ALCHEMY AND IATROCHEMISTRY: PERSISTENT TRADITIONS IN THE 17TH AND 18TH CENTURIES*

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The work of Walter Pagel did much to show the significance of both medical chemistry and alchemy in the Renaissance and Early Modern periods. There has been a long interest in the history of chemistry, as a separate science, but the history of science as a whole developes in this century largely through research on astronomy and mathematical physics. Pagel's interest in the history of medicine and more broadly, in the intellectual and cultural context of the figures he studied led him to recognize the importance of chemistry and alchemy during the period of the Scientific Revolution. His work has affected the field and few historians of science today would argue that modern science derives exclusively from the familiar progression leading from Copernicus to Newton.

But if we have a much greater acceptance today of the importance of chemistry in the sixteenth and seventeenth centuries, there are still many gaps in our knowledge of the late seventeenth and eighteenth centuries. Here I am not speaking primarily of the work of Lavoisier and his colleagues, but rather about other areas that affected the development of chemistry at that time. The points I would like to touch on briefly today relate to (1) the academic acceptance of chemistry, (2) the medical debates involving chemistry, (3) the move toward the separation of chemistry and medicine in the eighteenth century, and (4) the somewhat unexpected but persistent interest in transmutational alchemy.

CHEMISTRY AND THE UNIVERSITIES

Let me turn first to the educational problem. In the past emphasis has been placed primarily on the teaching of chemistry in Paris, particularly the courses offered at the Jardin des Plantes by a series of lecturers beginning with William Davisson (c. 1593-c. 1669) who was appointed in 1648. These lecturers and others... and the well known series of French chemical text books which began with the manual of Jean Beguin in 1610... were all independent of the University[1]. Rather, they were the result of the adamant opposition on the part of the Medical Faculty of Paris to any attempt to introduce chemistry into the medical curriculum. This opposition was maintained until late in the century.

In contrast with the situation in Paris, chemistry became widely accepted in the course of the seventeenth century in medical schools throughout Europe[2]. The first such appointment was Johann Hartmann at Marburg in 1609[3]. This appointment was specifically in the medical faculty and it was to set the pattern for future appointments elsewhere. Hartman was a Paracelsian and his job was to teach the preparation of chemical medicines. He was a prolific author and an effective teacher. His students found positions at other institutions and his books --- both his original texts and his editions of Beguin, Croll and others, were widely used and influential throughout Europe.

Not long after Hartman's appointment Zacharias Brendel offered a course in chemistry at Jena (1612) again in the Medical Faculty[4]. His son, also named Zacharias, continued in this tradition and he was followed by Werner Rolfinck who was named the first Professor of Chemistry at Jena in 1641. Over the course of the next fifty years chemistry became established at Wittenberg , Helmstedt, Erfurt, Leipzig and Halle. In almost all of these cases the initiative was taken through the medical faculties.

At Leiden, the University that was to become the center of chemical teaching in Europe in the eighteenth century due to Hermann Boerhaave, the Chair in Chemistry was established primarily due to the influence of Franciscus de la Boë Sylvius who had been appointed Professor of Clinical Medicine in 1658[5]. When Anton Deusing was being considered for an appointment to the Medical Faculty in 1666, Sylvius threatened to resign unless given a chemical laboratory and a Professorship in Chemistry. But although this was promised to him by the Board nothing came of it initially. Only three years later did the Board confirm its earlier decision in noting that "nothing was lacking to make the distinction of the Medical Faculty complete but the preparation of medicaments in a chemical manner and the performance of experiments in the field of chemistry."

The first appointment by the University was Carel de Maets (1640-1690) who had been trained by Glauber in Amsterdam and then had gone on to the University of Utrecht as an unsalaried Docent. But there he had had no laboratory and he was attracted to the new position at Leiden where the chemical laboratory was opened in 1669. He was appointed without salary, but by 1672 he was an ordinary Professor in the Faculty of Philosophy and seven years later he was given the same appointment in the Medical Faculty. At his death in 1690, Jacob Le Mort was given the management of the chemical laboratory, but his official appointment as Professor of Chemistry was not confirmed until 1702. He was to be succeeded in their chair by Boerhaave in 1718.

The Professorship in Chemistry at Leiden had been established because of the recognized need of this subject for medical students. But De Maet's two chemical textbooks, the one by Le Mort, and the *Collectanea chymica Leydensia* compiled by Christopher Love Morley, an English student, all testify to the fact that the chemistry being taught there had little to do with the chemical explanations of physiology favored by Sylvius. Rather, they reflected the practical preparations of pharmaceutical products and the long tradition of chemical textbooks that had originated with Jean Beguin.

In Paris much of the formal teaching had been carried on at the Jardin des Plantes and in private courses. At the medical school the opposition to chemistry was so strong that a formal appointment was delayed longer than elsewhere. The size of the Medical Faculty was gradually expanded over the course of the sixteenth and seventeenth centuries, but it was not until a 1566 ban on the use of antimony was rescinded exactly a century later that any change in attitude toward chemistry can be seen. In fact, it was not until two years after Statutes were revised in 1696 that a fifth Chair was established in the Medical Faculty to teach a couse in chemical and Galenic pharmacy for medical students. And although chemical pharmacy was finally introduced in 1698, it was not until 1756 that a Chair for Theoretical and Practical Chemistry was established in the Medical Faculty at Paris[6].

Even at Montpellier the move toward an appointment in chemistry was far from rapid[7]. Montpellier had had a long

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connection with medical chemistry and the most prominent French medical chemists had for the most part taken their degrees there. But although this is true, there was no appointment in chemistry until 1673 when Sebastian Matte became the Demonstrator in Chemistry. He had published a typical text on the chemical preparations of pharmaceutical products in 1671 and he was permitted to give a course in chemistry once a year. However, he was given a salary commensurate with that of a full professor with similar rights, prerogatives, exemptions and immunities. These privileges came as a shock to the members of the Medical Faculty who had no wish to see a chemical operator whom they considered to be illiterate raised to their own status. Arguing that this was a medical subject, they recommended that a new Chair in Chemistry be established and given to a medical doctor who would then be set over and above the chemical demonstrator. The first Professor of Chemistry at Montpellier was Arnaldus Fonsorbe who published very little, but he was followed by Antoine Deidier in 1695 who was to continue the seventeenth-century tradition of teaching chemistry in the form of chemical pharmacy until his retirement in 1732.

The point I wish to make is that although the famous textbooks of Begun, Lefèvre, Glaser, Lemery and others are all associated with Paris, they were certainly not the only works being produced for the teaching of chemistry. Similar texts were being turned out by most of the teachers of chemistry throughout Europe. More important is the fact that many of these teachers were introducing this subject at universities. Although the Galenists had been the first to condemn the introduction of chemistry to medicine, it was through the medical schools of Europe that chemistry was to become academically respectable in the course of the seventeenth century. I think that the fact that chemistry was considered a medical subject is important both because it helps to explain the relative lack of interest in chemistry in natural philosophy texts then and later, and also because by 1700 it was no longer simply a subject for outsiders as it had been a century earlier.

THE MEDICO-CHEMICAL DEBATES

The incorporation of chemistry into the medical curricula had not been accomplished without considerable opposition from the Galenic establishment[8]. In the sixteenth century the debates over the Paracelsian system had touched on both the mystical chemical world system as a whole and on the more practical subject of the use of chemically-prepared medicines. However, although there were always those who sought the acceptance of the entire system, the most persistent debates had centered on the medical use of chemical preparations--particularly inorganic substances and especially the metals.

The teaching of chemistry in the universities reflected this interest in pharmaceutical chemistry and surely the widespread opposition to Paracelsus had much to do with his natural magic and his use of the macrocosm-microcosm analogy. But the latter was largely condemned by the medical community by the early decades of the seventeenth century. This may be contrasted with the lack of agreement among physicians regarding the value of chemical remedies.

Paracelsus had also been interested in describing bodily processes in chemical terms. This was to become a major topic of debate among late seventeenth-century iatrochemists. Jean Baptiste van Helmont restated the Chemical Philosophy in his posthumously published *Opera omnia* (1648)[9]. And although he borrowed heavily from Paracelsus, he condemned his views--including the concept of the microcosm--as well as those of the Aristotelians and the Galenists. He considered his own work to be a "nova Philosophia" and he explained physiological processes in chemical terms.

Although few of van Helmont's works had been published before his death, he was well known to many European scholars during his lifetime. Gui Patin, the arch defender of Galen in the Parisian Medical Faculty wrote shortly after hearing of van Helmont's death that the man was a Flemish rascal who had never written anything of value. Indeed, he added, that van Helmont's rejection fo blood-letting had deservedly caused him to die raving mad[10].

Van Helmont's *Opera* were to be published frequently down to the early years of the eighteenth century, but Thomas Willis (1621-1675) and Franciscus de la Boë Sylvius (1614-1672) were to be more influential in the development of iatrochemistry[11]. Both were skilled anatomists as well as chemists. We have already noted the part played by Sylvius in bringing chemistry into the medical curriculum at Leiden.

Thomas Willis reflected the contemporary interest in atomic explanations and to this extent he may be classed among the corpuscular philosophers, but he was clearly influenced by van Helmont in his use of fermentation both for an explanation of inorganic and organic life processes[12]. In vegetables Willis identified the fermentation process with the growth of seeds, while his description of animal life centered on man. The life spirit resulted from a fermentation in the heart and was distributed throughout the body through the circulation of the blood[13]. He associated other sources of fermentation in the bowels, the genitals, and the spleen while both disease and its cure involved fermentation[14]. Willis did not refer to van Helmont's local archei, but there seems little doubt that his concept of the ferment was inspired by the work of the Belgian[15].

Willis repeatedly used chemical analogies. Disease was due to fermentation, the action of the muscles resulted from the reaction of nitrous and sulphureous spirits[16], and he used distillation both as a means of analysis and as a model for explanation. The body itself was likened to a distillation unit and his cardiovascular system reflects this as well as the works of Galen: blood, heated in the heart, rose to the colder brain where the animal spirits were separated from the cruder blood and passed on to the nerves[17].

Willis' persistent use of chemistry is similar to that of his contemporary, Franciscus de la Boë Sylvius[18]. For Sylvius chemistry was essential for a proper understanding of nature and for this reason it is also essential for medicine. He was convinced that all physiological processes could be explained chemically--primarily through fermentation, effervescence and putrefaction. And if van Helmont had pointed to acid, alkali, and neutralization as important factors in physiological phenomena, they became much more fundamental with Sylvius. Thus, he believed that the pancreatic juice was acid and that it effervesced with an alkaline gall in the duodenum. As in the case of van Helmont, Sylvius had a special interest in digestion[19]. It involved acid-base considerations, the effect of internal heat and an acceptance of the circulation of the blood. There is no need to discuss this in detail, but the circularity provides a continuous nourishment of the internal fire of the heart while at the same time maintaining vitality throughout the body[20].

Although their use of chemistry as a means of explanation seems to reflect the work of van Helmont, it may be best to interpret both Willis and Sylvius as men who logically extended a chemical tradition that may be traced to Paracelsus. An important distinction between them and earlier authors is their lesser interest in chemistry as a total philosophy of nature. While both surely subscribed to much a view in general, the thrust of their work centered on physiological problems. And although they were deeply interested in chemistry, theirs was a chemistry that was quite different from that of those chemists who confined themselves primarily to the preparation of chemical remedies. It is with these authors that we see the full development of a new phase of iatrochemistry. The many students of Sylvius in particular promoted his chemical interpretations throughout Europe after his death.

Perhaps the chief French exponent of this iatrochemical school was Raymond Vieussens (c. 1635-1715) who took his M.D. at Montpellier in 1670. His work reflects both Cartesian mechanism and late seventeenth-century iatrochemistry. Writing of his own research he said that he began his anatomical studies in 1671 and then went on to apply the principles of chemistry to the human body and to write a treatise on fermentation[21]. It was his work on blood that best reflects his interest in chemistry. Here he tells us he was influenced by reading the work of Boyle[22]. He, too, turned to analysis from which he concluded that blood is composed of phlegm, salt, sulphur and earth[23]. The salt could further be divided into volatile and fixed fractions. In his description of the passage of the blood from the right to the left ventricles he discussed the vital spirit which "I understand [to be] a very fine liquor diffused throughout all the mass of blood, and principally composed of a very subtle air, charged with entirely volatile nitrous particles and united to the volatile acid salt of food"[24]. This work places Vieussens at the end of a century-long quest for the material vital spirit that had engaged the interest of Fludd, van Helmont, Boyle and Mayow[25].

Viussens clearly represents a major figure in the iatrochemical tradition, but he is of even more interest because late in life he was converted to a more mechanical approach to life processes. That this should have happened reflects the debate between iatrophysicists and the iatrochemists--a debate that we still know far too little about. Even a cursory overview of the reviews in periodicals such as the *Journal des Sçavans* indicates the extent of this literature, but here let me refer briefly to a single author, Philippe Hecquet (1661-1737) who took his medical degree at Paris in 1697 and specifically attacked Vieussens in his work on digestion in 1712.

Comparing his own mechanical system with that of the iatrochemists, Hecquet wrote that mechanical trituration explained digestive processes more simply and with more certainty than the views of the chemists. They spoke of degrees of heat, concentrations, coagulations, fermentations, effervescences, humors and juices. The mechanists, however, had simpler explanations related to the oscillation of fibers, relative diameters of the vessels and forces. The chemists discussed bile, phelgm, blood, melancholy, acid, alkali, volatility, fixity, and they wrote of the aqueous, sulphureous, spiritous and phlegmatic nature of substances when, in fact, it was only necessary to speak of solids and fluids. And when they wrote of faculties, qualities and flavors, they should have limited themselves to resistances and forces. "In short, and because we do not wish to repeat ourselves too much, all these names and qualifications [used by the chemists] are in their imaginations..." [26]

For Hecquet the promises and attractions of chemistry have tarnished the reputations of otherwise great physicians. Surely, this has been the case of Willis and Sylvius, both of whom devoted themselves too much to the dreams of Paracelsus and van Helmont. Even today, Hecquet continued, we see the physicians of France too devoted to Paracelsian secrets and chemical delusions[27]. If this continues, medicine will degenerate to a monstrous science.

THE SEPARATION OF CHEMISTRY AND MEDICINE: BOERHAAVE, STAHL AND MONTPELLIER

The attack of Hecquet on Vieussens is characteristic of much early eighteenth-century literature in medicine. The reviews in the *Journal des Sçavans* give evidence of an extensive literature debating the merits of iatrophysics and iatrochemistry. But here let me limit my remarks specifically to the views of Hermann Boerhaave and Georg Ernst Stahl.

Boerhaave certainly considered himself to be a mechanist[28]. He is of special interest to us because in addition to his Chair in Medicine he held the Chair of Chemistry at Leiden ... and his published lectures on chemistry rank among the most widely read of the early eighteenth century. His belief in the importance of physics as a basis for medicine is clear from his academic oration of 1703. Here he discarded contemporary iatrochemical thought and turned rather to hydraulic and mechanical principles referring to the velocity of the blood, the diameter of the blood vessels, and the size and shape of particles[29]. The body was explained in terms of structure.

...we find some [of the parts] resemble *Pillars*, *Props*, Cross-Beams, Fences, Coverings, some like *Axes*, *Wedges*, *Leavers*, and *Pullies*; others like *Sieves*, *Strainers*, *Pipes*, *Conduits*, and *Receivers*; and the Faculty of performing various Motions by these Instruments, is called their Func tions; which are all performed by *mechanical Laws*, and by them only are intelligible[30].

He argued further that vital processes could and should be examined with the aid of the new mathematical physics[31].

Boerhaave became ordinary Professor of Medicine and Botany at Leiden in 1709 and Professor of Practical Medicine five years later. His lectures on medicine began with a history of the subject and here he attacked both Paracelsus and van Helmont for having tried to make medicine subservient to chemistry[32]. He felt that they had lived in a fabulous world little removed from that of the Rosicrucians[33].

What is the value of chemistry? He readily admitted the value of chemically-prepared medicines. But Boehaave's *A New Method of Chemistry* also states that chemistry is useful in pathology and for urinalysis as well phyisiology since it permits the physician to analyze the fluids of the body[34]. He clearly accepted the value of chemistry as long as it was confined to experimental results and was not used as an all encompassing system of nature and mankind. The truly basic science for organic and inorganic matter is physics to which all other sciences are ancillary. It would seem then, on the basis of Boerhaave's medical and chemical lectures, that he favored a chemistry that might be used by physicians for certain specified purposes, but this was a chemistry that would not dominate medicine. It was a chemistry that was losing its close connection with medicine and emerging as a more independent science.

Like his contemporary Boerhaave, Georg Ernst Stahl taught both chemistry and medicine[35]. Stahl's medicine also marked a rejection of the work of the iatrochemists. He insisted on a sharp differentiation between living and non-living matter[36]. At the end of life corruption sets in so there must be something present in a living body that preserves it from corruption and regulates its actions and bodily functions. This is the *anima*, the origin of directive, purposeful motion. In the organic world motion depends on mechanical causes and may be studied on the basis of the size, shape and motion of individual particles. In the living organism, mechanistic explanations are at best only partially useful since it is the *anima* which directs motion towards a purposeful end. Even in the case of a chemical process in the body it is the *anima* which directs it. Here Stahl differed from the Helmontian tradition which postulated separate *archei* in the bodily organs, each of which carried on its own action.

For Stahl, Paracelsus and van Helmont and been largely responsible for the invidious influence chemistry had developed in medicine[37]. This must be reversed because, he felt, chemistry is completely useless for any true medical theory. The chemists incorrectly explain life processes through coagulation and liquefaction, fermentation, volatility, acrimony, and more recently, through acids and bases. In fact, for Stahl, other than its pharmaceutical value, chemistry has now become one of the physical sciences. Even a brief glance at Stahl's *Fundamenta Chymia* indicates that for him this subject is largely devoid of medical value. The work concentrates on matter and its combinations, descriptions of specific substances, and on chemical processes--even alchemy, but not on medicine.

Stahl's animistic medicine differed greatly from the mechanistic medicine of Boerhaave, but both accepted pharmaceutical chemistry and both sought to separate chemical speculation from medical theory. Boerhaave was a mechanist who saw some value in the chemical investigation of living matter, particularly the analysis of body fluids. Stahl was more emphatic in separating the two fields. The *anima* was the director of life processes and the speculations of the iatrochemists seemed to him to have gone too far. His chemistry had been influenced primarily by Becher's *Physica subterranea*, a work which emphasized the inorganic chemistry of the subterranean world. Thus, with both authors the end result was to lessen--and nearly eliminate--the role of chemistry as a means of explanation of life processes.

If Stahl's phlogiston chemistry was to become the dominant chemical system in mid-century, his influence on medicine was no less significant. Here the French scene is of special importance[38]. Montpellier had been a center for the introduction of chemical medicines from the mid-sixteenth century. This had led to a general acceptance of iatrochemistry a century later. However, with the successes of the new philosophy in the physical sciences there had been a parallel attempt to turn to mechanical explanations in medicine of the sort we have already noted with Hecquet and Boerhaave. As mechanical explanations of life processes became more acceptable in medicine in the early eighteenth century, there remained the problem of accounting for the motion of the man-machine. Here Stahl's concept of the *anima* was to prove helpful. François Bossier de Lacroix Sauvages (1706-1767), originally a follower of the iatrophysicist Baglivi, found mechanist answers unsatisfactory for an understanding of the properties and functions of living matter and he soon found himself turning to the works of Stahl[39]. He began giving lectures on Stahl's system at Montpellier in 1737 holding to mechanistic explanations as long as possible and turning to the *anima* only when these had been exhausted. Nevertheless, his lectures initiated a debate that continued for six or seven years before his views were generally accepted.

The reaction initiated by Sauvages in 1737 continued throughout the century and beyond. Openly influenced by van Helmont as well as Stahl, Théophile Bordeu (1722-1776) argued in favor of localized vital forces in each organ[40] while Paul-Joseph Barthez (1734-1806) preferred a single vital principle which made possible all vital phenomena[41]. Stahl had insisted that chemical explanations were to be eliminated from medical theory and the physicians of Montpellier agreed. Bordeu complained that the followers of Paracelsus viewed man as a composite of alembics, ferments, salts, effervescences and distillatory vessels...none of which deal with life forces[42]. Barthez accepted this and added that effects of the vital principle are completely different from the phenomena of "dead" nature and it is only the latter which are determined by the operations of chemistry[43].

Here, then, was the result of the reaction against both iatrophysics and iatrochemistry in the eighteenth century. Chemistry--other than for pharmaceutical preparations--was divorced from medical theory and physiological explanations. The most prominent member of the medical school at Montpellier, Xavier Bichat (1771-1802) was to be in full agreement with his predecessors, Bordeu and Barthez, on this point. In her recent study of Bichat, Elizabeth Haigh has written that "he was one of the last medical theorists of any particular influence to insist uncompromisingly that physics and chemistry were separate sciences from physiology, making specious the application of their principles to the study of living processes" [44]. And indeed, this non-chemical and vitalistic medicine was maintained at Montpellier throughout the nineteenth century.

THE PERSISTENT LURE OF ALCHEMY

From what I have said to this point I think it is clear that much of the significance of chemistry from the sixteenth through the early eighteenth centuries may be found in its changing relationship to medicine. But wat of transmutational alchemy? Oddly enough, there seems to have been a persistent interest in this subject to the extent that the alchemical literature of the eighteenth century rivals that of the seventeenth in quantity. Nor is this literature confined to the fringe elements of the scientific community. Andreas Libavius had attacked the followers of Paracelsus because of their mysticism, but the allegorical plates he included in his masterwork, the *Alchymia* rank among the most frequently reproduced of their kind. Similarly, Johann Rudolf Glauber and Jean Baptiste van Helmont believed fervently in transmutation--indeed, van Helmont gives several accounts of having transmuted lesser metals himself. As for the current interest in Boyle and Newton this has only served to establish the fact that their interest in this subject was firmly rooted.

But since I have just touched on the work of Boerhaave and Stahl let me turn to them again on this subject. With advancing age Boerhaave resigned his chair in chemistry in 1729. However, his interest in this science heightened as he prepared his textbook, the famous *Elementa chemiae* (1723) to replace earlier publications based upon notes taken by others in his classroom. This was also a period when he intensified a long-standing interest in transmutational alchemy. The results of his research were published in three parts in the *Philosophical Transactions* of the Royal Society in 1734 and 1736 although he had offered his views on this subject for many years in his lectures. Indeed, in a lengthy section on the uses of chemistry in the *New Method of Chemistry* based upon those lectures there are pages devoted to alchemy[45]. Here he concluded that not only could chemical separation techniques isolate gold from other metals, it could also promote the natural growth of gold in a proper matrix through maturation. He commented that "we don't see why this art should absolutely be pronounced false ... And as for that branch of alchemy that "teaches how to make gold of other metals", "all the world cries out [that it] is impossible, tho' we don't see why..."

Boerhaave's experiments on mercury show that he had read the traditional alchemical authors with care. He named many of them and singled out Geber for special praise. Those who had read these authors will see plainly that "the most ancient Alchemists far surpassed the rest in their Accounts of the Nature of things"[46]. Boerhaave was particularly impressed that these authors agreed in so many of their beliefs. Here he referred to the general acceptance "that Metals are naturally generated in their veins, are nourished, grow, and multiply like other natural Things, each in their proper Place"[47]. He also noted a general agreement that these metallic growth processes required a metallic nutriment which would be changed by a metallic seed into its own kind. Thus, as the seeds of vegetables and animals change foods into their own nourish- ment, "so the vivificating Seed of growing Gold, having got a proper Food, in a fit Matrix, by the Help of a suitable and convenient Heat, digests the same into its own particular Nature"[48].

Since these authors agreed that mercury was the prime ingredient of metals Boerhaave investigated the possibility of promoting its maturation through lengthy heating. He carried on the process over months and sometimes over years. In one case he heated mercury for fifteen years but only found the formation of a black powder which could be turned into mercury on rubbing. In a similar experiment he heated mercury and obtained a powder which was then further subjected to heat reverted to mercury metal. In his description of this process he turned to alchemical terminology writing that "Thus the Serpent that has bitten itself dies. It arises again more glorious from Death"[49]. There is no indication that Boerhaave ever dismissed the real possibility of transmutation.

And what of Stahl? In his *Specimen Beccherianum* (1703) he asked whether there was a tendency toward the formation of metals in the subterranean regions, and further, whether metals actually moved toward perfection. Rather than a gradual maturation, Stahl favored instant generation. As he explained in the *Fundamenta Chymiae,*

> ... it may more easily be conceived, that Metals should be ... instantaneously generated, than that the imperfect metals should ... be converted into the perfect ... by long continued Concoction in the earth, or by lying therein for some hundreds of years, without the addition of any new matter, or any diminution of the old ... [And] if this instantaneous Generation of Metals cou'd once be established, it wou'd give great countenance to the action of the philosophical *Tincture* of *Substance* in the business of Transmutation...[50]

Clearly Stahl was sympathetic to the concept of transmutation, in a discussion of Philosophical Gold he explained that the adepts meant by this

> *Gold* most highly subtilized, and brought to a degree of fermentative mobility; so that being mix'd with pure running Mercury, it may by degrees assimilate the particles thereof to itself, and at lenght reduce the whole mass to a due degree of spissitude; whence the Mercury also may, in time, become true *Gold*; which, tho' softer than the common, is yet like it, in sustaining all the Proofs whereby the constancy of that is examin'd.[51]

Of special importance for the would-be alchemist was the work of Isaac Hollandus. Stahl reprinted his treatise on the salts and oils of metals as an appendix to his thoughts on alchemical transmutation. As it had been with Boerhaave, the study of mercury was of great importance. Stahl wrote in his section on "the Mercuries of Metals" that

> The principal use of these *Mercuries* is their advancement into Gold, by a moderate digestion with highly subtilized or philosophical Gold; whence they are said to be coagulated with it into a fix'd Precipitate; which if thrown into Silver or Gold in fusion, there proves and remains good and fix'd Gold.[52]

He went on to examine the three basic processes described by the adepts for making the philosopher's stone: from Vitriol, from Nitre, and from Mercury. But although he discussed these processes in as scientific a fashion as he could, he wrote as any other alchemist when he ascribed sucess in this endeavor to the Will of God.

> But as the Cautions with regard to all these cases are fundamentally circumscribed and defined by the *Divine Will,* which, without all dispute governs and directs the thing itself and its success, according to the various intentions and *moral Circumstances* of the Person; let everyone examine himself by this Rule, and accordingly expect success or failure, in his attempts.[53]

In short, eighteenth century chemists surely could not dismiss traditional transmutational alchemy simply by arguing that this belonged to the realm of the occultist and charlatan. The alchemical interests of Boyle and Newton may not have been widely known to all, while the work of Libavius and van Helmont may no longer have been considered current, but this was hardly the case with Boerhaave and Stahl --- surely among the most influential chemists of the century. And if one may note a declining interest in alchemy in mid-century, it is also necessary to recognize a marked revival at the end of the century, a period when a reaction against the mechanical world view led to romanticism and *Naturphilosophie.*

CONCLUSION

Let me conclude by saying that while we know that historians of medicine have seldom paid enough attention to chemistry, it is also true that historians of chemistry have rarely studied in enough detail the close connection of their science and medicine. Here I have emphasized first the debates with Galenists over the introduction of chemically-prepared medicines --- debates which were to result in the academic acceptance of chemistry in the medical faculties of Europe. I then turned to the increased interest in chemical explanations of physiological processes following the work of van Helmont which was eventually to lead to a new set of debates between iatrochemists and iatrophysicists. These were eventually to lead to the separation of chemistry from medicine other than primarily for pharmaceutical purposes. The work of Lavoisier and his colleagues did not have to be directed at a medically-based chemistry although that would have been the case at the beginning of the century. But if the new chemistry of the early eighteenth century was largely stripped of its medical heritage, its vitalistic component was transformed largely through the influence of Stahl's French disciples at Montpellier where it developed into the school of animist medicine.

Through all of this we see continued interest in traditional alchemy. Here I referred primarily to the work of Boerhaave and Stahl, but I could have mentioned the mass of German and French texts from the eighteenth century just as well. Since these works continued to be published throughout the century I think that they may be looked upon as forming one the factors underlying the revived mysticism of the antimechanistic reaction at the end of the century.

I would argue than that eighteenth century chemistry should be understood in terms of a real continuity with its past. Of course this means in part the development of phlogiston through the works of Becher as interpreted by Stahl and his disciples. But it means also a more broadly based--and legitimized--iatrochemistry that was accepted in the European medical schools. I have argued elsewhere that I think that we could well think in terms of a chemical revolution beginning in the sixteenth century and continuing through several phases down to the period of Lavoisier. To do so would give chemistry the place it deserves in the Renaissance reaction against the ancients. It would also establish the importance of medicine in the rise of modern science which I believe is long overdue.

NOTES AND REFERENCES

1. Although these textbooks are discussed by all historians of seventeenth century chemistry, the classic account is that of Hélène Metzger, Les doctrines chimiques en France du début du XVII^{e} à la fin du XVIII^{e} siécle, prémiere partie (Paris: P.U.F., 1923). I have discussed the relation of chemistry and the textbooks to the medical establishment in my forthcoming The French Paracelsians: The Chemical Challenge to Medical and Scientific Tradition in Early Modern France (Cambridge, New York et al.: Cambridge University Press, in press).

2. For an overview see Allen G. Debus, "Chemistry and the Universities in the Seventeenth Century", Academiae Analecta: Klasse der Wetenschappen, 48 (1986), 13-33.
3. Bruce T. Moran has published extensively on Hartmann in recent years. Of special interest is his Chemical Pharmacy Enters the University: Johannes Hartmann and the Didatic Care of Chymiatria in the Early Seventeenth Century (Madison: American Institute of the History of Pharmacy, 1991). Older accounts that are still of value include Lynn Thorndike, A History of Magic and Experimental Science (8 vols.; New York: Columbia University Press, 1923-1958), 8, pp. 116-17 and J.R. Partington, A History of Chemistry, 2 (London: Macmillan, 1962), p. 177.
4. Ernest Giese and Benno Von Hagen, Geschichte der medizinische Fakultat der Friedrich-Schiller-Universitat Jena (Jena: VEB Gustav Fisher Verlag, 1958), pp. 96-121.
5. J.W. Van Spronsen, "The Beginnings of Chemistry" in Leiden University in the 17th Century: An Exchange of Learning, ed. Th. H. Lunsingh Scheurleer and G. H. M. Posthumus Meyjes. With the assistance of A. G. B. Bachrach (Leiden: University Press, Brill, 1975), pp. 329-43 (335).
6. On the development of the Medical Faculty at Paris see Dr. August Corleiu, L'ancienne Faculté de Médecine de Paris (Paris: V. Adrien Delahaye et Cc, Libraires- Éditeurs, 1877), pp. 124-43.
7 Jean Astruc, Mémoires pour servir a l'Histoire de la Faculté de Medecine de Montpellier..., Revus & publiés par M. Lorry
8. On the development of the Chemical Philosophy in the century after the death of Paracelsus see Allen G. Debus, The Chemical Philosophy: Paracelsian Science and Medicine in the Sixteenth and Seventeenth Centuries (2 vols., New York Science History Publications, 1977).
9. Ibid., 2, pp. 295-379.
10. Letter dated 16 april 1645, Gui Patin, Lettres..Nouvelle Édition augmentée de lettres inédites, precédée d'une notice Biographique par J.-H. Reveillé-Parise (3 vols., Paris: J.-B. Baillière, 1846), 1, p. 355.
11. On Willis and Sylvius I have followed my previous discussion in The Chemical Philosophy, 2, pp. 520-31. The standard biographies are Hansruedi Isler, Thomas Willis 1621-1675. Doctor and Scientist (London: Hafner, 1968) and E. D. Baumann, François de la Boë Sylvius (1614-1672) (Leiden: E. J. Brill, 1949). See Also Partington, 2, pp. 281-90, 304-10.
12. Thomas Willis, "Of Fermentation or the Inorganical Motion of Natural Bodies" in Practice of Physick..., trans. S. Pordage (London: T. Dring, C. Harper and J. Leigh, 1681), pp. 2-11.
13. Ibid., p. 13.
14. Ibid., pp. 14-16.
15. Here I agree with Isler in Willis, p. 61.
16. Willis, "Of Convulsive Diseases" in ibid., p. 2 (separate pagination).
17. Willis, "Of Fermentation" in Ibid., pp. 14-15.
18. In addition to the references cited above, note 11, on Sylvius see Lester S. King, The Road to Medical Enlightenment 1650-1695 (London: Macdonald; New York; American Elsevier, 1970), pp. 93-112.
19. Sylvius' views on digestion are well treated by King in his Road to Medical Enlightenment, pp. 98-104. His discussion is the basis of the present account.
20. Like others in the Paracelsian tradition Sylvius noted the similarity of life and combustion and gave a significant role to the aerial niter in the respiratory process. Ibid., pp. 104-5.
21. Raymond Vieussens, Medecin ordinaire du Roi, de l'Académie des Sciences de Paris, & de la Societé Royale de Londres, Traité Nouveau de la Structure et des Causes du Mouvement Naturel du Coeur (2 vols., Toulouse: Jean Guillemette, 1715), 1, sig. e iii^{v}.
22. Raymond Vieussens, Medecin de la Faculté de Montpellier, Deux dissertations... Le Premiere Touchant l'extraction du Sel acide du Sang, La Second Sur la proportion de quantité de ses principes sensibles (Montpellier: Honoré Pech, 1698), sig. ã 2r.
23. Ibid., sig. ã 3r.
24. Vieussens, Traité Nouveau, p. 122.
25. Summarized by Allen G. Debus, "Chemistry and the Quest for a Material Spirit of Life in the Seventeenth Century" in Spiritus: IV° Colloquio Internasionale del Lessico Intelletuale Europeo, Roma, 7-9 gennaio 1983 edited by M. Fattori and M. Bianchi (Rome: Edizioni dell'Ateneo, 1984), pp. 245-63.
26. Philippe Hecquet, De Digestion, et des Maladies de L'-Estomac suivant de Systême de la Trituration & du Broyement, sans l'aide de Levains ou de la Fermentation, dont on fait voir l'impossibilité en santé & en maladie (2 vols., Paris: Guillaume Cavalier, 1730; lst ed. 1712), 2, pp. xliv-xlv.
27. Ibid., 1, pp. 564-65.
28. The standard treatment remains G.A. Lindeboom, M.D., Herman Boerhaave. The Man and his Work (London: Methuen & Co., Ltd., 1968). Lindeboom also prepared an abstracted version of his research for the Dictionary of Scientific Biography, Charles Coulston Gillispie, Editor-in-Chief (16 vols., New York: Scribners, 1970-1980), 2 (1973), pp. 224-28. Of special importance for his chemistry is the chapter in J.R. Partington, A History of Chemistry, vol. 2 (London: Macmillan & Co., Ltd., 1961), pp. 736-68 and the article by F. W. Gibbs, "Boerhaave's Chemical Writings," Ambix, 6 (1958), 117-35.
29. Discussed by Lindeboom, Herman Boerhaave, pp. 66-67. See also Lester S. King, M.D., The Philosophy of Medicine: The Early Eighteenth Century (Cambridge, Mass. and London: Harvard U.P., 1978), pp. 121-23.
30. [Herman Boerhaave], Academical Lectures on the Theory of Physics. Being A Genuine Translation of his Institutes and Explanatory Comment ... (6 vols., London: W. Innys, 1742-1746), 1, p. 81 (notes on passage continue to p. 85).
31. Boerhaave's Sermo Academicus de Comparando Certo in Physicis (Leiden: Petrum vander Aa, 1715) is a hymn of praise to the new science. Here see particularly p. 7.
32. Boerhaave, Academical lectures, 1, p. 40.
33. Herman Boerhaave, Sermo Academicus de Chemia Suos Errores Expurgante, Quem habuit, Quum Chemiae professionem in Academiâ Lugduno-Batavâ auspicaretur xxi. Septembris 1718 (Lugduni Batavorum: Sumptibus Petri Vander Aa, 1718). As an example ...

O si vesani homines temperassent sibi, nec ipsa Sacra Volumina interpretari voluissent ex Principiis & Elementis Chemicis! Sed pudet, omnia haec de iis dici posse & refelli non posse! Paracelsi, Helmontii, Fratrum Roseae Crucis, aliorum, scripta evolvat quis. Stupebit! Nugamentorum pudebit, in quae per verititum nefas ruit audax omnia fingere Turba Chemicorum. Quae fabulae superstitio inscitia!

34. Herman Boerhaave, A New Method of Chemistry; Including the Theory and Practice of that Art: Laid down on Mechanical principles and accommodated to the Uses of Life. The whole making a Clear and Rational System of Chemical Philosophy. To Which is prefix'd a Critical History of Chemistry and Chemists, From the Origin of the Art to the present Time, trans. P. Shaw and E. Chambers (London: J. Osborn and T. Longman, 1727), p. 194-6.
35. Stahl's chemistry is discussed at length by Partington, History of Chemistry, 2, pp. 652-90. Still excellent is Hélène Metzger, Newton, Stahl, Boerhaave et la doctrine chimique

(Paris: Félix Alcan, 1930), pp. 91-188. The reader is referred also to David Oldroyd, "An examination of G.E. Stahl's Principles of Universal Chemistry", Ambix, 20 (1973), 36-52. For Stahl's medical thought, see Lester S. King, "Stahl and Hoffman: A Study in Eighteenth Century Animism", Journal of the History of Medicine and Allied Sciences, 19 (1964), 118-30. King's survey of the work of Stahl is to be found in his biography of Stahl in the Dictionary of Scientific Biography, 12 (1975). pp. 599-606. Still helpful is Walter Pagel, "Helmont. Leibniz. Stahl," Sudhoffs Archiv für Geschichte der Medizin, 24 (1931), 19-59; Albert Lemoine, Le vitalisme et l'animisme de Stahl (Paris: Germer Baillière, 1864).

36. I have largely followed L.S. King's account of the anima.
37. Metzger, pp. 111-13.
38. Of special value is the recent paper by José M. López Piñero, "Eighteenth Century Medical Vitalism; The Paracelsian Connection" in Revolutions in Science: Their Meaning and Relevance, William R. Shea, Editor (Canton, Mass., 1988), pp. 117-32. Also valuable are the introductory chapters to Elizabeth Haigh, Xavier Bichat and the Medical Theory of the Eighteenth Century, Medical History, Supplement No. 4 (London: Wellcome Institute for the History of Medicine, 1984). A more nearly contemporary account is to be found in M.F. Bérard, Doctrine Médicale de l'École de Montpellier, et Comparison de ses principes avec ceux des autres écoles d'Europe (Montpellier et a Paris: Librairie au Rabais, 1819).
39. Haigh, Bichat, pp. 16-31.
40. Ibid., p. 36
41. P.J. Barthez, Nouveau Éléments de la Science de L'Homme (3rd ed., 2 vols., Paris, Germer Baillière, 1858; first published in 1778 and second edition, 1806), pp. 24, 93-94.
42. Théophile de Bordeu, "Analyse Médicinale du Sang" in Oeuvres complètes de Bordeu, Précédés d'une Notice sur sa vie et sur ses Ouvrages par le Chevalier Richerand (2 vols., Paris: Caille et Ravier Libraires, 1818), p. 930.
43. Barthez, Nouveaux Éléments, p. 37.

Les affections du Principe Vital qui produisent et renouvellent, dans un ordre constant, les fonctions necessaires à la vie, sont absolument différentes des causes productives des mouvements qui ont lieu dans la Nature morte, comme sont ceux que determinent les opérations de la Chimie.

44. Haigh, Bichat, p. 15.
45. Boerhaave, New Method of Chemistry,pp. 215-18.
46. Hermann Boerhaave, Some Experiments Concerning Mercury ..., Translated from the Latin, communicated by the Author to the Royal Society (London: J. Roberts, 1734), p. 6.
47. Ibid., p. 9.
48. Ibid., p. 10.
49. Ibid., p. 40.
50. George Ernest Stahl, Philosophical Principles of Universal Chemistry: Or, The Foundation of a scientific Manner of Inquiring into and Preparing The Natural and Artificial Bodies for the Uses of Life... Design'd as a General Introduction to the Knowledge and Practice of Artificial Philosophy; Or, Genuine Chemistry in all of its Branches. Drawn from the Collegium Jenense of Dr. George Ernest Stahl. By Peter Shaw M.D. (London: Printed for John Osborn and Thomas Longman, 1730), p. 249, 251.
51. Ibid., p. 319.
52. Ibid., p. 391.
53. Ibid., p. 424.