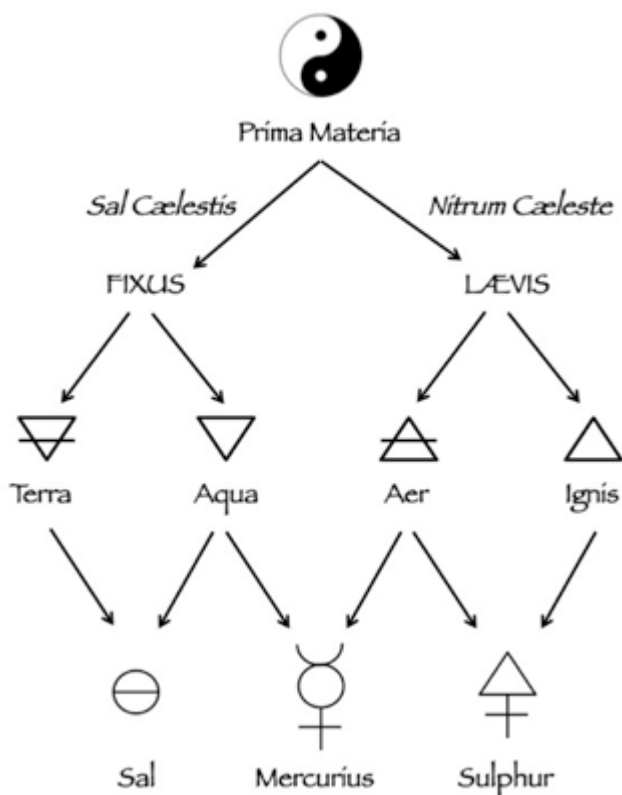


Figure 2. A picture of the unitary alchemical cosmology.

of his *Atalanta Fugiens* (see Figure 3) Michael Maier represents the first matter as cubes that pervade all the world as explained in an attached epigram:

The Stone that is Mercury, is cast upon the Earth, exalted on Mountains, resides in the Air, and is nourished in the Waters.

Maier also explains how to find the *materia prima*:

All persons that have once heard of the name or power of the Stone, unless they are altogether incredulous, ask presently where it may be found, that so they may run directly to it. The Philosophers answer is twofold: First Adam brought it with him out of Paradise, that is, in you and in me, and in every man that, birds flying, bring it with them out of far countries. Secondly, it may be found in the Earth, Mountain, Air and Rivers. Which path therefore must be taken? I say, both, but in a different respect, although the last pleases us best, and seems most safe.

But Newton's research for a unified theory through alchemy was unsuccessful and this is likely the reason why his alchemical results were neither included in the *Principia*, nor published in any form. However, concerning Newton's interest in alchemy there are two more points deserving a discussion.

A famous sentence by Newton concerning his major scientific achievements reads:

If I have seen further it is by standing on the shoulders of Giants.



Figure 3. Michael Maier, *Atalanta Fugiens* – Emblem XXXVI. See Ref. 13.

a metaphor, first used in a more elaborate form by Bernard de Chartres:

Dicebat Bernardus Carnotensis nos esse quasi nanos, gigantium humeris insidentes, ut possimus plura eis et remotiora videre, non utique proprii visus acumine, aut eminentia corporis, sed quia in altum subvenimur et extollimur magnitudine gigantea¹⁴

This same metaphor has later been used by several great scientists to signify that the scientific progress is not simply the achievement of a single leading scientist but is rather a collective enterprise with contributions by a series of researchers from the same and from previous times. The underlying idea in Newton's understanding was that of *prisca sapientia*. Newton believed that in the earliest times the truth about the natural world was revealed and was in the possession of mankind and that, dissipated in the arcane philosophy, was to be sought in the wisdom of the ancients by a correct interpretation of the occult language of alchemy and the accurate interpretation of the sacred scriptures, as we have already quoted:

This philosophy, both speculative and active, is not only to be found in the volume of nature, but also in the sacred scriptures, as in Genesis, Job, Psalms, Isaiah and others. In the knowledge of this philosophy, God made Solomon the greatest philosopher in the world.

The concept of a primeval revelation of the truth is a characteristic feature of the alchemical philosophy that we already find in the *Corpus Hermeticum* of Hermes Trismegistus, the supposed founder of alchemy:

Hermes saw the totality of things, and, seeing it, he understood; and with the understanding gained the strength to testify and reveal. He wrote down his thoughts and hid most of his writings, sometimes wisely keeping silent, sometimes talking, so that in the future the world would continue to look for these things.

To unravel the secrets of the ancient wisdom and of alchemy Newton proceeded with the same rigour as in the study of mechanics and optics.

A second point worth to be remarked is that the idea of a unitary universe is in harmony with the transmutation of the elements, and of the metals in particular, a transmutation in which Newton definitely believed as we can argue from this statement in *Opticks* (Query 31):

The changing of Bodies into Light, and Light into Bodies, is very conformable to the Course of Nature, which seems delighted with Transmutations.

The unitary concept, in fact, implied the transformation and convergence of opposites like, for instance, it can be seen from Figure 2 for fixed and volatile. Indeed, in Newton's transcription from Hermes Trismegistus we find:

That which is Above is like that which is Below and that which is Below is like that which is Above, to accomplish the miracles of only one thing.

This was an essential point in Newton's ideas about gravitation. In fact, he realized that, although the laws of attraction between the heavenly bodies had been laid down,

Thus far I have explained the phenomena of the heavens and of our sea by the force of gravity, but I have not yet assigned a cause to gravity. Indeed, this force arises from some cause that penetrates as far as the centers of the sun and planets without any diminution of its power to act, and that acts not in proportion to the quantity of the surfaces of the particles on which it acts (as mechanical causes are wont to do) but in proportion to the quantity of solid matter, and whose action is extended everywhere to immense distances, always decreasing as the squares of the distances,

the causes that maintained the planets in motion were not clarified:

It is inconceivable, that inanimate brute matter should, without the mediation of something else, which is not material, operate upon and affect other matter without mutual contact ... That gravity should be innate, inherent, and essential to matter, so that one body may act upon another at a distance, through a vacuum, without the mediation of anything else, by and through which their action and force may be conveyed from one to another, is to me so great an absurdity, that I believe no man who has in philosophical matters a competent faculty of thinking, can ever fall into it. Gravity must be caused by an agent, acting constantly according to certain laws; but whether this agent be material or immaterial, I have left to the consideration of my readers.

The existence of attraction forces between inanimate bodies at a distance, and not in contact through something intermediate, was not conceivable in the XVII century. The prevailing ideas were rather tied to the mechanist philosophy of Descartes which denied the possibility of any occult force and assumed that the action only depends on contact. The universe is packed with tiny material particles in continuous motion and colliding to form vortices that transmit the interaction. On the contrary, Newton refused this purely materialistic view thinking that the attraction occurred through something immaterial and that the motion of the planets was set

by a divine willing. Therefore, in Newton's view, the universe relied on the convergence of opposites, material and immaterial. The dispute about the two conceptions was harsh. From one side, the exaltation of Newton's figure could lead to things like the following drinking song:

The atoms of Cartes Sir Isaac destroyed;
 Leibniz pilfer'd our countryman's fluxions;
 Newton found out attraction, and proved nature's void
 Spite of prejudic'd Plenum's constructions.
 Gravitation can boast,
 In the form of my toast,
 More power than all of them knew, Sir

and on the other side we can find expressions of distrust of Newton's ideas of interaction through the vacuum:

Nor does great Newton's famous system stands,
 On one compact foundation, simply plann'd . . .
 Reflect how vainly is that Art employed,
 Which founds a stately fabrik on a Void;
 Can less the fair result of sober thought,
 WHO BUILDS ON VACUUM, MERELY BUILD ON
 NOUGHT

The discussion on the alchemy of Newton has been restricted to what we have called the spiritual side. But Newton heavily worked on the practical aspects of alchemy in a more properly chemical approach with the usual rigour of his method. One aspect of practical alchemy has been the pretention of fools and imposters to obtain miraculous medicines and elixirs, to transform lead in gold and other wonders. As already noted, it has been for these aspects of alchemy that the Newton's work on alchemy has been neglected for a long time. However, the role of imagination and of at first sight improbable ideas for the progress of science should not be minimized. Indeed, Newton writes that:

No great discovery was ever made without a bold guess.

Claude Bernard (1813-1878), the french physiologist founder of the experimental medicine, referring in particular to chemistry, writes that:

Even mistaken hypotheses and theories are of use in leading to discoveries. This remark is true in all the sciences. The alchemists founded chemistry by pursuing chimerical problems and theories which are false. In physical science, which is more advanced than biology, we might still cite men of science who make great discoveries by relying on false theories. It seems, indeed, a necessary weakness of our mind to be able to reach truth only across a multitude of errors and obstacles.

Along the same lines, August Kekulé turned into a legend his discovery of the cyclic structure of benzene

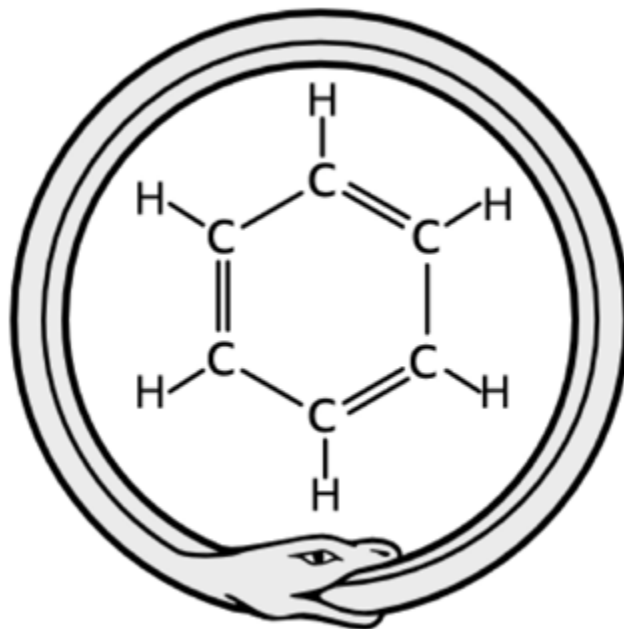


Figure 4. The cyclic molecular structure of benzene and the ouroboros eating its own tail. Image credit: Haltopub / CC BY-SA.

(see Figure 4) ascribing the discovery to a dream were a serpent, the ouroboros, appeared eating its own tail, again an image of opposites that meet. In a famous conference Kekulé, after recalling the metaphor of sitting on the shoulders of giants, concluded exalting the dream and the imagination for the progress of science:

*Let's learn to dream, gentlemen, then perhaps we shall find
 the truth
 And to those who don't think
 The truth will be given
 They'll have it without effort
 But let us beware of publishing our dreams till they have
 been tested by the waking understanding.*

Finally, the old dream of the alchemists to transmute one element into another has been realized in modern science, albeit not in the form they really looked for. The realization of today's chemistry closer the to dream of the alchemists to transform a base into a precious, valuable material has been the obtainment at high pressure of diamond, the most precious stone, from graphite or carbon, the most worthless material.

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4. For example, the vineyard in flower stands for green, one phase of the colours of the *Opus Alchemicum* (the Great Work of Alchemy), symbolizing the life force in the leaves of the plants, and the raven's head stands for blackening, another important phase of the great work.
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14. Bernard the Chartres said that we are like dwarfs, sitting on the shoulders of giants, such that we can see more things and farther away not quite by our own better insight or ability, but because we are brought to a higher position by the gigantic greatness.