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MICHAEL SENDIVOGIUS ON NITRE AND THE PREPARATION OF THE PHILOSOPHERS' STONE

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MICHAEL Sendivogius (1566–1636) was a highly respected author among those interested in alchemical themes in the seventeenth-century. The influence of his ideas on the chymists[1] of this period has already been suggested by historians of science such as Henry Guerlac, Allen Debus, Wlodzimierz Hubicki, Roman Bugaj, Zbigniew Szydlo and William Newman. It is the purpose of this paper to show how Sendivogius used his chymical philosophy – built upon symmetries and analogies – to explain chemical observational data. We are not looking for 'modern' ideas in Sendivogius' work, but for internal coherence. This analysis places Sendivogius in a tradition of chymical thinking of the late-sixteenth and early-seventeenth centuries – in which laboratory observations could be seen as glimpses of the analogies connecting all parts of the universe. Moreover, it may clarify why some of Sendivogius' ideas – on nitre, on the development of 'seeds of minerals' within the earth, on transmutation and on the structure of matter – were so influential among seventeenth-century chymists.

Guerlac[2] pointed to Sendivogius as the probable founder of the seventeenth-century idea about an 'aerial nitre' – a substance in the air that would play a role in the processes of combustion, respiration, plant growth, thunder and lightning, and many other phenomena. Variations on this theory were embraced by John Mayow, Robert Hooke, Robert Boyle, and Isaac Newton,[3] among several other contemporary authors. Debus[4] went deeper into the origins of the concept of an 'aerial nitre', arguing that one could find its embryo in the Paracelsian corpus of the sixteenth century. Following Guerlac, Debus recognized that Sendivogius was connected to the early elaboration of this theory, but he argued that even earlier roots could be traced, and that other authors such as Joseph Du Chesne, or Quercetanus (~ 1544–1609), were probably as important to the propagation of the theory as Sendivogius.[5] Therefore, Debus disagreed with the opinion of Hubicki,[6] who claimed originality for Sendivogius' 'nitre theory'. In his attempt to emphasize Sendivogius' role in the history of science, Hubicki used overly assertive statements such as 'Sendivogius' Nitre corresponds to what we now call oxygen.'[7]

Following this trend of picturing Sendivogius as a pioneer in the discovery of oxygen, Szydlo, in his paper devoted to analyzing Sendivogius' ideas on nitre, wrote that:

> The implication here is that there is a component of air which is necessary for life. The fact that this component of air can be obtained

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> in the solid state (*i. e.* fixed) is in accordance with what we know now: the life-supporting component of air, which is oxygen, is chemically combined in nitre, or potassium nitrate.[8]

Szydlo's work was in part based upon the writings of Bugaj[9], who was very concerned to provide an interpretation of the processes described by Sendivogius in terms of modern chemical theories.[10]

Furthermore, Newman recently noted the influence of Sendivogius' 'nitre theory' on enhancing the importance accorded saltpeter in the seventeenth century. Newman shows the coherence and explanatory power of the theory, and how it may have boosted interest in the production and study of nitre among chymists of the period (especially George Starkey, the subject of Newman's book).[11]

This paper will analyze Sendivogius' preparation of the Philosophers' Stone in the light of his own theories, suggesting that he was almost certainly referring to actual laboratory procedures. It also makes a tentative attempt to rationalize the process in terms of modern chemistry. However, more importantly, it shows that Sendivogius' 'recipe' for the Philosophers' Stone is coherent with his theories of matter, and that his 'nitre theory' must be seen as a part of a conceptual framework that is not readily commensurable with that of modern chemistry.

Biographical Summary

Michael Sendziwoj (Sendivogius, in Latinized form) was born in 1566 of a noble family from Cracow, Poland. He studied in the universities of Leipzig and Vienna. In 1593, Sendivogius went to Prague to work in the diplomatic service of the Holy Roman Emperor Rudolph II, a monarch very interested in alchemy. Taking part in alchemical experiments with Rudolph II, Sendivogius soon became one of the favorites in Court. In 1595, Sendivogius started to work also for King Sigismund III of Poland as a secretary – a fact that reflected the good relationship between the Courts of Prague and Cracow. Sendivogius traveled through several European countries during his restless life and was arrested at least twice. In 1599, the widow of a Prague nobleman charged him with borrowing money from her husband but never paying it back. Sendivogius was arrested, and released only after the diplomatic intervention of Sigismund III. More seriously, in 1604 Sendivogius published a book affirming his mastery of the secret of the Philosophers' Stone – a substance capable of transforming common metals into gold. Shortly afterwards, on passing by the Court of Duke Frederick of Württemberg in Stuttgart, he was arrested again and threatened with continued imprisonment unless he revealed his secret. The Duke, however, when pressed by Sigismund, Rudolph and other German princes, was forced to release Sendivogius. Eventually returning to Poland, Sendivogius joined a member of the Polish government in the construction of several steel, iron and brass smelting facilities – an enterprise that turned out to be highly profitable. Later, Sendivogius offered his services to Emperor Ferdinand II,

and built lead smelters in Silesia. The Thirty Years War brought some financial problems, but Sendivogius seemed to live at ease until his death in 1636.[12]

After his death, the name of Sendivogius was enshrouded by a number of fantastic stories, which were accepted as truth until very recently.[13] However that Sendivogius was interested in the possibility of producing gold from less noble metals is indeed true. His first published work was entitled *De lapide philosophorum tractatus duodecim* (1604) (*Twelve treatises on the philosophers' stone).* Later editions, some of them including other works, had a different title by which the book then became better known – *Novum lumen chymicum.* This work became highly popular, and was translated into German, English, French, Russian and Polish.[14]

Sendivogius' Theory of Matter: Seeds, Principles, *Archeus*

In the twelve treatises that constitute the first part of *Novum lumen chymicum,* Sendivogius discussed what we could call, in modern terms, a 'theory of matter', which he styled the 'operations of Nature'. The purpose of these speculations was to help philosophers, or alchemists, to understand the secret of the Philosophers' Stone. The preparation and properties of this marvelous substance were explained, although obscurely, in the eleventh and twelfth treatises. In the "Epilogue" to the twelve treatises, Sendivogius explained:

> I wrote the twelve foregoing treatises in love to the sons of Art, that before they set their hand to the Work they may know the operation of Nature, *viz.* how she produceth things by her working . . . [F]or he laboureth in vain, that putteth forth his hands to labour without the knowledge of Nature, in this sacred and most true Art. . .[15]

Sendivogius adopted many aspects of Paracelsian thinking, but was not interested in breaking radically with classical authorities. For instance, he grouped together, as wise alchemists whose examples should be followed, Hermes Trismegistus, Aristotle and Avicenna.[16] Nor, other than a passing mention of the importance of using alchemical operations in the knowledge of medicines, and in turning one into a 'most excellent physitian,'[17] was Sendivogius interested in the iatrochemical goals of reforming medicine and preparing new remedies employing alchemical principles.

Turning to some of Sendivogius' ideas on the origin and structure of matter, he believed that, in the beginning, there was the Chaos – from which God created and separated the four elements, arranging them in four concentric spheres of earth, water, air and fire. Since that time, Nature had produced everything by acting on the four elements.[18] According to Sendivogius, the four elements were able to generate *seeds* 'through the will and pleasure of God, and imagination of Nature.' Each seed was then thrown into the hollow existing in the center of the Earth,[19] where the 'central fire', or 'central sun', resided. Its movement generated a great heat,[20] hindering the permanence of anything in the center of the Earth. Therefore, the seed was

impelled through the underground regions, bound for the surface of the Earth.[21] Sendivogius described the seed, this primordial matter, as a 'moist vapor'.[22] In its centrifugal movement, a seed passed through several places, and depending upon where it stopped, it would generate a different mineral or metal. Using an analogy, Sendivogius explained the influence of the place on the transformation of the seed:

> . . . let there be set a vessel of water upon a smooth even table, and be placed in the middle thereof, and round about it let there be laid divers things, and divers colours, also salt, and every one apart: then let the water be poured forth into the middle; and you shall see that water to run abroad here and there, and when one stream is come to the red colour, it is made red by it, if to the salt, it takes from it the tast of the salt, and so of the rest. For the water doth not change the place, but the diversity of the place changeth the Water. In like manner the seed or sperm being by the four elements cast forth from the center into the circumference, passeth through divers places, and according to the nature of the place it makes things.[23]

According to Sendivogius, all metals originated from the same kind of 'prime matter'. If this matter were placed where the earth was 'subtil, pure and moist', gold would be produced. If the place were impure and cold, the product would be lead. If the earth were cold, pure and mixed with sulphur, copper would be produced; and so on.[24] The 'moist vapor' from the center of the Earth could, by chance, reach the surface. In this case, by the simultaneous action of the Sun, Moon and stars, the seed would generate grass or flowers[25]. Analogous processes explained the origin of clay and all kinds of stones – including precious stones. Diamonds, for instance, were the result of an interaction between 'moist vapor' and pure salt water, but only in cold places free from the 'fatness' of sulphur.[26]

When Sendivogius mentioned sulphur, mercury and salt (as in the passages above), he meant the *tria prima*, or the three principles that constituted matter, according to Paracelsus. Sendivogius believed that bodies were not created from the four elements directly; from these, only the three principles could be made. Fire, acting on air, generated sulphur; air, on water, produced mercury; and water, on earth, made salt. Moreover, earth was also the matrix in which the interaction between the three principles resulted in the minerals and all other substances.[27]

This centrifugal movement of the seeds, or 'moist vapor', would be guided by an entity, a sort of 'force' residing in the center of the Earth. Sendivogius called this cosmic entity the *archeus*, and qualified it as a 'servant of Nature'.[28] The archeus was responsible for receiving and combining the 'virtues' of the four elements, thus generating the seeds. Then, due to the heat resulting from its endless movement, the archeus would distill the seed just made. The upward motion of the seed through the underground regions would be analogous to the upward motion of vapor in a laboratory distillation.[29] Although some obscure passages in Sendivogius' text may suggest that the

archeus was the same as the 'central fire', an attentive reading clarifies this point:

> . . . the Archeus of Nature takes and sublimes it through the pores, and according to its discretion distributes it to every place . . . so from the variety of places proceeds the variety of things.[30]

Thus, the archeus was an autonomous entity, endowed with a kind of 'will'. Fire or heat, in turn, had a general, non-individualized character capable of irradiating itself throughout the whole universe. In another passage, Sendivogius clarified the relation between the two entities: the archeus 'governed' the 'central fire'.[31] We can conclude that the 'central fire' was an instrument used by the archeus in the exercise of its cosmic action.

The Archeus in Sixteenth and Seventeenth-Century Theories of Matter

The origin of the concept of the archeus is attributed to Paracelsus,[32] for whom the term had a somewhat different meaning than it did for Sendivogius. We can find the archeus as a part of Paracelsus' philosophy of the universe. According to him, every process of transformation of matter was regarded as alchemical. Paracelsus called *Vulcanus* anything that could promote any transformation of matter, that is, anything that operated alchemically. Vulcanus could be a human being as well as a kind of natural 'alchemical spirit'.[33] For instance, there was a Vulcanus in the Earth that produced grass and other plants.[34] But the blacksmith who changed ore into metal was also a Vulcanus, as was the peasant who reaped wheat and changed it into bread. Let us consider now that someone eats the bread. A series of alchemical operations would occur within the human body, until the final conversion of the matter of the bread into flesh and blood. According to Paracelsus, these operations too would be performed by an internal Vulcanus in the microcosm[35]. This 'inner alchemist' was called the archeus. Like any other Vulcanus, Paracelsus' archeus was the performer of transformations by means of alchemical processes.

> Alchemy is an art, and vulcanus is the operator therein . . . All things are made as prime matter and subsequently the vulcanus goes over it and makes it into ultimate matter through the art of alchemy. The archeus, the inner vulcanus, proceeds in the same way, for he knows how to circulate and prepare according to the pieces and the distribution, as the art itself does with sublimation, distillation, reverberation, etc.[36]

The concept of the archeus was one that Paracelsus elaborated throughout his career. In other treatises, one can find the archeus as a kind of 'force' working in Nature at large, a concept difficult to distinguish from the Vulcanus, as noted by Walter Pagel.[37] Paracelsus used the archeus, for instance, when explaining the origin of minerals. In his *De mineralibus* (written

around 1526),[38] Paracelsus wrote that water was the 'matrix' in which the 'three principles' – sulphur, mercury and salt – combined to generate minerals.[39] In the same fashion that a man worked upon minerals to extract metals, or made a tool out of a piece of metal, so in Nature there would be a manipulative 'power' working upon the 'three principles' within their matrix, changing them into metals. This alchemical 'power' was the archeus:

> The Archeus is he who in Nature disposes and arranges all things therein, so that everything may be reduced to the ultimate matter of its nature. From Nature man takes these things and reduces them to their ultimate matter. That is, where Nature ends man begins.[40]

Many followers of Paracelsus adopted and elaborated the concept of the archeus. Paracelsian dictionaries published in the sixteenth and seventeenth centuries throw light on the early development of the concept. Considering the large number of new terms coined by Paracelsus – some of them curious and of uncertain etymology – these dictionaries were probably very useful for readers of the Paracelsian corpus. They indicate how difficult the terminology was, even for contemporaries. For example, if we take the glossaries prepared by Adam von Bodenstein[41], Gerhard Dorn[42] and Martin Ruland,[43] we can see that their definitions of the archeus were broad and subjective enough to allow a variety of interpretations: the archeus could be seen as a 'cosmic force' related to the generation of everything, or as a kind of 'spirit' acting like a physician or alchemist within bodies. The same trend can be observed by analyzing works of other chymical philosophers of the period. In general, those authors, more concerned with speculations concerning the composition of matter and its transformations, especially processes involving minerals and metals, viewed the archeus as a cosmic entity responsible for the generation of bodies on a universal scale. For example, this can be observed in Sendivogius' *Novum lumen chymicum*, as well as in the few instances in which the word archeus appears in the contemporary 'Basilius Valentinus' corpus.[44]

On the other hand, the idea of the archeus as an inner Vulcanus, or 'spirit' within the body, seems to be the one chosen by those chymical philosophers more concerned with medical theories. As examples we can cite Oswald Croll (~1560–1609), who wrote about the archeus as an 'inner chymist' in the human body, responsible for digestion and natural healing processes.[45] The Belgian physician, J. B. Van Helmont (1579 – 1644), enhanced the concept and gave it more importance than did any other author. According to Van Helmont, the archeus was not only an 'alchemist' existing inside the body of human beings and animals; the archeus was like an immanent spirit in matter, existing in each and every material body, animate or inanimate. Each archeus was specific and characteristic of the body. This explained how from only one elementary prime matter – water – so many different kinds of substances could be generated. Moreover, the concept of the archeus also played a central role in Van Helmont's theory about diseases and their cures.[46] Although Sendivogius was one of his sources ,[47] it is clear that Van Helmont elaborated

a much more complex idea of the archeus than that circulating among the majority of chymical philosophers of the period. In conclusion, we may affirm that archeus, like other Paracelsian terms, acquired several meanings as it diffused through time and place.

Sendivogius and the Preparation of the Philosophers' Stone

Returning to Sendivogius' work and main goal, it is clear that his speculations on matter were preliminary measures directed towards justifying the possibility of preparing the Philosophers' Stone. Since all kinds of matter had their origin in the four elements and in the three principles, he believed it would be possible to transform one substance into another. Moreover, Sendivogius believed that all bodies were formed from seeds. If the seed within a piece of gold were allowed to 'germinate' in a suitable kind of matter, then a multiplication of the gold would follow. Within this framework, Sendivogius developed his theories on the transmutation of metals.

Sendivogius wrote that 'vulgar gold is like an herb without seed; when it is ripe it brings forth seed.'[48] If so, why was it not usual to see gold's seeds and their multiplication? According to Sendivogius, gold was not capable of ripening in the 'crudity' of air, which did not have enough 'heat' to take the process to its end. He made an analogy: there are orange trees in Italy and other places which flourish and yield fruits because there is enough heat in those lands. However, if the same trees were planted in colder places, they would never bring forth oranges. Thus, to make gold, the artificer should help Nature to do what it could not by itself. This help was to be given by means of fire.[49]

The first step to promote the ripening of gold was to open its pores by dissolution. This should be done in a natural, non-violent way by means of a very special 'water'.[50] Sendivogius described it as being 'heavenly, not wetting the hands'.[51] Ten parts of this water should be mixed with one part of 'living gold', and the mixture heated up to provide the 'resolution' of the body of gold, thus leading to the production of the 'radical moisture' of metals. 'Water of salt-nitre' should then be added to the product, and the new mixture kept over heat for a long time, during which it should be possible to observe color changes. When the fluid part of the mixture became capable of 'tingeing' a piece of iron into gold, the 'milk of the earth' or 'menstruum of the world' should be added – a liquid that could 'calcine gold'. At this point, Sendivogius concluded: 'So far reached my experience, I can do no more, I found out no more'[52] – completing his treatment of the preparation of the Philosophers' Stone.[53] The elusiveness of this last sentence is intriguing, for one may wonder if there was 'more' to be found, and if Sendivogius was communicating only a partial success. The general tone of the treatise, however, seemed to suggest that Sendivogius really had the mastery of the Philosophers' Stone:

> I have been willing here to discover to thee all things; and if thou shalt understand my meaning sometimes, and not the letter, I have revealed all things . . .[54]

It is tempting for a modern chemist, to discover whether Sendivogius was describing real laboratory operations, with definite chemicals, or if he made a mere allegorical or hypothetical description, or may even have been talking about purely abstract entities. Although Sendivogius' language was encoded most of the time, there are enough hints to suggest that real laboratory processes were involved. However, it is necessary to be very careful not to attribute to Sendivogius conclusions that he could never have reached, and indeed was perhaps never even interested in reaching. Sendivogius was in search of cosmic analogies; his alchemical work was an attempt at discovering a plan to the whole universe, not an analysis of mere chemicals. However, he did use chemicals; but it is important to realize that Sendivogius framed his chymical observations in a very different context and therefore drew different conclusions from those that a modern chemist would draw.

Bugaj affirms that Sendivogius wrote, in addition to what has been collected in the different editions of *Novum lumen chymicum*, a treatise describing chymical processes in 1598, *Processus super sal centrale*.[55] Doubts remain about the authenticity of this work. It was not published during Sendivogius' lifetime: it appeared for the first time almost fifty years after its supposed author's death, in a collection made by J. J. Becher, *Chymischer Glucks-Hafen oder Grosse Chymischer Concordanz* (Frankfurt, 1682). As Lawrence Principe pointed out, this text, as well as some others attributed to the Polish chymist, 'might conceivably turn out to be Sendivogian,' but more consistent evidence of their authenticity is still lacking, while the arguments so far presented are 'flimsy at best'.[56] Even if the attribution to Sendivogius is apocryphal, however, the book will be useful for our analysis as we may consider it a late-seventeenth-century interpretation of Sendivogius' ideas. In any event, the information contained in *Processus super sal centrale* is important for understanding the Sendivogian view of the alchemical process described above. This treatise allows us to determine the identity of the mysterious 'water that does not wet hands', in which Sendivogius was able to dissolve the 'living gold'. Following a recipe for preparing nitre, the author of *Processus* wrote:

> Pure salt of the Earth, otherwise known as nitre, is formed in the cauldron. This now has to be dissolved and concentrated, and purified and rinsed, until it becomes beautifully transparent and crystalline. It then acquires the name nitre of the philosophers' earth, ... water which does not wet hands, without which nothing in this world can be born or come to exist.[57]

Here, the 'water that does not wet hands' is identified as nitre.[58] Accepting this, we can speculate that the first step to obtain the Philosophers' Stone, according to the process described above, was reacting the 'living gold' with molten nitre.[59] Remember that fire was a privileged instrument to accomplish what Nature was not able to do by itself; so high temperatures were required. The name 'living gold' probably meant gold as it is found naturally, that is, before being fused and worked by the smelter. There is a passage in *Novum*

lumen chymicum that suggests this interpretation. When discussing the existence of seeds in metals, Sendivogius wrote that we should not look for them in common metals – that is, in the smelted ones – but in those still 'alive' within the earth:

> . . . these [vulgar] metals, especially the gold of the vulgar, are dead, but ours are living, full of spirit . . . [T]he life of metals is fire [of the earth] whilst they are yet in their mines; and their death is the fire, *viz.* of melting.[60]

The next step in Sendivogius' recipe involved pouring 'water of salt-nitre' over the mixture. He probably meant the acid obtained from saltpeter, that modern chemists call 'nitric acid', a liquid that can be produced by the distillation of nitre under appropriate conditions. Again, this interpretation may be supported by an excerpt from the *Processus super sal centrale.* In this book, the author described, with details about the procedure and equipment, a recipe to prepare nitric acid from nitre.[61] After a long period of heating under the described conditions, dissolution of gold – at least, of some part of it – was possible. Of course, the resulting solution would be able to 'tinge' iron or other metals, by depositing metallic gold on its surface. The last step mentioned the addition of a 'water' capable of 'calcining gold', followed by another heating. This water could be *aqua regia* – whose preparation, according to Bugaj, was also described in *Processus super sal centrale.*

Modern chemists would not say that the interaction between a metal and a solution containing gold was a transmutation. However, for Sendivogius it was, or at least appeared so. In *Novum lumen chymicum,* he wrote: 'Chymists know how to change iron into copper ... and there are some that make silver out of lead.'[62] It was a well-known fact at that time that it was possible to obtain metallic copper by immersing a piece of iron in a solution of blue vitriol (copper sulfate). This process for producing copper was already in use by the Arabs in Spain (where iron was copious) during the Middle Ages.[63] Many chymists had long considered this a transmutation. In his book on mining and metallurgy, for instance, Lazarus Ercker stated that he was convinced that the process was a transformation of iron into copper:

> I have . . . been forced to the conclusion that iron turns into copper because, even though copper is precipitated by iron from vitriol and other coppery solutions, you end up with more copper than the amount contained in the solutions.[64]

The idea of transforming lead into silver, however, probably originated in the fact that it is common to find silver associated with lead ores, particularly galena.[65] The German chymist Johann Rudolph Glauber, for instance, described a method for obtaining silver from lead in the middle of seventeenth century.[66] If Sendivogius considered processes like these as transmutations, he could also count the gilding of a metal as a transmutation.

The interpretation of Sendivogius' 'recipe' in terms of modern chemistry shows that he was a skillful observer. It is more important, however, to understand that his theories were coherent with the described processes. For Sendivogius, the recognition that nitre was fundamental not only to performing transmutations of metals, but also to allowing the development of all living things, meant much more than the identification of a chemical substance. The respect devoted to Sendivogian ideas in the seventeenth-century shows the continuing significance of traditional alchemical tenets – such as the search for cosmic analogies – among the chymists of the period. Sendivogius indeed played an important role in the dissemination of the idea of an 'aerial nitre', and in the increasing interest in the study of saltpeter. However, the reason for this does not reside in the supposed 'modernity' of his ideas, but in his mastery of a coherent chymical philosophy for explaining observational data and nature in general; his work seemed convincing and useful to his followers.

Sendivogius and Nitre in Context

A fundamental point in Sendivogius' philosophy of nature was his belief in analogies between the macrocosm (the universe as a whole) and microcosm (the human being). This was a very common theme in his time; it originated in Antiquity and was extremely important within Paracelsus' philosophical system.[67] All parts of the universe were interconnected: analogies and symmetries could be seen everywhere. According to Sendivogius, there was, for instance, symmetry between the Sun and the 'central fire' residing within the Earth:

> . . . the Sun is the center amongst the spheres of the planets; and out of this center of the heaven it scatters its heat downward by its motion; so in the center of the Earth is the sun of the Earth, which by its perpetual motion sends its heat or beams upward to the superficies of the Earth.[68]

This symmetry played a very important role in the generation of beings. The joining of heat and emanations from the celestial Sun with the ones from the central 'sun' generated life. There was also symmetry between the sea related to the central sun (*i. e.*, waters upon the earth) and another sea related to the celestial Sun – the atmosphere.

> I have said also that the celestial Sun hath a correspondency with the central sun ... [F]or heat is easily joyned to heat, and salt to salt. And as the central sun hath its sea, and crude water, that is perceptible; so the celestial Sun hath its sea, and subtill water that is not perceptible. In the superficies [of Earth] the beams of the one are joyned to the beams of the other, and produce flowers, and all things. Therefore when there is rain made, it receives from the air that power of life, and joyns it with the salt-nitre of the earth . . .[69]

In this excerpt, and in its sequel, Sendivogius revealed another funda-

mental analogy: the one between the 'power of life' in the air, governed by the celestial Sun, and the 'salt-nitre of the earth', related to the central sun. This nitre was capable of attracting the 'power of life', in the same fashion as a magnet attracts iron, because of the analogy. This property explains why Sendivogius also called nitre 'magnet' or *chalybs*, the Latin word for 'steel'.[70] Sendivogius gave another example: the 'attractive power' of 'salt-nitre of the earth' was similar to the power of 'calcined tartar', that attracts air to itself and converts it into water.[71] He was probably referring to what we nowadays would call anhydrous potassium carbonate; this substance is deliquescent, so it absorbs water from moist air and dissolves itself into a saturated solution.[72]

After the union of celestial Sun beams with the heat of the Earth, there occurs the multiplication of the nitre of the earth due to the assimilation of the 'power of life' contained in the air:

> . . . by how much the more abundantly the beams of the Sun beat upon it, the greater quantity of salt-nitre is made, and by consequence the greater plenty of corn grows, and is increased, and this is done daily.[73]

After this passage, Sendivogius quoted several names for this entity: 'our salt-nitre abiding in the sea of the world', and 'our water that wets not our hands, without which no mortal can live, and without which nothing grows, or is generated in the whole world'.[74] Thus, Sendivogius affirmed the omnipresence of his nitre – in the form of a 'power of life' dwelling in the air, or fixed in the earth, or in any other body. Elsewhere, Sendivogius pointed out that:

> In brief, the whole structure of the world is preserved by air. Also in animals, man dies if you take air from him, &c. Nothing would grow in the world, if there were not a power of the air penetrating, and altering, bringing with it self nutriment that multiplies.[75]

Considering these aspects of his theory, we can achieve a better understanding of Sendivogius' views on the preparation of the Philosophers' Stone. According to him, air is volatile, but could be fixed; once fixed, air would be capable of penetrating any substance.[76] Moreover, air was the matrix of the seeds of everything. We saw above that, by means of sunbeams, air is fixed into nitre, and this nitre could in turn penetrate the body of gold. In doing so, nitre would unite with the 'congealed air' within gold – that is, the natural matrix of gold's seed.[77] Therefore, nitre was like an extension of this matrix, allowing the multiplication of gold's seed – that is, transmutation. According to Sendivogius, the 'moisture' (or nitre) that dissolved gold was also the origin of everything.

In the light of what has been discussed here, it does not seem appropriate to equate Sendivogius' nitre with oxygen.[78] The analysis of the two concepts, when made within their respective contexts, reveals far more fundamental differences than similarities. Let us suppose that the speculations we made

about the chemicals used by Sendivogius were correct – that is, that his 'nitre' was the same substance we nowadays call 'potassium nitrate'. Even so, to state that the relation between Sendivogius' 'nitre of the earth' and 'aerial nitre' is the same as that between our 'potassium nitrate' and 'oxygen' is not accurate nor particularly useful – taking into account all the conceptual differences. Sendivogius' idea did originate from some experimental observations, but it belongs to a world of symmetries and analogies, alien to our own. There was an 'aerial nitre' and a 'nitre of the world' in the same fashion that there was a celestial Sun and a 'central Sun', the celestial 'ocean' of the atmosphere and oceans on the earth. For Sendivogius, the explanation for the transmutations of metals (iron into copper, lead into silver) included analogies with the position of the planets in the heavens.[79] Sendivogius' 'nitres' are not 'substances' in the same sense that oxygen and nitre are for the modern chemist; they are 'powers of life', manifestations of a power that nourishes the whole world. The modern concept of 'oxygen' requires at least an operational definition of element (that is, a totally different view about materiality), and its relation to 'potassium nitrate' involves qualitative chemical synthesis and analysis – 'simple' manipulations of well-defined types of matter that are not an unveiling of the universal unity. Sendivogius' nitre theory is about correspondences, not about the inter-conversion of chemicals; and it is part of a chymical philosophy that intended to encompass the whole universe. It cannot be measured against concepts of a theory of matter that are completely alien to Sendivogius' own.

Sendivogius had a broad and very appealing project indeed, and the preparation of the Philosophers' Stone was only part of it. He shared with many other chymical philosophers the ideal of explaining the whole universe in chymical terms; in his world system the 'nitre theory' was an essential feature. Thus, his work was important for stimulating later interest in nitre, which resulted in studies on the nature, properties and practical applications of saltpeter. Sendivogius also contributed to the development of theories about the presence of 'something' in the air that is responsible for the maintenance of life and combustion. This 'something' could be conceived as a 'vital power', a 'spirit' or an 'emanation from the stars' – long before it was identified with a gaseous chemical elementary substance and styled 'oxygen'. As other historians have already shown, and we mentioned at the beginning of this paper, those theories were developed throughout the sixteenth and seventeenth centuries. Sendivogius was not the first proponent of them, but surely he was important to their propagation. His fame throughout the seventeenth, and even the eighteenth, century has already been pointed out by historians of science. Hubicki mentioned several chymical authors who praised Sendivogius, like Jean Beguin, Croll, Michael Maier and John French. In addition, Hubicki also lists several other chymists who, according to him, were influenced by the noble Pole's writings.[80] Szydlo pointed out that Sendivogius was also read by Newton, Boerhaave and Lavoisier.[81]

It is worth noting, however, that Robert Boyle makes no mention of

Sendivogius when dealing with the subject of a substance in the air which would be suitable for respiration and combustion, even when Boyle speculated about the possibility of a 'volatile nitre' being involved.[82] Moreover, the name of Sendivogius is completely absent from John Mayow's *Tractatus Quinque* (1674), where a theory about a 'nitro-aerial spirit' is discussed – although historians of science have already shown the similarities between Mayow's and Sendivogius' ideas.[83] Debus suggested that this fact may be explained considering that ideas on an 'aerial nitre', similar to Sendivogius', were widespread among Paracelsian chymical philosophers. Thus, citations from specific authors were probably unnecessary for contemporary readers.[84] Robert Frank's study on the Oxford group of physiologists also showed that they were well acquainted with these 'aerial nitre' theories.[85] Sendivogius was certainly one of the authors connected to these ideas, but was not the only source of them. Therefore, it is useful for understanding this specific chapter of the history of chemistry to insert Sendivogius into this tradition of chymical philosophers.

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NOTES AND REFERENCES

1 Throughout this paper, I use the terms *chymistry, chymical* and *chymists* in the sense suggested by Lawrence Principe and William Newman in their recent paper "Alchemy *vs.* Chemistry: the etymological origins of a historiographic mistake," *Early Science and Medicine,* **3** (1998), 32–65, on p. 41: ' ... since all the topics we today associate under the two terms "alchemy" and "chemistry" were indiscriminately classed under either term by early modern writers, we advocate the use of the archaically-spelt *chymistry* to express inclusively the undifferentiated domain. This usage will help evade the potential arbitrariness and consequent misunderstandings evoked when the terms "alchemy" and "chemistry" are used casually in reference to activities between the time of the Reformation and the end of the seventeenth century.'

2 H. Guerlac, "The Poet's Nitre: Studies in the Chemistry of John Mayow – II," *Isis,* **45** (1954), 243–55.

3 The acquaintance of Newton with Sendivogius's works was also indicated, for instance, by B. J. T. Dobbs, in *The Foundations of Newton's Alchemy* (Cambridge: Cambridge University Press, 1975), p. 152.

4 A. G. Debus, "The Paracelsian Aerial Niter," *Isis,* **55** (1964), 43–61.

5 In another work, Debus focused on Sendivogius' theory of a 'Central Fire' within the Earth, and its role in earthly phenomena. Sendivogius serves as an exemplary proponent of a 'chemical geocosm' within the Paracelsian tradition. See A. G. Debus, *The Chemical Philosophy* (New York: Science History Publications, 1977), vol. 1, pp. 84–96.

6 W. Hubicki, "Michael Sendivogius's Theory, its Origin and Significance in the History of Chemistry" in Actes du Xe. Congrès International d'Histoire des Sciences / Proceedings of the Tenth International Congress of the History of Science (Ithaca 26/08/1962 – 02/09/1962) (Paris: Hermann, 1964), vol. 2, pp. 829–33.

7 *Ibid.*, p. 830.
8 Z. Szydlo, "The Alchemy of Michael Sendivogius: His Central Nitre Theory," *Ambix*, **40** (1993), 129–46, on p. 138.
9 See the notes and references used by Szydlo, *ibid.*, pp. 144–46.
10 See Z. Szydlo, "The Influence of the Central Nitre Theory of Michael Sendivogius on the Chemical Philosophy of the Seventeenth Century," *Ambix*, **43** (1996), 80–97; and *idem*, *Water Which Does Not Wet Hands. The Alchemy of Michael Sendivogius* (Warsaw: Polish Academy of Sciences, 1994). Some of Bugaj's and Szydlo's interpretations of Sendivogius' ideas are based on works of uncertain authenticity, as noted by Principe in his review of Szydlo's *Water Which Does Not Wet Hands* in *Ambix*, **42** (1995), 188–89.
11 W. Newman, *Gehennical Fire* (Cambridge, MA: Harvard University Press, 1994), pp. 78-91, *passim*.
12 This brief biographic sketch is based on W. Hubicki, "Michael Sendivogius" *DSB*; *idem*, "The True Life of Michael Sendivogius" in *Actes du Xie. Congrès International d'Histoire des Sciences, Varsovie-Cracovie 24-31 août 1965* (Warsaw, 1968), vol. 4, pp. 31 – 35; Szydlo, *op. cit.* (8), pp. 129–46.
13 See for example, J. Read, *Humour and Humanism in Chemistry* (London: G. Bell and Sons, 1947), pp. 50–65; E. Ostachowski, "Michael Sendivogius, the Polish alchemist (1556 – 1636)" in *Archives Internationales d'Histoire des Sciences, Nouvelle Série d'Archeion*, **33** (1954), 267–75; R. Hall and M. B. Hall eds., *The Correspondence of Henry Oldenburg*, 13 vols (London: Mansell, 1975), vol. 10, p. 406, note 13.
14 W. Hubicki, *DSB*, vol. 12, p. 308. To produce this paper, we used the English translation by John French, published in 1674.
15 M. Sendivogius, *A New Light of Alchymy*, tr. J. French (London: A. Clark for Tho. Williams, 1674), p. 40.
16 *Ibid.*, p. 134.
17 *Ibid.*, p. 135.
18 *Ibid.*, p. 146.
19 *Ibid.*, pp. 6–7.
20 *Ibid.*, pp. 34, 85–86.
21 *Ibid.*, pp. 6–7.
22 *Ibid.*, pp. 11, 17–18, 20.
23 *Ibid.*, pp. 7–8.
24 *Ibid.*, pp. 11–13.
25 *Ibid.*, p. 14.
26 *Ibid.*, pp. 15–17.
27 *Ibid.*, pp. 114, 146.
28 *Ibid.*, p. 9.
29 *Ibid.*, p. 11.
30 *Ibid.*, p. 12.
31 *Ibid.*, p. 90.
32 W. Pagel, *Paracelsus*, 2nd ed. (Basel: Karger, 1982), p. 105.
33 T. P. Sherlock, "The Chemical Work of Paracelsus," *Ambix*, **3** (1948), 33–63, on p. 41.
34 Pagel, *op. cit.* (32), p. 105.
35 That is, the human body, believed to be a synthesis, in miniature, of the universe as a whole (the macrocosm). Thus, there would be analogies between the parts of both 'cosmos'.
36 Paracelsus, *Labyrinthus medicorum errantium*, book 5, quoted by Sherlock, *op. cit.* (33), p. 41; also in *The Hermetic and Alchemical Writings of ... Paracelsus the Great*, A. E. Waite ed. and tr., 2 vols (New York: University Books, 1967), vol. 2, pp. 165–67.
37 Pagel, *op. cit.* (32), p. 106.
38 This date is given by Jolande Jacobi, in *Paracelsus – Selected Writings* (Bollingen Series XXVIII, Princeton: Princeton University Press, 1988), p. 236. The treatise was included in Johannes Huser's edition of Paracelsus' papers (1589–1590).
39 Paracelsus, A Book about Minerals in The Hermetic and Alchemical Writings ..., op. cit. (36), vol. 1, pp. 238–39.
40 *Ibid.*, p. 240.
41 A. von Bodenstein, *Onomasticon Theophrasti Paracelsi* (Basel: Peter Perna, 1575).
42 G. Dorneus, *Dictionarium Theophrasti Paracelsi* (Francoforti, 1584).
43 M. Ruland, *Lexicon alchemiae* (Frankfurt: Zachariae Palthenii, 1612).
44 See two of the works attributed to Basil Valentine: *Of Natural & Supernatural Things*, tr. Daniel

Cable (London, 1670), pp. 38–39 and 51–52; and *Basil Valentine, His Triumphant Chariot of Antimony*, Louis G. Kelly ed. (New York: Garland Publishing, 1990; reprint of the 1678 translation with commentary by Theodore Kirkringius), pp. 48–49.

45 O. Crollius, *Discovering the Great and Deep Mysteries of Nature*, in *Philosophy Reformed and Improved*, tr. Henry Pinnell (London: M. S. for Lodowick Loyd, 1657), pp. 118, 142–143, 146.

46 About the concept of the archeus in Van Helmont, see: J. B. Van Helmont, *Ortus medicinae* (Amsterdam: Ludovicum Elzevirium, 1648), pp. 40–41, 112–13, 548–55; W. Pagel, *Joan Baptista Van Helmont – Reformer of Science and Medicine* (Cambridge: Cambridge University Press, 1982), pp. 96–102; P. A. Porto, *Van Helmont e o Conceito de Gás* (São Paulo: EDUC-EDUSP, 1995), pp. 73–78.

47 There are references to Sendivogius among Van Helmont's writings. For instance: referring to the 'seeds' within the bodies, Sendivogius wrote: '[T]here is in every body a center, and a place or the point of the seed or sperm, and it is always the 8200th. part.' (Sendivogius, *op. cit.* (15), p. 10). In his *Ortus medicinae*, Van Helmont wrote: '[E]very seed is (according to the chymist, Cosmopolita) scarce the 8200[th] part of its body.' (Van Helmont, *op. cit.* (45) p. 105.) 'Cosmopolita' was a pseudonym traditionally attributed to Sendivogius.

48 Sendivogius, *op. cit.* (15), p. 28.

49 *Ibid.*, pp. 28–29.

50 The use of 'solvent waters' is an ancient alchemical theme; see, for example, their use in early medieval alchemical texts: Ana M. Alfonso-Goldfarb, *Livro do Tesouro de Alexandre* (Petrópolis: Vozes, 1999), p. 148, n. 187.

51 Sendivogius, *op. cit.* (15), p. 30.

52 *Ibid.*, p. 31.

53 This 'recipe' to prepare the Philosophers' Stone was compiled from three different passages, in which the process is described with more, although obscure, details: Sendivogius, *op. cit.* (15), pp. 28–30 (tenth of the "Twelve Treatises," containing the 'theoretical part' of the process); pp. 30–31 (beginning of the eleventh treatise, the 'practical part') and pp. 42–43 (part of the "Epilogue or Conclusion of these Twelve Treatises").

54 Sendivogius, *op. cit.* (15), pp. 31–32.

55 Szydlo, *op. cit.* (8), p. 145, n. 9.

56 Principe, *op. cit.* (10), pp. 188–89.

57 Quoted by Szydlo, *op. cit.* (8), pp. 140–41.

58 Nitre crystallizes as needle-shaped, colorless, transparent crystals; their appearance may have suggested the analogy with water.

59 Sendivogius wrote that the mixture should be heated over fire, and it would turn into a 'dry liquor' (*op. cit.* (15), pp. 30 – 31). Perhaps he was referring to a waterless liquid, like fused nitre.

60 Sendivogius, *op. cit.* (15), p. 10.

61 Szydlo, *op. cit.* (8), pp. 131–33.

62 Sendivogius, *op. cit.* (15), p. 27.

63 C. Singer *et al.* eds., *A History of Technology*, 8 vols (Oxford: Clarendon Press, 1957), vol. 2, p. 11.

64 L. Ercker *Treatise on Ores and Assaying*, tr. from the German edition of 1580 by A. G. Sisco and C. S. Smith (Chicago: The University of Chicago Press, 1951), p. 223.

65 C. Klein and C. S. Hurlbut Jr., *Manual of Mineralogy*, after J. D. Dana, 20th ed. (New York: John Wiley and Sons, 1985), p. 274.

66 J. R. Glauber, *The Works*, tr. Christopher Packe (London, 1689), pp. 403–4.

67 Pagel, *op. cit.* (32), pp. 214–15, n. 45.

68 Sendivogius, *op. cit.* (15), p. 33.

69 *Ibid.*, p. 44.

70 *Ibid.*, pp. 27, 42.

71 *Ibid.*, pp. 44–45.

72 As has already been noted by Szydlo, *op. cit.* (8), p. 136.

73 Sendivogius, *op. cit.* (15), p. 45.

74 It was a common belief, in the seventeenth century, that saltpeter could multiply itself within the earth. This belief originated from the observation that certain 'nitrous earths' after the extraction of their nitre with water, after some years yielded nitre again. The process required the mixture of organic matter with the earth. Procedures for the artificial production of saltpeter by this method were described as early as 1405, and they are present in some of the most popular technical treatises of the sixteenth century: V. Biringuccio's *Pyrotechnia*, G.

Agricola's *De re metallica* and L. Ercker's *Treatise on Ores and Assaying*. The belief that something in the air took part in the process was also widespread, according to the testimony of Robert Boyle (1627 – 1691): '... Seems evident from that notable practice of the boylers of salt-petre, who unanimously observe, as well here in England as in other countries, that if an earth pregnant with nitre be deprived, by the affusion of water, of all its true and dissoluble salt, yet the earth will after some years yeeld them salt-petre again ... Though I deny that some volatile nitre may by such earths be attracted (as they speak) out of the air ...' [R. Boyle, *The Sceptical Chymist*, Everyman's Library (London: J. M. Dent & Sons, 1911), pp. 194–95.] See the study of A. R. Williams on the production of saltpeter from artificial 'nitre-beds', with an explanation about the role of the materials used in the period (lime, urine, dung and earth) and of the bacteria, from the point of view of modern science ("The Production of Saltpetre in the Middle Ages," *Ambix*, **22** (1975), 125–33). On ancient uses of saltpeter and other nitrogen compounds, see: Maria H. Roxo-Beltran, "Ácido Nítrico: uma poderosa água dissolutiva; " Alfonso-Goldfarb, "As compilações herméticas e a recuperação de compostos de nitrogênio em receituários antigos; " and *idem*, Roxo-Beltran and Márcia H. M. Ferraz, "Compostos de nitrogênio: um mapeamento histórico" in *20a. Reunião Anual da SBQ – Livro de Resumos*, vol. 3 (São Paulo: Sociedade Brasileira de Química, 1997), pp. HQ04 – HQ07.

75 Sendivogius, *op. cit.* (15), p. 98.
76 Ibid.
77 Cf. *Ibid.*, p. 45.
78 As Hubicki, *op. cit.* (6), p. 830, and Szydlo, *op. cit.* (8), p. 138, suggested.
79 Sendivogius, *op. cit.* (15), pp. 26-27.
80 Hubicki, *op. cit.*(6), pp. 830–31.
81 Szydlo, "The influence ...," *op. cit.* (10), pp. 80 and 94.
82 Hubicki, *op. cit.*(6), p. 832.
83 Guerlac, *op. cit.* (2); *idem*, "John Mayow and the Aerial Nitre: Studies on the Chemistry of John Mayow – I" in *Actes du Septieme Congres d'Histoire des Sciences* (Jerusalem, 1953), pp. 332–49; Szydlo, "The influence .," *op. cit.* (10).
84 Debus, *op. cit.* (4), pp. 60–61.
85 Robert G. Frank Jr., *Harvey and the Oxford Physiologists* (Berkeley: University of California Press, 1980).