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CHAPTER II

The Chemical Key

A new interest in chemistry is very noticeable in the late Renaissance. Relatively few chemical books had been published in the period prior to 1550, but during the next century a veritable flood of chemical and medico-chemical texts was printed. Those who wrote these books or who printed older texts insisted on the importance of their work. They not only spoke of the large number of those who had abandoned the teachings of the ancients to follow their chemical philosophy, but they also frequently named the chemical authorities to whom their readers could turn for truth in philosophy and medicine. They all hoped that the doctrines of the ancients would soon be overturned and that their "new philosophy" of nature would triumph. On the other side, scientists as prominent as Johannes Kepler and the early mechanists Marin Mersenne and Pierre Gassendi were to write at length against the mystical philosophy of nature elaborated by the chemists. But why was chemistry such a center of debate? The immediate answer may be found in the controversial writings of Paracelsus, but to understand him we must look briefly at the chemical background to his work.

The Chemistry of the Latin West

Chemical texts were introduced to Western Europe in the twelfth century along with other treasures of Greek science, philosophy, and medicine by way of translation or abstraction (for the most part) from the Arabic. The early translations already characterize chemistry as a secret art, so secret that it is often difficult if not impossible to identify the original texts from which they were made. But when we pass beyond the indistinct scene of the twelfth century, we become aware of a rapidly increasing interest in this subject throughout the next two centuries prior to a decline in the

quantity – and quality – of new texts in the fifteenth century. There are numerous references to alchemical allegory in medieval literature, and Chaucer's late-fourteenth-century "Canon Yeoman's Tale" remains the best description of the gold-making charlatan.

Medieval alchemy incorporated much Aristotelian doctrine. The four elements of earth, water, air, and fire had served not only as the basis of Aristotelian physics but, in the form of the related four humors (blood, phlegm, yellow, and black bile), had also served as the bedrock of Galenic medical theory. The qualities associated with these elements (hot, cold, wet, and dry) were interchangeable and thus permitted the transmutation of one element into another. Islamic scholars had added to this a new theory of metals in the eighth century. They had taught that metals were composed of a hypothetical philosopher's (not actual) mercury and sulfur. When these two occurred in perfect proportion the resultant metal would be gold.

But along with Aristotelian and Islamic element theory, alchemy carried with it an aura of secrecy and mysticism. This may in part be a carry-over of the atmosphere in which the early metalworkers of Egypt operated. But a second source might well be the occult tradition of the mystical religions of late antiquity. Gnostic, neo-Platonic, and neo-Pythagorean elements did much to differentiate these alchemists from the students of optics, astronomy, and mathematics. And surely the religious currents run deep in the alchemical literature. The great work itself was seen as a religious experience, and processes and substances were frequently explained in terms of soul, body, and spirit.

Along with this allegorizing and mysticism the alchemist placed a new emphasis on observational evidence. We have already noted Paracelsus's call for the adept to learn from nature rather than books, but the same message is evident in the earlier literature. The fourteenth-century alchemist Bonus of Ferrara observed that

"If you wish to know that pepper is hot and that vinegar is cooling, that colocynth and absinthe are bitter, that honey is sweet, and that aconite is poison; that the magnet attracts steel, that arsenic whitens brass, and that tutia turns it of an orange color, you will, in every one of these cases, have to verify the assertion by experience. It is the same in Geometry, Astronomy, Music, Perspective, and other sciences with a practical aim and scope. A like rule applies with double force in alchemy, which undertakes to transmute the base metals into gold and silver . . . The truth and justice of this claim, like all other propositions of a practical nature, has to be demonstrated by a practical experiment, and in no other way can it satisfactorily be shown."

Related to this emphasis on observation was the alchemist's interest in laboratory procedures. The medieval period saw great advances in distillation techniques. Far more efficient furnaces were built than had been available earlier. Now, with higher temperatures and better condensation, it was possible to add new reagents (most notably alcohol and the mineral acids) to the chemical laboratory. The Latin Geber (early fourteenth century, an assumed name referring to the eighth-century Jābir ibn Hayyān) produced the outstanding work of this sort describing equipment and chemical processes.

Geber made little reference to medicine, but this connection was to become an important aspect of medieval alchemy. The search for chemicals of pharmaceutical value appears among Islamic authors in the writings of the al-Rāzī (Rhazes) (c.854–925/926) and then frequently among his followers. In the West Roger Bacon noted in the *Opus tertium* (1267) that although many physicians used chemical processes to prepare their medicines, very few knew how to perform those works which led to the prolongation of life. His younger contemporary Arnald of Villanova (d. c. 1313) and the fourteenth-century author John of Rupescissa continued to emphasize the medical value of chemistry. By the early sixteenth century this form of scientific literature had blossomed into the many distillation books so very characteristic of the period. These all included descriptions of the chemical equipment needed for the production of oils and spirits from plant substances of all kinds. The benefits of these "quintessences" seemed so great that sixteenth-century editions of the ancient herbal of Dioscorides were furnished with a chemical appendix to bring it up to date.

This chemical knowledge was not considered to be in any way opposed to the science of the Aristotelians or the medicine of the Galenists. To be sure, there were some who complained about the conservatism of the schools, but alchemy had come to the West along with the rest of the body of ancient knowledge. It had been cultivated with classical philosophy and medicine in the Near East – and it was not to be immediately divorced from this earlier union. Nor is there any indication that chemistry was viewed as a dangerous rival discipline by physicians or natural philosophers.

The translation of the *Corpus hermeticum* by Ficino in 1463 added one more factor that was to affect the chemistry of the Renaissance. Fostering occult learning of all kinds, alchemy was shortly brought to the attention of all learned men as an area of study that had not received proper attention in the past. Both Heinrich Cornelius Agrippa von Nettesheim and John Baptista Porta were to point to alchemy as a fundamental science for the understanding of nature. John Dee applied "geometrical method" through twenty-four theorems to the construction of his "hieroglyphic monad," a figure that closely approximated the alchemical symbol for mercury. In the course of this construction Dee felt that he had repeated the first steps of the Creation. The reader was promised the understanding of great mysteries and the entire work would appear to be no less than a veiled representation of the alchemical process itself. But Dee's emphasis was clearly of a piece with the spiritual mathematics favored by those Renaissance Pythagoreans who sought a key to the Creation in mysticism and numerical analysis. The truths of magic were avowed whereas more conventional mathematical proofs, chemical laboratory techniques, and practical medical applications were of relatively little interest. It was in this way that Dee felt that alchemy might be recognized as the most fundamental subject for the natural philosopher.

Nearly half a century earlier Paracelsus had found in alchemy a new basis for the theory of medicine. This, in turn, was to be developed into a universal philosophy of nature validated by the natural correspondences linking man and the world about him. And if Dee's mystical, "mathematicized" alchemy had little impact beyond a devoted circle of alchemists, the views of Paracelsus were to lead to a European debate relating to both medicine and natural philosophy.

Paracelsus: A Lifetime Search

Born near Zurich in the small town of Einsiedeln in 1493, Philippus Aureolus Theophrastus Bombastus von Hohenheim was only later referred to as "Paracelsus," or "greater than Celsus." As a child he was exposed to a heady mixture of Renaissance thought. His father was a country physician who dabbled in alchemy, and the son was never to lose his interest in either medicine or the chemical laboratory. Young Paracelsus was to study under the famed abbot and alchemist, Johannes Trithemius (1462–1516), and was to learn the lore of mines when he worked as an apprentice in the Fugger mines in Villach when his father moved there in 1500. This experience was to bear fruit later in his speculations on the growth of metals and his book on the diseases of miners, the first book ever written on an occupational health problem.

At the age of fourteen Paracelsus left home to study, and over a period of more than two decades he traveled widely. He visited many universities and may have received a medical degree at Ferrara, but if so, he was willing to work in the far less prestigious position of surgeon with the armies that were ever on the move throughout Europe. By the third decade of the century his travels become easier to follow. Now in his thirties, he confined his travels to Central Europe, where he moved constantly from town to town both writing and offering his services as a physician. There were occasional moments of glory such as his appointment as municipal physician at Basel in 1527, but these were always short due to his rash temper. He made no effort to disguise his contempt for the universities and their academic circles. As for the physicians, they need hardly be considered:

"I need not don a coat of mail or a buckler against you, for you are not learned or experienced enough to refute even one word of mine . . . you defend your kingdom with belly-crawling and flattery. How long do you think this will last? . . . Let me tell you this: every little hair on my neck knows more than you and all your scribes, and my shoe-buckles are more learned than your Galen and Avicenna, and my beard has more experience than all your high colleges."

Such outbursts were to lose him position after position, for they offended even those who most wanted to help him. As a result he was constantly on the move; he died in Salzburg in 1541, where he had only recently been called by the bishop suffragan Ernest of Wittelsbach.

The Paracelsian Chemical Philosophy

At the death of Paracelsus there was little to indicate that his work would become the focal point for debate among scholars for more than a century. True, he had been a controversial figure during his lifetime, but relatively few of his voluminous writings had been published while he had been alive. The flood of Paracelsian texts began to issue from the presses only later. The legend of the man's near-miraculous cures began in the years after 1550 and soon there was a widespread search for his manuscripts, which were often published with notes and commentaries. Toward the end of the century vast collected editions were printed, and a whole school of Paracelsians battled with Aristotelians and Galenists over the course of natural philosophy and medicine alike.

Because of the late publication of the texts it is as proper to speak of the philosophy of the Paracelsians as it is that of Paracelsus. But even if we make this allowance the chemical philosophy is difficult to reconstruct,

partly because no simple textbooks were published and partly because the views of these men are alien to those of the twentieth-century scientist.

Actually there is much in the work of the Paracelsians that is reminiscent of other Renaissance natural philosophers. Above all, they sought to overturn the traditional, dominant Aristotelianism of the universities. For them Aristotle was a heathen author whose philosophy and system of nature was inconsistent with Christianity, a point of considerable concern during the Reformation. They stated that his influence on medicine had been catastrophic because Galen had uncritically accepted his work and the Aristotelian–Galenic system had subsequently become the basis of medical training throughout Europe. For them the universities were hopelessly moribund and unyielding in their adherence to antiquity.

The Paracelsians hoped to replace all this with a Christian neo-Platonic and Hermetic philosophy, one that would account for all natural phenomena. They argued that the true physician might find truth in the two divine books: the book of divine revelation – Scripture – and the book of divine Creation – nature (Figure 2.1). Thus, the Paracelsians applied themselves on the one hand to a form of biblical exegesis, and on the other to the call for a new philosophy of nature based on fresh observation and experiment. An excellent example of this may be found in the work of the important early systematizer of the Paracelsian corpus, Peter Severinus (1540–1602), physician to the king of Denmark, who told his readers that they must sell their possessions, burn their books, and begin to travel so that they might make and collect observations on plants, animals, and minerals. After their *Wanderjahren* they must "purchase coal, build furnaces, watch and operate with the fire without wearying. In this way and no other you will arrive at a knowledge of things and their properties."

One senses a strong reliance on observation and experiment in the work of these men even though their concept of what an experiment is and its purpose was often quite different from our own. At the same time one notes an underlying distrust of the use of mathematics in the study of nature. They might well, as Platonists, speak of the divine mathematical harmonies of the universe. Paracelsus, in addition, spoke firmly of true mathematics as the true natural magic. But it was more customary for the Paracelsians to react with distaste to the logical, "geometrical," method of argument employed by the Aristotelians and Galenists. They condemned this "mathematical method" along with the traditional scholastic emphasis on geometry and they very specifically attacked mathematical abstraction in the study of natural phenomena – particularly the study of local motion. Their reason for this was primarily religious, and they were particularly in-

Figure 2.1. The true chemical philosopher learns through divine revelation as well as chemical studies. From Heinrich Khunrath, *Amphitheatrum sapientiae* (1609). From the collection of the author.

censed by the *Physics* of Aristotle. There – through the study of motion – it was argued that the Creator God must be immobile. The Paracelsian chemists of the period of the Reformation stated firmly that any argument imposing such a restriction on the omnipotent Deity could not be ac-

cepted – and that for this reason alone the texts of the ancients were sacrilegious and must be discarded. The chemical philosophy was to be a new science based firmly on observation and religion. Those who turned to quantification might recall that God had created "all things in number, weight and measure." This was interpreted as a mandate for the physician, the chemist, and the pharmacist – men who weighed and measured regularly in the course of their work (Figure 2.2).

If the Paracelsians rejected what they called the "logico-mathematical" method of the schools, they turned to chemistry with the conviction that this science was the basis for a new understanding of nature. It was an observational science, and its scope was universal. These claims were to be found in the traditional chemical texts. For Paracelsus alchemy had offered an "adequate explanation of all the four elements," and this meant literally that alchemy and chemistry might be used as keys to the cosmos either through direct experiment or through analogy. Paracelsus explained the Creation itself as a chemical unfolding of nature. The later Paracelsians agreed and amplified this theme. Gerhard Dorn (fl. 1565–1585) gave a detailed description of the first two chapters of Genesis in terms of the new chemical physics, and Thomas Tymme argued that the Creation had been nothing but an "Halchymicall Extraction, Separation, Sublimation, and Conjunction."

The chemical interpretation of Genesis helped to focus attention on the problem of the elements as the required first fruit of the Creation. Although the Paracelsian *tria prima* (salt, sulfur, and mercury) was a modification of both the earlier sulfur-mercury theory of the metals and other elemental triads, it has a special significance in the rise of modern science. The Aristotelian elements (earth, water, air, and fire) served as the basis of the accepted cosmological system. They were used by the alchemists as a means of explaining the composition of matter, by the physicians (through the humors) as a system for the interpretation of disease, and by the physicists as the basis for the proper understanding of natural motion. The introduction of a new elemental system thus ran the risk of calling into question the whole framework of ancient medicine and natural philosophy.

Although the new principles can properly be interpreted as part of an attack on scholastic philosophy, it is clear also that they led to considerable confusion. Paracelsus had not clearly defined these principles, and, indeed, they were of little value in the development of modern analytical chemistry inasmuch as they were described as differing qualitatively in different materials. Nor had Paracelsus offered the principles specifically as a replacement for the Aristotelian elements. Rather, he had used both systems –

Figure 2.2. The earliest illustration of an enclosed analytical balance is to be found in this picture of an alchemical laboratory. From the *Theatrum Chemicum Britannicum,* ed. Elias Ashmole (1652). Courtesy of the Department of Special Collections, The University of Chicago.

and often in a seemingly contradictory fashion. By the fourth quarter of the sixteenth century we find element theory in a state of flux, with chemists choosing from observational evidence and Paracelsian texts as they saw fit. Nevertheless, from the texts of this period we can see that the chemical physicians were turning in increasing numbers to the three principles as a means of explanation. Some were attracted by the trinitarian analogy of body, soul, and spirit, whereas others turned to them in search of an alternative to the humors. For chemical theorists they represented philosophical substances that might never be isolated in reality, whereas for the practical pharmacist they were nothing else but his distillation products. It was not uncommon for a medicinal herb to yield a watery phlegm, an inflammable oil, and a solid, and it was felt that these at least indicated the presence of the primal principles of mercury, sulfur, and salt.

The concept of a chemical universe went beyond the chemical interpretation of the Creation and the problems of element theory. Those authors interested in meteorology explained thunder and lightning as a combination of an aerial sulfur and niter analogous to the explosion of sulfur and saltpeter in gunpowder. Similarly, Paracelsian authors were the first to offer a hypothesis meaningful for the development of agricultural chemistry. Seeking a cause for the beneficial effects of manuring in farming, they correctly postulated that the manure offered essential soluble salts to the soil.

Indeed, for the Paracelsians, the earth was seen as a vast chemical laboratory and this explained the origin of volcanoes, hot springs, mountain springs, and the growth of metals. The old concept of an internal fire was given as the explanation of volcanoes, which were understood as the eruptions of molten matter through surface cracks (Figure 2.3). Mountain streams were explained in an analogous fashion. Here they argued that subterranean water reservoirs were distilled by the heat of the central fire. As this vapor reached the surface, mountains acted as chemical alembics, and the result was the "distilled" mountain stream. Yet some rejected the possibility of such a fire, arguing that the air requisite for such a conflagration did not exist within the earth. Henri de Rochas (fl. 1620–1640) suggested that the heat of mineral-water springs derives from the reaction of sulfur and a nitrous salt in the earth. The English physician Edward Jorden (1569–1632) offered a more comprehensive chemical alternative. A thorough vitalist like most chemists of the period, Jorden accepted the commonly held notion of the growth of metals, but accounted for it in a new way. He turned to the alchemical process of "fermentation," which he defined as a heat-producing reaction requiring no air. This, he argued, must be the cause of inorganic growth. This new source of heat enabled one

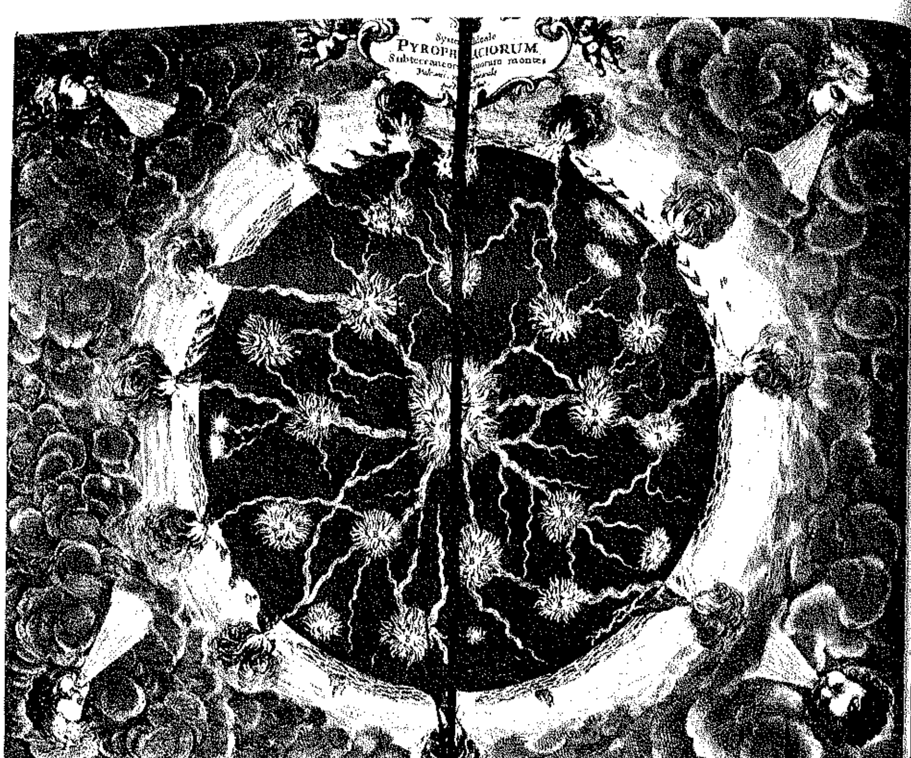

Figure 2.3. Diagram depicting the interrelation of volcanoes and the central fire. From Athanasius Kircher, *Mundus subterraneus* (1678). Courtesy of the Department of Special Collections, The University of Chicago.

to understand volcanoes and mountain streams without the troublesome notion of the central fire.

The Microcosm and Medical Theory

The Paracelsian chemical philosophy was considered to be a new observational approach to all nature, but from the beginning it had a special appeal for physicians. Paracelsus had insisted that God rather than the constellations had created him a physician; his followers repeated this and added that because of its divine origin medicine stood above the other sciences. Here they both reflected the priest–physician concept of Renaissance neo-

Platonism, and it is likely that their ultimate source may be found in Ecclesiasticus 38:1, "Honor the physician for the need thou hast of him: for the Most High hath created him." Indeed, for Paracelsus the role of the physician might properly be compared with that of the true natural magician.

Paracelsus and his early followers firmly believed in the macrocosm–microcosm analogy. Man is a small replica of the great world about him, and within him are represented all parts of the universe (Figure 2.4). At all times it was considered fruitful to seek out correspondences between the greater and lesser worlds, and the theory of sympathy and antipathy was employed to explain universal interaction. In contrast to Aristotelians, who insisted on action through contact, the Paracelsians found no difficulty in accepting action at a distance. It is thus easy to understand why Paracelsian Hermeticists should have been among the first to defend the experimental research of William Gilbert on the magnet. In the field of medicine, the controversial weapon salve cure (cure by sympathy involving treatment of the weapon rather than the wounded person) surely assumed the possibility of action at a distance.

For the Paracelsian the humoral theory of Galenic medicine was no longer adequate. The traditional explanation of disease as an internal imbalance of the humors was rejected by Paracelsus. He preferred to emphasize local malfunctions within the body that were ascribed to one of the three principles. A major cause of disease for him was to be found in external seedlike factors that were introduced to the body through the air, food, or drink. These localized themselves and then grew in specific organs. Here an analogy coud be drawn between the macrocosm and the microcosm. In the same fashion that metallic "seeds" in the earth resulted in the growth of metallic veins, "seeds" of disease grew within the body while they combated the local life force of a specific organ. This life force separated pure substance from waste in a manner analogous to the alchemist who sought to isolate pure quintessences from gross matter in his laboratory.

The relationship of the macrocosm to man had further chemical implications. The French Paracelsian Joseph Duchesne (c. 1544–1609) exemplified the persistent search for chemical analogies among the Paracelsians when he spoke of respiratory diseases in terms of the same distillation analogy utilized by other iatrochemists (or medical chemists) when explaining the origin of mountain streams. Special significance was attached to the air, recognized as essential for the maintenance of both fire and life. If, on the one hand, an aerial sulfur and niter might combine to cause thunder and lightning in the sky or hot springs in the earth, on the other hand, they might react within the body when inhaled to generate diseases charac-

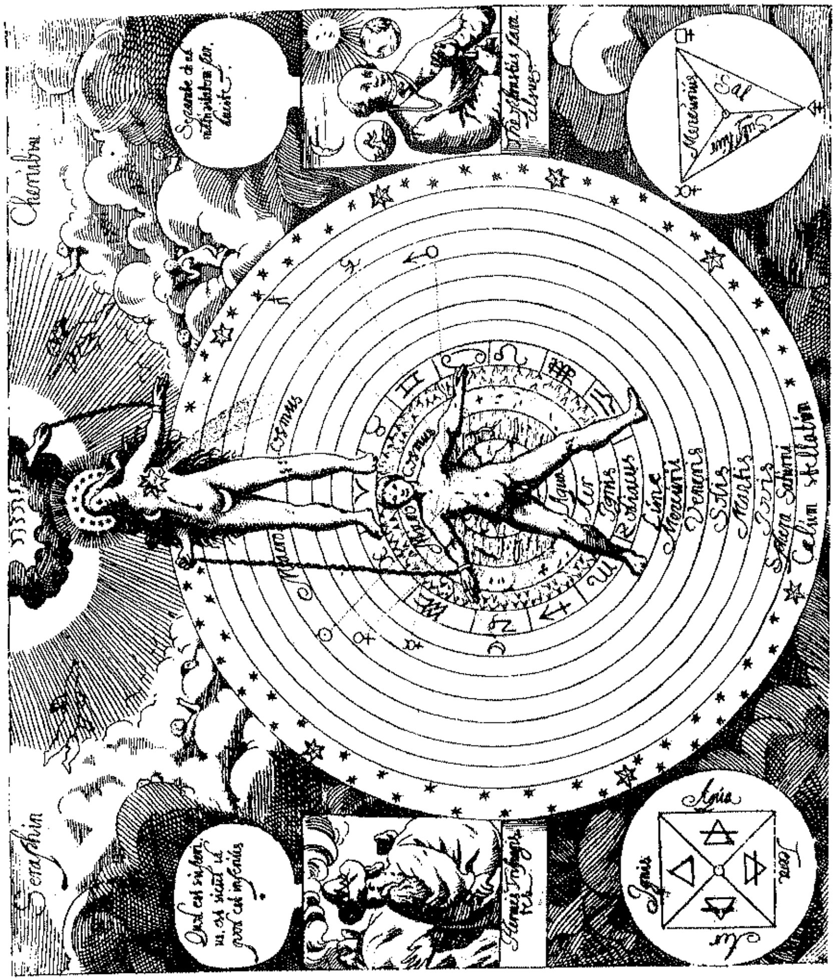

Figure 2.4. Man as the microcosm joined to his creator by the chains of nature, depicted as a young woman. Note the portraits of Hermes and Paracelsus plus the diagrams of the four elements and the three principles. From Tobias Schütz, *Harmonia macrocosmi cum microcosmi* (1654). Courtesy of the Department of Special Collections, The University of Chicago.

terized by hot and burning qualities (Figure 2.5). By the early seventeenth century aerial niter had become associated with a life force requisite for man. Indeed, this life force was on occasion identified with the *spiritus mundi*. It was postulated that after having been separated from gross air in the lungs, this substance was formed into arterial blood. Inasmuch as they maintained this concept – or modifications of it – it is little wonder that we find seventeenth-century Paracelsians rejecting the common practice of bloodletting. This operation, they argued, would only diminish the essential life force of the patient. At the same time, the rejection of bloodletting served to reflect their opposition to traditional humoral pathology.

If the Paracelsian chemical philosophy of nature provided a conceptual framework for the iatrochemist, it also provided a basis for his practical work. Because of the importance of heat and of fire, both the new chemical analysis of urine and the new chemical doctrine of signatures were to be characterized by distillation procedures. Similarly, in a search for the ingredients of medicinal waters at spas the Paracelsians furthered the development of analytical chemistry. A long medieval tradition in this field had resulted in the development not only of isolated tests, but of real analytical procedures, and it is understandable that the Paracelsians quickly adopted this tradition and added to it. By 1571 Leonard Thurneisser (c. 1530–1596) was using quantitative methods, solubility tests, crystallographic evidence, and flame tests, and early in the next century Edward Jorden was advocating the red-blue color change of "scarlet cloth" as a regular test for those liquids that we would classify as acids and bases. The work of these men provided the basic information necessary for Robert Boyle's analytic research later in the century.

The results of the new chemical analyses were put to practical use. Chemists could now give directions for the preparation of artificial mineral waters to those who could not travel to the spas, and at the same time this analytical information added an argument for the use of chemically prepared medicines. The Paracelsians argued passionately that theirs was a new and violent age – one that had spawned ravaging diseases unknown to the ancients. (They were particularly appalled by the venereal diseases.) As a result they needed new medicines, more potent than the traditional Galenicals prepared from herbs. Their meaning was clear: These new medicines were their chemically prepared metals and minerals. The Paracelsians were not innovators in this. Nevertheless, as R. Bostocke stated in 1585, the true Paracelsian could be distinguished from others through his careful attention to dosage and his use of the chemical art to extract only the valuable essence of dangerous minerals. Furthermore, in his defense of these

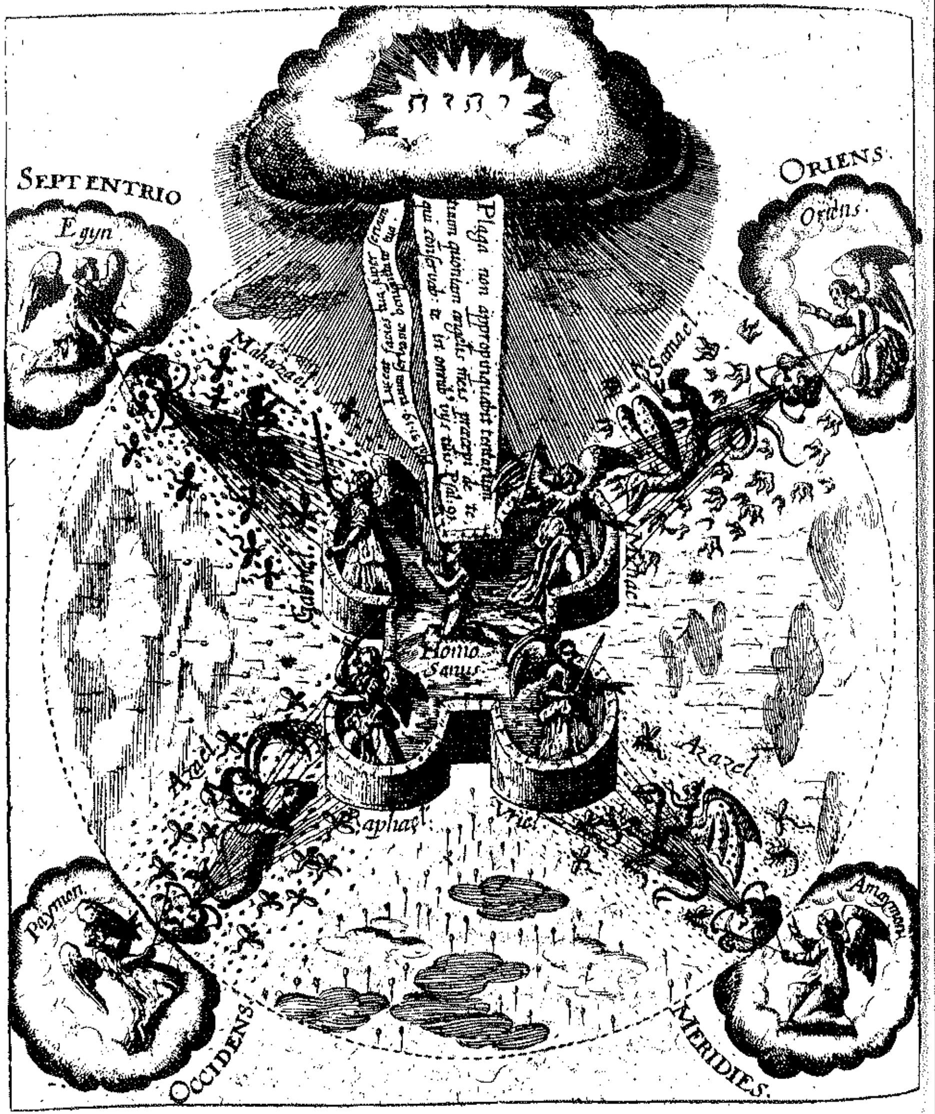

Figure 2.5. Man besieged in his castle of health. From Robert Fludd, *Integrum Morborum Mysterium* (1631). From the collection of the author.

medicines (1603), Duchesne relied upon the spa-water analyses to demonstrate that minerals had beneficial medicinal effects.

The defenders of the traditional *materia medica* were far from satisfied by apologies for the chemical medicines, and, in truth, their fear of the new drugs was not groundless. Paracelsus had broken with the Galenic dictum that "contraries cure" and turned instead to Germanic folk medicine, which insisted that "like cures like." The physician was told to investigate poisons rather than bland vegetable concoctions. That poison that causes a disease should now – in proper form – become its cure. And although the chemists sought to remove the toxic qualities, the medical establishment were not reassured by this claim. For them many of the proponents of the new drugs were uneducated charlatans. In a Galenic text the very name "Paracelsian" had an unsavory connotation. Thomas Erastus (1524–1583) accused Paracelsus of advocating the internal use of lethal poisons (1572). John Donne (1573–1631), in his comparison of the innovations of Copernicus and Paracelsus, admitted only the latter to the inner sanctum of Satan's lair as the governor of the "Legion of homicide Physicians." In answer chemists spoke ever more forcefully in defense of their medicines and methods. In the mid-seventeenth century it was suggested that several hundred sick poor people be taken from the hospitals and the military camps. They were to be divided into two groups, one to be treated by the Galenists, the other by the chemists. The number of funerals would determine whether the chemical or the traditional medicine had triumphed. The trial was never made, but the fact that it was proposed indicates the heat of the controversy.

The new drugs became a subject of intense debate at the university level in the early seventeenth century. The most inflammatory pamphlets appeared at Paris in the first decade of the century, but these were soon translated and published in other parts of Europe, with histories of the conflict being written as early as 1606. In London the fellows of the Royal College of Physicians had for several decades been engaged in plans for the publication of an official pharmacopoeia. When the French chemical physician Theodore Turquet de Mayerne (1573–1655) moved to London as the physician to King James I, he increased their interest in the new chemicals. And when the pharmacopoeia did appear in print in 1618, it was seen that a careful compromise had been reached. While the bulk of the volume was devoted to the traditional Galenicals, several sections were reserved for the new chemically prepared medicines. Official sanction was given to them both there and in the preface, which called attention to their efficacy in difficult diseases.

We may then speak properly of an increasing polarization between the Hermetic physicians and the Galenists. Yet at the same time the position of the London College of Physicians shows the eventual tendency toward compromise on the difficult question of the internal use of the new medicines. Among the chemical physicians themselves an ever-increasing number sought to maintain chemistry as the basis of a new philosophy of nature, but rid it of its most mystical and least experimental aspects. Influential iatrochemists such as Daniel Sennert (1572–1637) and Andreas Libavius (1540–1616) agreed with Paracelsus that chemistry was a proper basis of medicine and was thus the chief of all sciences. But they did not wish to see the works of Aristotle, Galen, and Hippocrates discarded and burned in the marketplace. Rather than resorting to polemics, the true physician should examine both the old and the new medicines and accept the best of both. For many seventeenth-century iatrochemists the chemical philosophy could be safely followed because this seemed to provide a new observational basis for the sciences. But many of the same men were disturbed no less than the Galenists – or later, the mechanical philosophers – by the mystical, alchemical cosmology of some of their fellows. Thus, the reader of this literature will find a bewildering spectrum of medical and chemical views. These books and pamphlets encompass everything from traditional allegorical alchemy to practical chemical pharmacopoeias. And, as we shall see, the debate itself was of great concern to both physicians and scientists until well into the seventeenth century.

We might pause to reflect on the significance of the chemistry and the medical debates it engendered in this period of the late Renaissance. What had the Paracelsians accomplished? How had they influenced medicine and science in this period?

Above all, Paracelsian medicine represented a reaction against the traditional veneration for antiquity. The early Paracelsians spoke harshly of Aristotle and Galen (if not always Hippocrates) and they turned instead to the recently translated Hermetic, alchemical, and neo-Platonic texts. A vitalistic universe founded on the macrocosm–microcosm analogy and the divine office of the physician was the basis for a new Christian understanding of nature as a whole. In their drive for reform the Paracelsians proceeded to strike at the very foundations of the older system. Both the Aristotelian elements – upon which the old cosmology was founded – and their attendant humors – upon which Galenic medicine depended – were questioned. Chemists now turned to the three principles as an explanatory device, and Paracelsian physicians spoke in terms of local seats of disease governed by internal *archei* rather than the imbalance of fluids.

The Paracelsian answer to antiquity was best expressed in the emphasis on observation and experience as a new basis for the study of nature. Surely the Paracelsians were not alone in this plea, but their special interest in chemistry as a guide for the study of man and the universe distinguishes them from other Renaissance philosophers of nature. Their extensive use of chemical equipment in distillation experiments and their constant reference to chemical analogies as a means of understanding all natural phenomena place them squarely in the Hermetic–alchemical tradition.

The medicine of the Paracelsians was strongly tinged with chemistry, but not with mathematics. While they might still pay lip service to the certainty of mathematical proof, in fact their concept of quantification was closest either to neo-Pythagorean mysticism or to practical measurements by weight. Mathematical abstractions of natural phenomena and geometrical proofs savored of scholasticism, which was plainly to be avoided. Logic itself was suspect as a form of the "mathematical" science and medicine of antiquity. The medico-science of the Paracelsians thus tended to be a less rather than a more mathematicized approach to nature than that of the past.

The opinions of these chemical physicians were set forth with conviction, but often with little tact. They decried the current overreliance on antiquity. They called for a new medicine and a new natural philosophy based on chemically oriented observations and experiments. And they demanded educational reforms so that their "Christian" concept of nature might be taught at the universities. On these points they came into direct conflict with tradition. Yet they argued no less vehemently amongst themselves. Here they debated questions such as the place of mathematics in the formation of the new philosophy, the truth of the elements, the reality of the macrocosm–microcosm analogy, and the meaning of astral emanations. We can, of course, credit the Paracelsians with specific advances – their concept of disease or their recognition of the importance of chemistry for medicine (both as a basis for the understanding of physiological processes and as a new source for medicinal preparations) serve as excellent examples. And there is little question that some of the "modern" concepts of the late seventeenth century have their roots in the "nonmodern" concepts of the iatrochemists of the preceding century. Nevertheless, it was primarily by defining their vision of a new science based on medicine and interpreted through chemistry that they found themselves engaged in a debate that was to be influential in the definition of significant aspects of modern science.